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Obstacles to the Globalisation of Corporate Research and Development in Technologically Underdeveloped Countries

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Declaration and Copyright

I declare that the thesis does not include any work-forming part of a thesis presented successfully for another degree. I declare that the thesis represents my own work except where referenced to others.

Abstract

Over two decades, the globalisation of research and development (R&D) has become a subject of considerable academic interests. The majority of studies concerning it describe this phenomenon in developed countries. Little is known about it in technologically underdeveloped countries. No study has systematically identified the possible obstacles to the R&D globalisation process in these countries. This suggests that this research topic is a distinctive topic for study. This study takes Libya as an example of a technologically underdeveloped country and aims to investigate the obstacles to the R&D globalisation process in Libya. To achieve this aim and in fulfilling the research objectives, the thesis utilises both qualitative and quantitative approaches. They were conducted through case studies of two transnational corporations (TNCs) working in Libya and an interview-based survey with three R&D related managers located in their offices there. Additionally, a questionnaire-based survey was conducted on 30 R&D related managers at 10 Libyan organisations. These methods are complemented by an archival analysis of several sources, related to both TNCs selected and the Libyan business environment.

Key findings of this thesis include; corporate R&D activities are limited and often confined to one way technology transfer, oriented towards resolving and fixing technical problems. Libya does have a domestic R&D capability, but it does not translate to innovations, with many obstacles hindering the practice of R&D activity. Libyan science and technology (S&T) and industrial policies have failed to provide concrete ways and means to reinforce R&D or to encourage the evolution of R&D subsidiaries. There is a lack of and weakness in the institutional mechanisms for encouraging and attracting foreign R&D activities.

The conclusion drawn suggests that some TNCs have begun conducting modest corporate R&D activities in Libya and most of these activities can be linked to the development phase of R&D. However, Libya was found to have a low technological capability and R&D capacity as well as weaknesses in relevant core competences. Thus, the foreign R&D activities are driven by demand rather than supply factors, based mainly on a market seeking strategy. Major obstacles hindering the corporate R&D activities were identified, including institutional, human resource, management and technological factors. Most of them link to weaknesses in and limitations of the national innovation system (NIS) in Libya. A key contribution of this thesis is that it provides both TNCs and host country perspectives on the possible obstacles to the R&D globalisation process in technologically underdeveloped countries. It also addresses possible improvement opportunities for these countries to join the global R&D networks.

Dedication

This thesis is dedicated to my grandmother, Asma (1910- 2011) whose faith in my abilities had no limits. She did not live to see me through to the end of the tunnel, but she never doubted the fact that I would, one day, be there.

It is also dedicated to the Soul of my colleague and friend, Ahmad Al-Tarhoni (1969-2003).

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This thesis represents my struggles with the complexities of studying the R&D globalisation process in a periphery context. It has been successfully defended on Wednesday the 02ed of November, 2011. As it reflects a part of myself, first and foremost, thanks to Allah for help and guidance. Then, I would like to sincerely thank a number of people who have provided invaluable support during the writing of this thesis. My supervisor Professor David Smith has over the last four years taught me a great deal about the art of research. He has never shrunk from providing criticism whenever required, and I have learnt much from his deep insights, sharpening suggestions and specific comments. This has been extremely valuable. Indeed, I thank him for being not just my advisor, but my mentor as well. Prof. Smith has far exceeded his normal duty as a Director of Study by taking a very active role, showing sincere interest in my research and continuously encouraging me to move forward. In addition, I would like to express my deep gratitude to Dr Michael Zhang who has later joined the supervision team and done remarkable work on deeply reviewing several parts of this research and extraordinarily provided useful comments and valuable suggestions. Special thanks to Dr Gamal Ibrahim for his specific comments on and suggestions for the proposal of this research, which have truly beneficiated the whole thesis. My thanks also go to Prof. John Medcof for providing me useful academic materials. I owe a gratitude to my colleagues at Nottingham Business School and Graduate School of Law, Business and Social Sciences, where some of them have helped in many ways along the road. I was quite lucky to be part of a research unit with inspiring people and was able to participate in leading international conferences on R&D Management and contribute in increasing the stock of knowledge of Technology Management, Innovation and Entrepreneurship (research group). Acknowledge the Libyan state for the scholarship that enabled me to complete this PhD thesis. Special tribute to all whose names do not appear here and who have contributed to the successful completion of this thesis, those are such as administrative staff at the University as well as people who agreed to be interviewed and who accepted to answer questionnaires' questions for this study. I am grateful to my family and close friends for providing me with the necessary distraction from work and my research. In particular, I thank my brother Mohammed and parents for all their love and vital support. Finally and foremost, I am grateful to my wife for her continuous interest and enthusiasm. Indeed, her love and understanding were essential for me to complete this thesis. Her encouragement makes it all worthwhile.

List of Acronyms

BRIC	Brazil, Russia, India and China
BRICS	Brazil, Russia, India, China and South Africa
CIA	Central Intelligence Agency
CIS	Commonwealth of Independent States
DCCI	Dubai Chamber Commerce & Industry
EIU	The Economist Intelligence Unit
EU	European Union
FDI	Foreign Direct Investment
G8	Group of eight industrial countries
GDP	Gross Domestic Product
GNI	Gross National Income
MHESR	The Ministry of Higher Education and Scientific Research
IAEA	International Atomic Energy Agency
ICT	Information and Communication Technology
IFIA	International Federation of Inventors' Associations
IMF	International Monetary Fund
IPRs	Intellectual Property Rights
ISO	International Organization for Standardisation
IT	Information Technology
LDCs	Least Developed Countries
M&A	Merger and Acquisition
MBRF	Mohammed bin Rashid Al Maktoum Foundation
MENA	Middle East and North Africa
MIEM	The Ministry of Industry, Electricity, and Mining
MNEs	Multinational Enterprises
NBSR	National Board for Scientific Research
NCED	National Council for Economic Development
NIS	National Innovation System
NOC	National Oil Corporation
NORD	National Office for Research and Development
NPC	National Planning Council
NSB	National Science Board
OBG	Oxford Business Group

OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
RADMA	Research and Development Management' Association
RAND	Research ANd Development Corporation
SMEs	Small and Medium-sized Enterprises
S&T	Science and Technology
STI	Science, Technology and Innovation
TBP	Technology Balance of Payments
TFP	Total Factor Productivity
TNCs	Transnational Corporations
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNDP/RBAS	United Nations Development Programme/Regional Bureau for Arab States
UNESCO	United Nations Educational, Scientific and Culture Organisation
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organisation
WTO	World Trade Organisation
WWII	The Second World War

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Chapter One

Introduction

1.1 An overview on the research topic

Science, technology and innovation are important ingredients in the process of industrialisation and development (UNIDO, 1998). The limitations of neoclassical theories in explaining economic growth have been recognised by economists and instead technological change has been incorporated endogenously in the new growth theories, and the importance of these factors has come to the forefront (see Romer, 1990). These theories recognise technology as a factor of production in its own right, along-side capital and labour (Kumar and Siddharthan, 1997). Thus, bridging the technology gap between countries is significant in fostering a sustainable economic development. Developing countries that fail to build capabilities enabling them to participate in the evolving global networks of knowledge creation risk falling further behind in terms of the competitiveness and the economic and social development (UNCTAD, 2005b). To build technology capabilities in developing countries, TNCs can play a role (UNCTAD, 2005a; Lall, 2003).

There is a growing consensus amongst economists that corporate R&D activities can play an important role in economic growth by helping to transfer technology, and building and enhancing technology capability (UNCTAD, 2005a). Increasingly, TNCs have internationalised corporate R&D activities through both foreign direct investment (FDI) and technology alliances (Chen, 1997). Traditionally, R&D internationalisation took place in developed countries as both home and host country. However, TNCs have recently started to undertake R&D activities in developing countries. In addition, some TNCs from developing countries have begun to conduct R&D on a global scale (UNCTAD, 2005a; Gammeltoft, 2006; OECD, 2008b; Reddy, 2011).

In the light of the changing dynamics of global R&D, the research seeks to shed light on the globalisation of corporate R&D in terms of the possible obstacles to this process. There have been few studies on an international scale which focus on some of the issues regarding R&D globalisation. These studies have focused on developed countries, and generally neglected some aspects and dimensions which are increasingly becoming essential for facilitating the R&D globalisation process, especially in developing countries.

Little consideration has been given to how technologically underdeveloped countries can be involved in international R&D activities and what they can actually do to reap the benefits of the globalisation of R&D activity. In this context, Figueiredo (2002) confirms that little is presently known about the technological capability in late industrialised countries and its impact on the international R&D organisation. The literature related to the R&D globalisation does not reveal empirical studies regarding technologically underdeveloped countries. Thus, this thesis adds to current knowledge and contributes to better understanding of the obstacles to the R&D globalisation process in technologically underdeveloped countries. This further underlines the importance of exploring the globalisation of corporate R&D activity and its implications for these countries.

1.2 Background

The globalisation of corporate R&D activity is not just a recent phenomenon (Reddy, 2000). It has been widely practised by TNCs, and this does not merely involve the development of research facilities abroad, but also extends to other aspects such as the international exchange of know-how, licenses and patents co-operation and the training of scientists (Farhad, *et al*., 2003). The new aspect is that the globalisation of corporate R&D activity is encompassing more geographical areas outside developed countries (Reddy 2000; UNCTAD, 2005a; Gammeltoft, 2006; OECD, 2008b). There are clear trends towards locating more R&D activities to developing countries (see Jaruzelski and Dehoff, 2008; UNCTAD, 2005a).

However, the participation of developing countries in R&D globalisation has so far been uneven (UNCTAD, 2005b). A survey of more than 1000 Greenfield FDI projects involving R&D during the period 2002- 2004 shows that the majority 739 were located in developing countries. The Asia Pacific countries accounted for more than half of these projects, 563, and the main recipients were India and China (UNCTAD, 2004b: 6). In addition, data on the geographical distribution of 2584 R&D foreign affiliates shows that 264 were located in developing countries. The whole of Asia had 216, while Latin American and the Caribbean had 40, and Africa only had four (UNCTAD, 2004b: 6).

The evidence suggests that improved host country environments have facilitated R&D globalisation and the liberalisation of trade and investment regimes over the past two decades has also contributed to it by TNCs (UNCTAD, 2005b: 12). Narula and Dunning (2000: 160) stress that for developing countries breaking away from natural asset-based

activity and encouraging TNCs to invest in higher value adding activities can only be achieved by improving their country-specific location advantages, which require changing policies, improving infrastructures, investing in the education and the development of innovation capability.

The globalisation of corporate R&D activity is an under researched phenomenon (UNCTAD, 2005a; OECD, 2006a), and researchers in the field of international R&D business have examined and explored various aspects of this phenomenon. These studies provide valuable insights on firms' motivations to internationalise their R&D activities (Ambos, 2005; Kuemmerle, 1999b), on the location of R&D activities (Dunning, 1993; Brockhoff, 1998), on the coordination and control of international R&D networks (Serapio and Hayashi, 2003; Ambos and Schlegelmilch, 2004), on the management and organisation of international R&D activities on a global scale (Gassmann and Zedtwitz, 1998; Zedtwitz, *et al*., 2004), and on the international collaboration in R&D and innovation (Asakawa, 2001; UNCTAD, 2005a). Most of these studies were generally attempting to answer one or more of three main research questions:

- What are the determinants of conducting R&D outside the home country?
- How should TNCs manage a globally dispersed portfolio of R&D sites?
- What is the nature of the R&D internationalisation process?

Although these studies analyse the R&D internationalisation process from different perspectives, these processes have generally only been explored in R&D sites in developed countries (Helble, 2004). These studies seem to have neglected non-traditional R&D locations, where TNCs have started locating some of their strategic R&D in some developing countries (Reddy, 1997: 1822; Reddy, 2011; UNCTAD, 2005a). This could mean that, so far, research in these phases has focused on developed countries, leaving room for further research on the same fields in developing countries.

Few recent studies have focused upon R&D in late industrialised countries (Reddy, 2000, 2011; Helble, 2004). Some recommendations have been that the extent to which developing countries connect with the international R&D networks of TNCs depends in particular on the strength of their NIS and improving the quality of human resources, institutions, as well as the production and innovation capabilities of enterprises. This was without giving any detailed analyses about the obstacles to this internationalisation process. In this context, UNCTAD (2005b) highlights that there is a need for further

analysis of the implications of the R&D globalisation process for both host and home countries. This implies that 'in spite of the increasing number of analyses of the international R&D, its extent, significance and novelty remain the object of some debate' (Gammeltoft, 2006: 183). Edler (2007: 2) confirms that 'the knowledge on the current developments of R&D globalisation is rather broad and has constantly improved'. Thus, it is significant to explore critical issues related to the R&D globalisation process.

1.3 Justifications of the research

There are two main reasons why there is a rationale to do such research. First, the theoretical perspective: most of the studies that relate to the phenomenon of the globalisation of corporate R&D activity focus upon developed countries, and the few studies which have attempted to examine causalities of the limited share of developing countries in this phenomenon provide a mixed picture. Second, the practical perspective: the available evidence strongly suggests that the technological and innovative capability gap between developed countries and developing countries in general and between developed countries and technologically underdeveloped countries in particular is tending to widen. Thus, the real challenge is to narrow this gap by involving these countries in the global R&D networks. Indeed, the investigation of obstacles to the R&D globalisation process in these countries is aligned with this aspect and there was way of describing it in a systematic way. Hence, there is potential in considering the obstacles to these processes in order to obtain holistic perspective about the behaviour of this phenomenon.

1.4 Importance of the research

A number of features highlight the importance of this research. For example, the 'research gap' this thesis addresses has been identified as the lack of research into the development of corporate R&D in technologically underdeveloped countries. Therefore, this research seeks to fill this gap and contribute further to the existing literature. It is one of the few empirical studies exploring R&D sites in technologically underdeveloped countries, which attempts to advance an understanding of technological developments in those locations and their impact on international R&D. This provides some new implications for theory, practice and policy. Thus, this research can contribute to this field through creating a new primary data set and associated statements that address neglected issues.

1.5 Research problem and questions

As highlighted in previous sections, there are some issues that seem to be neglected by researchers in the research topic, which need to be studied. For instance, UNCTAD (2005b: 16) addresses that 'attracting corporate R&D and benefiting from it could remain a challenge for the majority of developing countries, rather than an opportunity'. Recently, developing countries undertake less than eight per cent of the formal R&D activities globally (UNCTAD, 2005b: 47).

Available data indicates that although some African countries (especially, middle income countries) are putting emphasis on FDI as a carrier of new scientific knowledge and technological innovation (UNCTAD, 2005b). Africa attracts a low level of FDI in general and negligible R&D-related activities. Until 2005, it was around three per cent and more than 50% of FDI targeted natural resources industries. Overall, Africa is generally marginal in R&D by TNCs (UNCTAD, 2005a, b). Moreover, it has been observed that the few R&D activities to be found in Africa are restricted to the application of existing knowledge rather than the development and application of new ideas. Potential reasons have been addressed; 'weak domestic R&D capabilities and, in many cases, the absence of institutional mechanisms that provide explicit incentives to investors to target knowledge-based and-intensive activities' (Mugabe, 2005: 194).

Furthermore, it has been suggested that 'the role of TNCs and FDI in promoting the scientific and technological development of African countries and the extent to which FDI stimulates R&D in and transfer of new technologies to Africa are the subjects of increasing debate and academic research' (Oyelaran-Oyeyinka, 2004, cited in Mugabe, 2005: 195). Overall, UNCTAD (2005a: 183) considers whether the question of corporate R&D activities spreading to a growing number of developing countries will remain open and, if so, under what conditions. Thus, more empirical studies are needed before any conclusions can be drawn, because those studies have been based on some assumptions without considering the differences between African countries regarding their technological development level and their ability to attract foreign R&D activities.

In this context, Libya as one of the African countries and technologically underdeveloped countries, that has made some progress on policy and economic reforms, which helped it to attract FDI by TNCs particularly in the petroleum industry. According to Porter and Yergin (2006), it has several advantages to become one of the main destinations in Africa to FDI.

However, evidence shows that the corporate R&D activities and collaborative agreements in this arena are too limited. Little attention has been paid to what can motivate investors to invest in R&D (Omar, 2000). On the other hand, it should mention that TNCs have been conducting some sort of R&D activities in Libya since 2004 (UNCTAD, 2005a: 148).

Based on all these aspects, the research question can be generally formulated as follows:

Why have technologically underdeveloped countries lagged behind other developing regions in attracting global R&D activities? And how can these countries (especially, middle income countries) become involved in global R&D networks?

Thus, more specifically, this research addresses the following core questions:

What are the principal obstacles to the R&D globalisation process in Libya as a host country example of a technologically underdeveloped location?

What are the main factors that should be considered to overcome these possible obstacles?

It can be said that these questions lead to consider several dimensions of the R&D globalisation process, but according to the scope of this thesis, the emphasis is placed upon the international R&D by TNCs in the host countries and relevant issues affecting this process. These questions were derived from the evidence that indicates the limitation of corporate R&D activity in Libya.

1.6 Aim and objectives of the research

The main aim of this research is to investigate the principal obstacles that face and hinder the corporate R&D globalisation process of both international and joint R&D projects in Libya, and to draw some implications that can help to overcome these obstacles. Generally, this research is devoted to a consideration of the possible obstacles, and will act as a background to contribute to the base of knowledge about the globalisation of corporate R&D's phenomenon, with a particular reference to Libya as an example of a technologically underdeveloped country. Thus, to achieve this aim, a number of objectives have been addressed as follows:

1- To identify the nature and patterns of corporate R&D activities conducted in Libya.

2- To evaluate the capability of R&D activities in Libya and the ways that have been used to foster it.

3- To examine the impact of Libyan S&T and industrial policies upon R&D subsidiary evolution and corporate R&D activities.
4- To ascertain institutional mechanisms, which have been applied to encourage and attract foreign R&D activities.

It can be noticed that these objectives cover the most important aspects and dimensions that can clarify the situation of corporate R&D activities in Libya and the possible obstacles to globalisation of corporate R&D activity there. These objectives utilise both TNC and host country perspectives for achieving the aim of this research.

1.7 Research strategy and methods

This research utilises quantitative and qualitative research methods. Case studies were the main research strategy, complemented with archival analysis and a survey in order to achieve a deep understanding of the research problem. Evidently, case studies are suitable for examining highly complex recent phenomena (for instance, the globalisation of corporate R&D activity beyond developed countries) and for obtaining in-depth insights into the obstacles to the process of this phenomenon, which is relatively un-researched area, especially that, this research studies corporate R&D in different sectors where their boundaries are not clearly defined.

The main data collection methods were semi-structured interviews to collect data from TNCs. Additionally, a self-administrated-questionnaires was used to collect data from Libyan organisations. To have a TNCs' perspective, two representative cases have been selected according to criteria determined for this purpose. Two TNCs working in the oil and gas industry field in Libya. For a host country's perspective, 10 Libyan organisations have been selected based on relevant criteria. The sample includes five research centres and five industrial firms. For analysing quantitative data, the descriptive statistics were mainly used, whilst the analysis of qualitative data was done through the thematic analysis. The methodology used in this research bridges the different research traditions of quantitative versus qualitative research and takes advantage from such a triangulated approach.

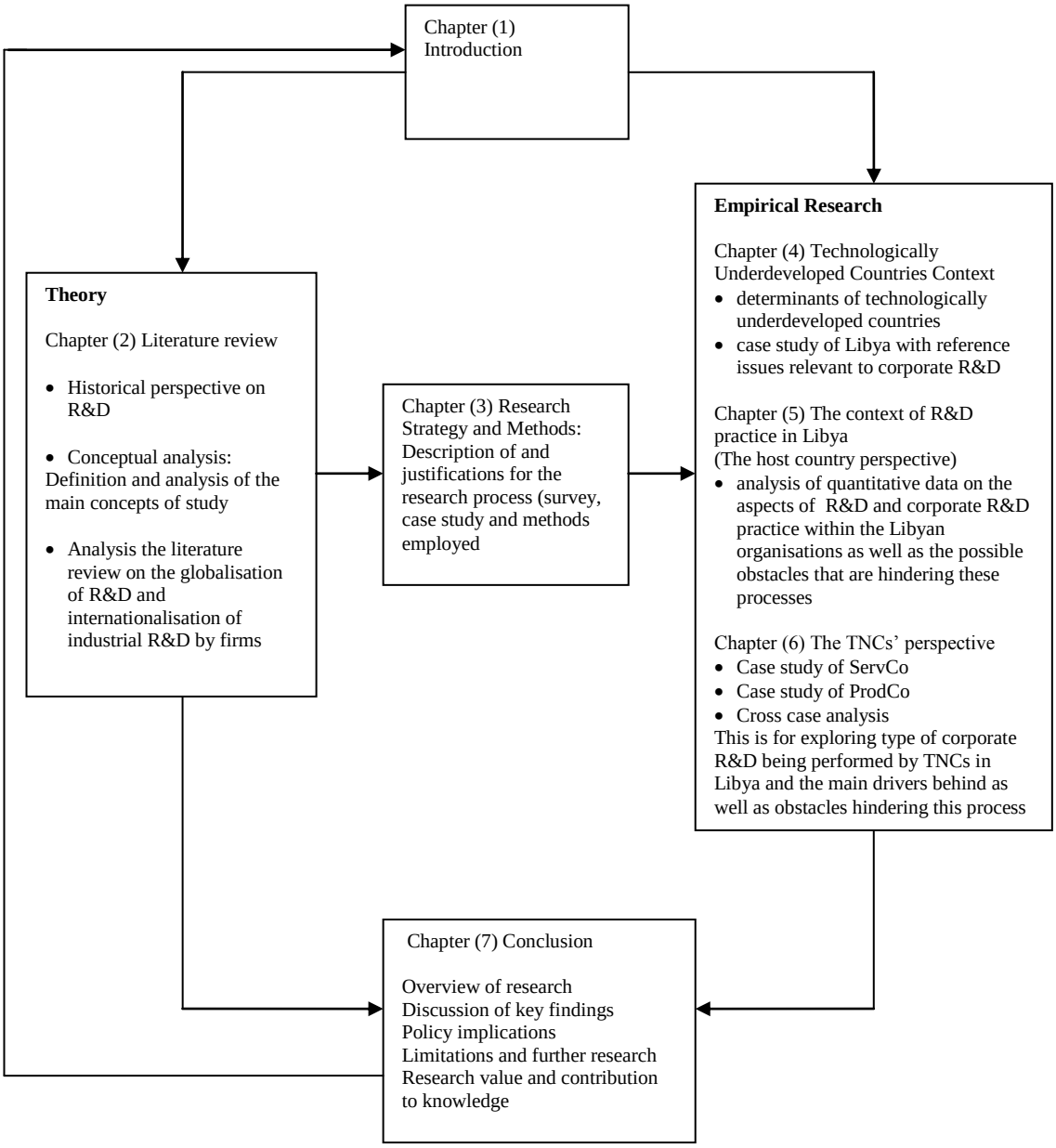
A guarantee of confidentiality and anonymity was given within all research design stages about protecting the rights of the participants and their organisations (see attached letters in Appendix No. 1, 3). Overall, permission was not given by the Research Ethics Committee

to commence the surveys, until the committee was adequately reassured about the protection of research participants' confidentiality and anonymity. Furthermore, participants have been informed by me about their right to refuse answering any questions or participating in this study.

1.8 Structure of the thesis

The format of the thesis follows the structure that relies upon three main cornerstones as presented in Figure 1.1, which can serve as an outline of the thesis:

Figure 1.1 Overview and organisation of the thesis



1.9 Conclusion

This chapter has introduced the reader to the thesis in hand. It introduces the research's topic and clarifies that it has not previously been adequately studied and remains an under-researched topic and is therefore not fully understood in academia. This may be explained in terms of little consideration being given to how technologically underdeveloped countries can be involved in international R&D activities and what they can actually do to reap the benefits of the globalisation of R&D activity. This chapter introduces the rationale of how to go about the study in hand. It addresses the research problem and questions, where the research aim and objectives have formulated in the way that make good directions to answer the research questions. Then, the research methodology adopted to study the research's topic has been briefly highlighted. The structure of the thesis has been outlined in a diagram to clearly show the linkages and interactions of the components of the thesis. Overall, this chapter addresses the research gap this thesis seeks to fill and indicates a possibility to contribute further to the existing literature. This is specially that the globalisation of R&D is a growing area of academic research.

Chapter Two

Literature Review

2.1 Introduction

Theoretically, to achieve a good understanding of the globalisation of corporate R&D activity, a number of conditions should be considered. The international R&D business field is a new field of study and it treats a multifaceted subject, which stands at the intersection of at least seven intellectual disciplines: International Business, Technology and Innovation Management, R&D Management, Organisation Theory, Strategic Management, Economics and Entrepreneurship. Therefore, no single perspective is able to deal with and provide a comprehensive analysis to study topics related to this subject. In this context, the literature that underpins the study of the R&D globalisation process covers a number of these academic disciplines, which have been chosen to address the topic of this research. These include international business (for globalisation and FDI involving R&D), innovation (for R&D activity, NIS and technology transfer), economic development (for developing countries, technological development and polices) and international strategic management (for drivers of global R&D activities). They cover all the theoretical parts related to the research problem, aim and objectives of this research.

The purpose of this chapter is to provide a careful review of existing knowledge about trends and issues on the globalisation of R&D. This is by reviewing the relevant literature on the historical background, related terms and concepts, theories and perspectives on this phenomenon, with especial references, where it is possible, to the development of this phenomenon in so called developing countries and its implications for these countries. This is in order to find out the research gap and neglected issues. Due to the complexity and heterogeneity of this research field, the chapter is necessarily selective and limited more to the international R&D by firms. Hence this chapter elaborates the determinants, drivers, nature and patterns of international R&D activities by firms. This chapter also highlights the effects of the R&D globalisation process on home and host countries.

2.2 Historical perspective on R&D

2.2.1 Introduction

In this part, an attempt is made to highlight and follow the historical roots of corporate R&D activity and the development of relevant R&D management context. This leads us to

look at some of the significant stages in the development of industrial R&D and international R&D business. This can beneficially clarify the reflection of this development on the world, and represent an introduction to where and when this activity evolved and has been developed through different phases and stages, and at different levels.

2.2.2 R&D activity in a historical perspective

In general, the conduct of in-house corporate R&D by industrial companies is a German organisational innovation, developed in the chemical industry in the second half of the nineteenth century and originally intended to create new synthetic dyes for the textile industries (Freeman, 1982, cited in Niosi, 1999b: 111). That organisational form subsequently spread to Belgium, the UK and USA (Mowery and Rosenberg, 1998). However, industrial research, as we know it at present, was started in the early twentieth century by pioneers in Europe and the USA, notwithstanding a general scepticism among businessmen who saw little connection between 'academic' science and product innovation and who valued hard assets over intellectual property. After the Second World War (WWII), R&D emerged as a widely recognised industrial force. The success of leading firms in industries such as chemicals, electronics and pharmaceuticals in exploiting new discoveries for rapid growth in revenues and profits, based on technical developments, generated a wide interest in R&D in firms in the USA, Europe and among emerging Japanese firms (Ganguly, 1999: 13). In the 1950s, large industrial firms were boasting about their scientific proficiency (see Journal of Scientific American, 1952, No. 6).

Industrial firms did not pay considerable attention to the organisation of research and discoveries process until the latter part of the nineteenth century. It is well known that most new products were a result of some individual inventors' efforts such as Edison, Bell, and Wright. But due to the increasing complexity of industrial products and productivity operations, these efforts were not enough to be in line with market requirements and expectations. 'Most modern scientific and technological break-throughs are achieved by the efforts of multidisciplinary teams' (Ganguly, 1999: 3). Therefore, large industrial firms started establishing R&D units, attracting scientists and engineers to work in, and allocating huge amounts for expenditure on this activity. This contributed to create a revolution in the research and innovation world. For example, in the latter part of the nineteenth century, Thomas Edison established a laboratory at Menlo Park, New Jersey. In the early twentieth century, several other American companies, including DuPont, Corning, Kodak, and Alcoa, set up their own R&D organisations (Petroski, 2009). This

organisational novelty spread to other companies, including GE, AT&T, among university laboratories, few other corporations, created their first R&D labs (Niosi, 1999b: 111).

The establishment of a formal research laboratory united a company's previously independent researchers into a collaborative community. Among other purposes for having a R&D lab were the development of new products, the maintenance of competitive edge in industry, and avoidance of antitrust suits by a firm doing its own exploratory work (Petroski, 2009). Thus, 'the mission of corporate R&D was the development of competitive advantages through new and exclusive products and processes. Corporate R&D is thus, most often, commercially applied R&D' (Niosi, 1999b: 111).

Here, it is useful to shed light on different stages that R&D activity has been passed in the three types of organisations (company, private and public research centres and university R&D). With the occurring deep changes in business environments have come major changes in R&D strategies and the manner in which R&D activities should be conducted. These developments can be divided into six phases. Each phase represents which has been called a generation. Table 2.1 shows these generations and their implications:

Table 2.1 Description of six generations of R&D processes

R&D Generations	Context	Process Characteristics
First generation	Black hole demand (1950 to mid- 1960s)	R&D as ivory tower, technology-push oriented, seen as an overhead cost, having little or no interaction with the rest of the company or overall strategy. Focus on scientific breakthroughs.
Second generation	Market shares battle (mid-1960s to early 1970s)	R&D as business, market-pull oriented, and strategy-driven from the business side, all under the umbrella of project management and the internal customer concept.
Third generation	Rationalisation efforts (mid-1970s to mid-1980s)	R&D as portfolio, moving away from individual projects view, and with linkages to both business and corporate strategies. Risk-reward and similar methods guide the overall investments.
Fourth generation	Time-based struggle (early 1980s to mid-1990s)	R&D as integrative activity, learning from and with customers, moving away from a product focus to a total concept focus, where activities are conducted in parallel by cross-functional teams.
Fifth generation	Systems integration (mid-1990s to mid-2000s)	R&D as network, focusing on collaboration within a wider system – involving competitors, suppliers, distributors, etc. The ability to control product development speed is imperative, separating R from D.
Sixth generation*	Extended systems integration and external leverages by open innovation and open R&D Globally dispersed networked innovations Dedicating technology brokering strategies (early 2000s to onward)	R&D as network and linkage, depending more on outsourcing and offshoring R&D. This has led to be more aspects and actors involved. The need for taking more aspects into account is driven by product and technology complexity; the demand to cooperate with more actors is driven by larger technological investments and rational specialisation; and the necessity of efficient and effective commercialisation of new technology is driven by rate-of-return demands and the cost of being late. Also, more and more shift from attempting to invent towards the focus upon how existing technologies in one market could be used to create breakthrough innovations in another.

Source: Based on (Nobelius, 2004: 370) who have developed and adapted from (Roussel, *et al*., 1991: 39; Rothwell, 1994; Miller and Morris, 1998: 19; and Chiesa, 2001: 12).
* Adopted from (Chesbrough, 2003a; Hargadon, 2003; Nobelius, 2004: 373- 374; and Enkel, *et al*., 2009).

In practical terms, 'the notion of R&D generations is a difficult term, especially since most companies constitute a mixture of the generations and since the relevant time period for them most likely differs depending on industry segment, demographics, company age,

research intensity, legislation demands, etc.' (Nobelius, 2004: 375). In brief, the perspective on how to best manage processes and undertake R&D activity has changed significantly throughout the years. These changes and developments could be divided into six stages or generations. Furthermore, it can be said that each generation of R&D management has increasingly become complex as the boundary of what constitutes R&D has expanded. Nowadays, corporate R&D is not assigned to an isolated activity, conducting in-house but instead is spread out everywhere to exploit all possible different forms of external knowledge sources. Hence, as the boundaries of the corporation are increasingly blurring while the international competition increases, the model of undertaking this activity has been as a network, crossing corporate boundaries in the fifth and sixth generation. The last developments go in line with adopting the open innovation approach by many companies. This approach has been introduced by Chesbrough (2003a: 36) as 'the use of purposive inflows and outflows of knowledge to accelerate internal innovations and expand the markets for external use of innovation, respectively'.

One aspect that should be mentioned here is that most of corporate R&D laboratories are reappearing but with a new role. This has come as a result of the recognition of the importance of knowledge and its development within companies. Bamfield (2006: 73) points out the new key roles as: 1) to leverage technologies and platforms, 2) to house critical competencies and expertise, 3) to create new technology, and 4) to fuel growth and business development. However, it still remains the case that each company's R&D enterprise has its particular characteristics and focus (Petroski, 2009).

2.2.3 Historical overview on international R&D

Science and technological development has always been an international endeavour (European Commission, 2007b: 6). Indeed, 'scientific and technical information has been accessible to motivated and knowledgeable people interested in tapping into this body of knowledge. With the development of modern scientific methods and the scientific journal system, scientists have communicated their findings to each other, both formally and informally' (Lundin, *et al*., 2004: 5). Many scientific ideas have been transferred from one country to another, as academic researchers correspond and travel widely over the centuries, exchanging such knowledge and ideas.

However, although conventional wisdom always considers science to be transnational and universal by nature (Merton, 1942; Petrella, 1992), the internationalisation of corporate

R&D is a more recent phenomenon that follows quite different dynamics. Its spread has intensified under the current wave of globalisation and the communications revolution and is a major policy concern for industrialised countries (UNCTAD, 2005a). Firms were tending to concentrate their R&D activity in their home countries and this picture has just changed in the last few decades of the twentieth century (Horrocks, 2007). Most advanced forms of conducting R&D activities on a global scale have just existed since the 1980s (Petrella, 1992), when the globalisation of trade was extended to services and intangibles such as R&D activity. It could imply that the globalisation of S&T has been involving more and more in a commercial context. As a result, firms tend to place more emphasis on the global management of technology (Chiesa and di Milano, 1996), and they adopt different technology sourcing strategies to maximise the benefits that can be obtained from their R&D activities on a global scale.

In this context, a study by Pearce and Singh (1992) indicates that the age of the overseas subsidiary R&D units of multinational enterprises (MNEs) had been established before 1929 and they had exchange programmes of scientists with local research institutions. For example, British Thomson-Houston which was wholly owned by General Electric of the US formally established an R&D laboratory in 1924 (Sanderson, 1972). Cantwell (1998) finds that the largest European and American companies conducted seven per cent of their total R&D as overseas R&D activities since the 1930s (cited in Kuemmerle, 1999a: 179). Later during the 1940s, corporate laboratories sprang up around the new platform technologies of electrical energy and petrochemicals (Mowery and Rosenberg, 1998).

The concerted move to internationalise corporate R&D began after WWII, an example being IBM that established its main R&D facility in New York in 1945 but within a decade had set up IBM Zurich (1956), to be followed by IBM Haifa (1972), IBM Tokyo (1982), IBM Beijing (1995) and IBM Delhi (1998) (Kahn, 2007: 7). Since the 1980s and later, their roles have often been redefined to encourage more active support of product development in the companies' operating divisions (Casson, *et al*., 1992: 119). In general, it has been noticed that 'American MNEs have seemingly had a particularly strong tendency to establish overseas R&D units during the two post war decades, whilst other European companies have strongly implemented such facilities since 1966' (Pearce and Singh, 1992: 132). Reddy (2000) confirms that companies have generally performed some kind of R&D activity abroad since the 1960s for one reason or the other. By the late 1960s that picture seems to have gradually and significantly changed (Horrocks, 2007: 241).

The spread of R&D value chains is now found in manufacturing industry such as aerospace, automobiles, electronics, semiconductors and the health sciences (Kahn, 2007), and it appears to be more prevalent in high technology intensive industries than medium and low technology industries (Niosi, 1999a). Many TNCs have decentralised their R&D activities, but they still keep core technological competences in headquarters. For example, in 2006, 3M had 32 R&D locations worldwide in 30 countries supported by a central research centre at corporate headquarters in St. Paul, USA (Ohmayer, 2007: 18).

Booz Allen Hamilton's Global Innovation 1000 (2008) ranked and assessed the world's 1000 biggest corporate R&D investors, where the globalisation of R&D was the big trend found among that year's top R&D investors (Jaruzelski and Dehoff, 2008). It indicates that the Global Innovation 1000 spend an average of 55% of their R&D funds in other countries and 91% of the world's 1000 largest R&D spenders undertake innovation activities outside their home countries (Jaruzelski and Dehoff 2008: 3- 4). This can lead to conclude that the globalisation of corporate R&D activity has become the norm for the world's most innovative firms.

These recent developments in the global business environment make clear that the R&D globalisation is one of the key strategic decisions that almost every TNC might find itself having to make. But not every firm can identify and capitalise on opportunities that this phenomenon offers. There are many obstacles surrounding firms. Hence some parts of the world have the lion's share of these opportunities. In this regard, Jaruzelski and Dehoff (2008: 4) mention that 'while the traditional R&D leaders are moving much R&D offshore, the pattern is not simply one of outsourcing to other locations. A wider circulation of R&D is happening, as Triad (North America, Europe, and Japan) invest overseas, but also attract incoming R&D dollars, too. In fact, 40% of corporate R&D spending in the US is generated from firms headquartered elsewhere'.

2.2.4 International R&D in developing countries: a historical overview

According to Dunning (1992: 22), spreading of corporate R&D activities in developing countries began in the 1980s, when there was a noticeable increase in their technological capacity. However, the significant R&D operations of TNCs in developing countries existed since the1990s (UNCTAD, 2005a). For example, Motorola established the first foreign owned R&D lab in China in 1993. Pharmaceutical companies such as Astra-

Zeneca, Eli Lilly, GlaxoSmithKline, Novartis, and Pfizer all ran clinical research activities in India since the 1990s. From practically nothing in the mid-1990s, the contribution by South-East and East Asia to global semiconductor design reached almost 30% in 2002 (UNCTAD, 2005a). In addition, similar significant operations have commenced in the 2000s to grow in some other developing countries. For instance, STMicroelectronics has some of its semiconductor design done in Rabat, Morocco. General Motors in Brazil competes with its other affiliates in the USA, Europe and Asia (UNCTAD, 2005a).

Thus, it seems that since the late 1990s, the wave of R&D globalisation has spread across the world. However, most developing countries still remain excluded from these developments (Pasimeni, *et al*., 2007; Kahn, 2007). Trends show that the share of developing countries in global R&D actually fell between the mid-1980 and the mid-1990s from six per cent to four per cent (UNDP, 1999: 67). Evidence suggests that the main actors (Triad) had a significant role to play in S&T and have accepted this as an unavoidable reality (Petrella, 1992). This is because a high proportion of R&D carried out in the world is directed by TNCs based in these countries. They play the major role in the generation and international diffusion of technology, and account for around 80% of world trade in technology (Arocena and Senker, 2003: 17).

The debate surrounding this phenomenon has taken two opposing perspectives. On one hand it is expected to continue and in contrast it is not expected to continue to involve so called developing countries. Both of them provide logical illustrations to prove the validity of their views. UNCTAD (2005a) summarises these perspectives as follows:

Table 2.2 Qualitative indicators on the directions to the R&D globalisation process

Main reasons driven the expectation of R&D globalisation to continue	Main reasons driven the limitation of R&D globalisation to continue
• In most cases, R&D activity undertaken abroad supports production. Thus, based on the fact that many TNCs increase production in developing countries, some R&D (of the adaptive kind) can be expected to follow. • R&D is a form of service activity. Thus, as many other services are fragmenting in a process whereby certain segments are located in countries with lower wages and appropriate skills, it is not surprising that R&D activity is following suit.	• As R&D is a service activity with very demanding skill, knowledge and support needs – traditionally only met in developed countries with strong national innovation systems (INS). • As R&D is taken to be the least "fragmentable" of economic activities because it involves knowledge that is strategic to firms, and because it often requires dense knowledge exchange (much of it tacit) between users and producers within localised clusters.

Source: Based on (UNCTAD, 2005a: 100).

Generally, these indicators are derived from a variety of evidence. For example the survey of Europe's largest firms conducted by UNCTAD and Roland Berger shows that all

services activities -including R&D- are currently candidates for offshoring (UNCTAD, 2004c cited in UNCTAD, 2005a: 100). In contrast, a home-country bias in R&D 'reflects the linguistic and geographic constraints imposed by person-embodied exchanges and transfers of tacit knowledge' (Patel and Pavitt, 2000: 218 cited in UNCTAD, 2005a: 100).

It can be concluded that the history of R&D globalisation tells us that the time is now due for a rethink about changing the academic question (how to facilitate the efficient transfer of knowledge and technology from developed to developing countries) into how the latter countries can be involved in global R&D networks. This stresses the fact that the first question is still reflecting a realistic issue at least in many technologically underdeveloped countries, especially those countries with very limited technological capability. The importance of this orientation comes from a necessity of narrowing knowledge and technology gaps between developed and so called developing countries, especially as most R&D is directed toward creating and satisfying a large market in developed countries and their dominance on R&D seems to be likely to continue (Arocena and Senker, 2003).

2.3 Definitions and terminologies about globalisation of corporate R&D activity

2.3.1 Introduction

It is argued that the most significant development in the world economy during the past two decades has been the increasing globalisation of economic activities. Globalisation of R&D has accompanied this trend, and it is one of the major developments of the 1990s (NSB, 2002) and beyond. Thus, this part sheds light on illuminating the concept of the globalisation of R&D activity and the central term R&D, where relevant definitions, classifications and related concepts are defined and discussed.

2.3.2 Definition of R&D activity and related terms

In general, R&D has been studied by scholars for a long time within different contexts throughout the years. According to international guidelines, 'R&D comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge for man, culture and society, and the use of this stock of knowledge to devise new applications' (OECD, 2002: 30). In this context, corporate R&D covers activities undertaken by companies for the purpose of discovering or developing new products (goods and services) or more efficient production processes, including improved versions of existing products and processes (OECD, 2002).

Research, the 'R' of R&D is an exploratory activity that seeks to discover the principles of nature (knowledge), whereas, development 'D' of R&D is the application of existing scientific principles (knowledge), along with economic and other constraints, to the design of devices and process that meet the needs of human kind (Gibson, 1981). In other words, 'R&D is one of the preferred means by which companies (and other organisations, including societies) increase their stock of knowledge' (Noisi, 1999b: 111). From a business perspective, research denotes the process of discovering this knowledge, providing a platform for product and process development for targeted markets (Zedtwitz, 1999: 16). Indeed, R&D activities are the foundation of science efforts for most companies and have been responsible for most of their major product breakthroughs. R&D provides both leveraged scientific services to these companies and long-term research activities (Bamfield, 2006: 73). Hence, 'companies use a range of organisational, budgetary strategic business unit structures to manage these various R&D activities' (Anil, 2006: 49).

R&D activities are usually conducted in three main types of units: company laboratories, government or private research centres, and university laboratories (Noisi, 1999b: 111). It has been highlighted that R&D activity consists of and covers a range of activities. In this context, Anil (2006, p. 49) acknowledges six types of R&D activities; basic research, applied research, new product development, product adaptation and extension, product support engineering, and process engineering. He clarifies that the first two are normally classified as 'research' and the last four as 'development'. Gibson (1981: 143- 144) categorises R&D activities into two groups (research and development) and classifies them as following types:

- *Basic research is the systemic investigation of natural phenomena in an effort to define more precisely or to extend the principles of nature in particular scientific area.*
- *Applied research is research carried out in particular restricted field or within defined parameters for purpose of laying down a firmer base of knowledge for possible application*
- *Exploratory development is the organisation of existing scientific knowledge to create in concept a new device or process accomplish desired societal goal.*
- *Advanced development is the extension of concepts created in exploratory development, along with known technological limitations, to create an operating prototype device or process.*
- *Engineering development (full-scale design) is the application of practical constraints such as economic requirements, manufacturability limitations, and field maintainability, to the*

practical implementation. The purpose of the engineering development phase is to produce a process or device ready for full-scale production and field operation.

Amsden and Tschang (2003) cast an interesting light on the typology of R&D characteristics. They provide a new typology and a classification for R&D activities, which consider the extent to which latecomer countries undertake R&D activity. For example, differences in its complexity between foreign/ national and public/ private organisations and also about appropriate government policies. They categorise it into 'pure science, basic research, applied research, exploratory development and advanced development. Thus, this seems to be similar with Gibson's classification, but they add pure science in the phase of research. In contrast, Gibson goes further to include engineering development in the phase of development. Table 2.3 shows their characteristics of R&D types and related conditions:

Table 2.3 Characteristics of R&D types

Characteristic	**(a) Pure Science**	**(b)Basic Research**	**(c) Applied Research**	**(d) Exploratory Development**	**(e) Advanced Development**
Search	Intrinsic knowledge	New knowledge for radically new marketable product	Differentiated product "on paper"	Prototype in a system	Prototype for manufacture
Research objective	Uncover new scientific principle	Same as (a) but with applications that are unknown or diffuse	Transform, variate and reapply known concept for new application	Implement concept as engineered system	Reduce costs, uncertainties of manufacturing
Expected output	Concept-based IP (papers, patents)	Product-based IP for transfer to (c), (d)	Differentiated product for specific market	Detailed product design or prototype	Manufacturable product
Measure of performance	IP	Product-based IP	Differentiated/ niche product with IP	Market results (e.g., time to market)	Market results (e.g., number of rejects)
Time horizon (theoretical)	Infinite/ long-term	Long-term	Medium-/ short-term	Short-term	immediate
Techniques	Scientific experimental and mathematical techniques	Same as (a)	Scientific techniques (formulation of equations, algorithms)	Engineering design tools, including simulation	Same as (d) plus testing Q/C
Qualifications of researchers and skills	PhD in fundamental science, mathematics or engineering	Same as (a), plus management expertise and oversight	BS/ MS/ PhD, well-trained and experienced	Same as (c), but PhD unnecessary	Same as (d), plus people-related management skills, process know-how
Size of research effort	Depends on branch of knowledge under study	Critical skill mass related to whole product; specialisation and integration	Smaller critical mass appropriate for exploiting niche hand-me-down from (b)	Scales up with size of system	Related to production

Source: (Amsden and Tschang, 2003: 555). IP= intellectual property. Q/C= quality control

In this context, Amsden and Tschang (2003) argue that the R&D activities of middle-income countries appear to fall somewhere in between the extremes of basic research on the one hand and advanced development on the other hand. They clarify that this classification may provide a framework for predicting in which countries TNCs are likely to locate different types of their R&D activities.

In this arena, Medcof (1997: 306) categorises the type of technical work that is performed in internationally dispersed technology units into 'research, development, and support', and classifies them as:

- *Research is the process of discovering new scientific knowledge which has the potential to act as a platform for the subsequent development of commercially viable products and manufacturing processes. There is no expectation that the outputs of research will have immediate commercial value.*
- *Development is the process of creating new products and processes which do have commercial value, through the application of currently available platforms of scientific knowledge. Development is not intended to advance fundamental science.*
- *Support is the process of adapting an already established product or process technology to particular conditions and/ or helping to use those applications. Support does not aim to create fundamentally new products or processes. Support can take such forms as the modification of them for a particular market and advising of buyer of technology on its use.*

This new taxonomy provides a platform for more effective understanding of collaboration patterns which exist in practicing R&D activities between headquarter and subsidiaries, and also between any related R&D bodies and industrial firms. In this context, R&D activity may be conducted in different levels of the development of technological activities. To know what level of corporate R&D activities are actually being carried out, it is useful to classify them on the characteristics of their technological level and complexity (Amsden and Tschang, 2003: 571). In this regard, Karlsson (2006) provides a classification to such these activities. Based on his view, different corporate R&D activities can be ranked in terms of technical complexity, both in manufacturing and in services sectors. Table 2.4 demonstrates these levels and characteristics of possible relevant R&D activities:

Table 2.4 Level of technical complexity of corporate activities in overlapping types

Complexity	Manufacturing	Services
High-level	Advanced R&D, "frontier innovation", &specialised R&D services	
Mid-level	Development, design and adaptation	High-end services (i.e. software development)
Low-level	Basic manufacturing	Low-end services

Source: (Karlsson, 2006: 56, based on UNCTAD, 2005a).

As can be seen from Table 2.4, there can be three hierarchical levels of corporate functions and different technological activities. According to Karlsson (2006: 56), 'technical complexity means higher value added and higher requirements for skills and capabilities. A company's decision to establish or relocate activities abroad typically starts with functions of lower technical complexity and may then gradually move up the value ladder'.

There are some singular characteristics, which can be described as R&D activities. First, 'R&D has been the commitment of resources to invention and innovation' (Audretsch, *et al*., 2002: 157). Second, the R&D process shows a high degree of complexity. This involves long time frames and much high degrees of uncertainty and risk (Medcof, 1997: 317), and serendipity (Niosi, 1999b: 112). Third, 'R&D activities are, at large, considered to be knowledge-intensive and discretionary by nature' (Maskell, *et al*., 2007: 244). R&D activities are performed to generate new knowledge by controlled process (Brockhoff, 2003), and strategic control of R&D activities is considered crucial since knowledge has become the most important factor in the global business and R&D knowledge is a very important invisible asset of the firm (De Meyer, 1993a: 110). Fourth, there is dividing line in R&D between the different types of R&D activities; it is probably easier to distinguish them by outputs for example (Amsden and Tschang, 200: 558). Fifth, R&D is a key factor among important factors which are affecting the speed and direction of technological development. Thus, it represents a strategic dimension for both, companies and countries (Barry, *et al.*, 1991). Sixth, according to processes which R&D activity is undergone, and as it is usually rewarded with large budgets and populated by highly skilled professionals, R&D itself has become a major industry in modern times which can reflect its importance for any country (Iaccarino, 2004). Seventh, 'R&D, almost by definition, represents the long-term technological capability of the organisation' (Hauser and Zettelmeyer, 1996: 1). Eighth, The new technological developments, especially IT, and with the increase of R&D globalisation, the concept of business-driven R&D has become a reality (Ganguly, 1999).

Overall, one of the recent explanations on the implications of R&D activity in the business world has been provided by Nobelius (2004: 369) as 'Many companies perceive R&D as somewhat fuzzy, involving high uncertainty, with unclear rate of return, and troublesome to manage. On the other hand, companies that succeed at commercialising new technology in a rapid and precise manner achieve possibilities of attaining a greater market share, premium prices and dominant designs, leading to a much sharper competitive edge'. In line with this explanation, Gunasekaran (1997: 637) points out that 'the purpose of R&D in promoting the use of advanced technology, mainly in the R&D of the business units, is to achieve a competitive advantage'. Indeed, it is clear that many companies have changed their technology strategy to become more closely linked to their business strategy. But, evidence suggests that the most successful R&D operations depend largely upon the manner on how this activity is organised, structured and managed within the firm.

An important methodological issue that may need to be clarified here is the differences in definitions of R&D and S&T. In fact, R&D activity is one of the components of S&T activities. According to commonly used international classification from UNESCO, S&T activities concept is defined as 'systematic activities, which are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge in all fields of S&T. These consist of such activities, as R&D activity, scientific and technological education and training, and the scientific and technological services' (UNESCO, 1979: 23, Annex I). It is significant to mention that 'the boundary between research, development and other forms of technological innovation activities is difficult to establish in reality. R&D is related to the broader notion of innovation and R&D activity is considered to be as part of a total innovation system. The relationship between R&D and innovation can be seen from a crucial linkage element. 'Corporate R&D, due to innovation commercialised by the different sectors of industry has a long history of making major contributions to the welfare and development of mankind' (Bamfield, 2006: 73).

There is a consensus about categorising three main types of R&D activities (basic research, applied research and development); however, there are seemingly some differences about classifying them. There has been agreed among scholars that if most research performed is oriented toward a current or future field of potential commercial interest, then most business of R&D falls in the applied research and development categories. While R&D activities that related to no potential business relevance mostly fall in basic research category. For the purposes of this study, the R&D definition deeming in this thesis relies on the R&D classification developed by both Gibson (1981); Medcof (1997); and Amsden and Tschang (2003), who attempt to distinguish between different technological capabilities and stages within R&D activities. Even though their perspectives are not completely similar in every respect, the classification resulting from their contributions has been adopted because it is a comprehensive definition of R&D activity and included more aspects and phases that could be suitable for the technologically underdeveloped context.

2.3.3 Definition of corporate R&D activity on a global scale

From an international perspective of carrying out R&D activities, it has been noted that there is generally a lack of defining these activities in the literature. An early one of which I have found is that De Meyer and Mizushima (1989: 135) point out that 'internationalisation of corporate R&D activities refers to the fact that a significant portion

of a firm's R&D activities are conducted in an international setting'. Karlsson (2006: 63) defines the internationalisation of corporate R&D as 'the distribution of R&D operations of companies, primarily large ones, among different countries and the cross-border flows of R&D-related resources such as knowledge, technologies, researchers and engineers, and capital (investment and trade)'. These definitions may be academically true and valid, but they are still on a high level of abstraction. It can be noticed that these definitions do not take into account the R&D activities that are performed between firms and research centres, universities, as well as between two or more non-transnational firms are located in different countries. Other aspects like international exchange of know-how, licenses, patents cooperation, training of scientists and collaboration between firms and knowledge-created bodies are not clearly expressed.

Before an attempt is made to define the globalisation of corporate R&D, it should be mentioned that there seems to be similarly used concepts 'internationalisation' and 'globalisation' in most of literatures on corporate R&D. On the other hand, it can be however said that it is not elusive to classify. These concepts are used in somewhat differently by different researchers. For example, Petrella (1992) distinguishes between three levels involved in international R&D process (multinationalisation, internationalisation, and globalisation). According to Petrella (1992: 6), 'R&D multinationalisation occurs when an industrial firm has established one or more R&D activities in one or more countries other than the country of origin of the mother firm (the same applies to public research organisation or a university that creates foreign extension programmes outside the country'. He also regards that 'R&D internationalisation occurs when two or more industrial firms, research bodies, or universities from different countries carry out joint R&D programmes or activities, and this internationalisation can be of a bilateral or multilateral nature'. While Petrella (1992: 6) illuminates that:

'*R&D globalisation occurs when an industrial firm has developed a global strategy and vision of its R&D activities at both internal level (in house R&D through, for instance, internationalisation and multinationalisation) and external level (R&D alliances with other firms, mergers and acquisitions; agreements with universities, national research bodies, or governments from different countries; participation in worldwide scientific and technical cooperative programmes in all types and R&D areas (for example, basic, strategic, applied research, pilot projects, demonstration programmes, product development, norms and standard funding)*'.

Overall, Petrella (1992) thinks that it would be a mistake to analyse the globalisation of R&D activities in isolation from the processes of R&D national development and strategies, and R&D internationalisation and multinationalisation. As a result of that, one can classify that the R&D globalisation process as including both/ or some of R&D internationalisation and multinationalisation processes. Another thing should be here clarified that international R&D activities are not just limited or related to industrial firms in the manufacturing sector, rather than they are also related to the services sector, especially that, some recent evidence suggests that several firms belong to the services sector have begun to conduct R&D activities on a global scale (Miozzo and Soete, 2001).

In the light of these developments, Casson and Singh (1993: 31) distinguish between R&D internationalisation and globalisation on the basis of that 'internationalisation is an approach in which overseas R&D units are given a small and usually subordinate role in corporate research activity, whereas globalisation involves a greater commitment to overseas R&D, based on systematic division of labour between laboratories in different countries'. Furthermore, Reddy (2000) argues that internationalisation is usually motivated by the need to support overseas production and marketing, whereas globalisation is independent of such motives. Thus, despite the recognised significance of the globalisation of corporate R&D activity, the perspective has not gone unchallenged. It could be criticised as conceptually vague and tautological and that it lacks empirical grounding. The tautology surrounding its concept may be caused by the fact that it is frozen within theoretical TNCs activities derivations instead of broader international R&D activities. This is temporally and logically expected to be, especially given that TNCs' activity was concentrated mainly in knowledge intensive industries, characterised by a high level of R&D expenditure (Buckley and Casson, 2009: 1564). Overall, TNCs are the main players in global R&D activities and the major drivers for the process of R&D globalisation. Further, they are the main producers of technology and innovations (Gerybadze, 2003; OECD, 2006b). In review on the historical roots of globalisation and the developments of international R&D business, it reveals that TNCs are often seen as the major engines and shapers of the globalisation process. Evidence suggests that TNCs are mostly involved as an active actor in most dimensions and aspects of this phenomenon.

Seemingly, there is no definite conclusion on this argument, nor there is a single definition about the globalisation and internationalisation. Thus, I will depend in particular on the classification that has been provided by Petrella (1992) as mentioned above, and I will also

rely in a general sense on Dicken's view about distinguishing between them. Dicken (1992) points out that although these terms are not synonymous, they are often used interchangeably. Dicken (1992: 1) regards that 'internationalisation refers simply to the increasing geographical spread of economic activities across national boundaries', whereas globalisation of economic activity 'is qualitatively different. It is a more advanced and complex form of internationalisation which implies a degree of functional integration between internationally dispersed economic activities'. This can help to give clearly a key distinguishing characteristic between these terms, with which one can say that globalisation is built on and extending to internationalisation phenomenon and it is emerging as the norm in a growing range of economic activities. According to this distinction and with considering that R&D activity is the latest economic activity to have been globalised, the context of technologically underdeveloped countries need 'functional integration' between their local R&D activities and foreign R&D activities, rather than opening R&D subsidiaries in their countries. Therefore, the term of globalisation is adopted to describe a stage of conducting internationally corporate R&D activities.

Despite the fact that –as far as I know- there appears to be a limited consensus exists about classifying what the globalisation of corporate R&D activity actually is, I however believe that it could be defined as 'conducting R&D activities on a global scale via global inter and intra- organisational network between companies and/ or knowledge-creating bodies around the world, as well as even collaboration between countries in the field of research or innovation'. This definition considers the stock of current understanding about this phenomenon, explores new developments, and provides an integrated picture accordingly.

2.3.4 An overview on national innovation systems

The competitiveness of nations has become more technologically-oriented, and consequently science, technology and innovation (STI) activities play a leading role, with STI policies aimed at building and updating the components of a country's technological capability. The environment in which these activities are supported and empowered is referred to NIS. Indeed, there are big differences in the innovative performance of nations and this is increasingly recognised as having links to the characteristics of particular NIS (Smith, 2010: 284). According to Baskaran and Muchie (2008: 2), NIS is not just a tool to achieve the narrow goal of industrial/economic competitiveness, but it is about achieving a broader development and wider social benefits.

Thus, it is sensible to clarify the meaning of NIS. One of the definitions considered by scholars has been provided by Metcalfe (1995b). He defines it as follows; 'system that sets of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies' (Metcalfe, 1995b: 38). The concept of NIS rests on the premise that understanding the linkages among the institutions, especially how these institutions relate to each other as elements of a collective system of scientific and technological knowledge creation, acquisition, diffusion, and utilisation, is a crucial instrument for improving a country's innovative performance (OECD, 1997: 9). In addition, it can go further to include the body of policies, regulations, institutional and infrastructure arrangements and activities that facilitate the system's processes (UN, 2003: 3). This system refers to the set of institutions, which may include aspects of the financial system, the education system, the attitudes and behaviours of firms and the role of government organisations (Smith, 2010: 284). The interactions between these institutions determine the innovative performance of national firms (Nelson, 1993).

In this regard, Smith (2010: 288) classifies the main institutions that NIS may involve into:

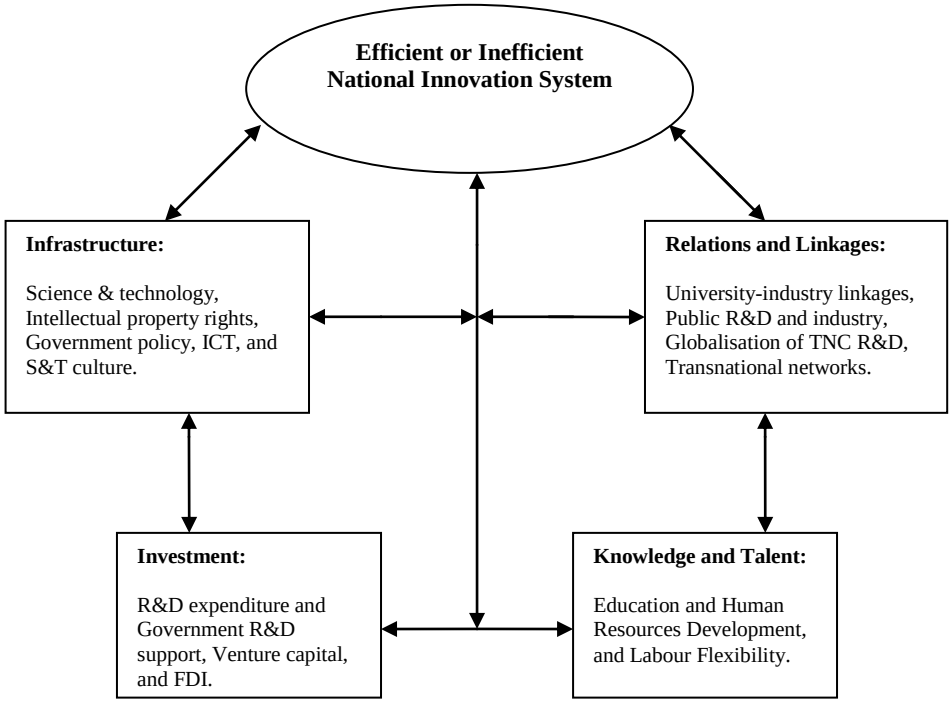
- Industrial institutions, e.g. firms and industrial sectors
- Financial institutions, e.g. banks and venture capitalists
- S&T institutions, e.g. universities, public research laboratories and consortia
- Educational institutions, e.g. schools, colleges and training providers

The institutions are the heart of a NIS, where the network of them may involve different sectors (both public and private sectors), whose activities and interactions usually initiate, import, modify and diffuse technologies (Freeman, 1987, cited in Smith, 2010: 287).

In this context, Baskaran and Muchie (2008: 2) suggest that major elements of a NIS can be identified as: 1) Conceptual framing of growth and wellbeing within political and economic systems, 2) Co-evolution of institutions/ technological capability/ knowledge, 3) Incentives, 4) Implementation/ learning/ outcomes, and 5) Feedback/ socio-economic changes. All these elements (both economic and non-economic) need to be linked and co-evolved to achieve an efficient innovation system leading to higher level of technology accumulation and economic and social development (Baskaran and Muchie, 2008: 2).

Generally, the innovative performance of a country depends to a large extent on how the mentioned actors relate to each other as elements of a collective system of knowledge creation and use, as well as the technologies they use. The linkages can take the form of joint research, personnel exchanges, cross patenting, purchase of equipment and a variety of other channels (OECD, 1997). Thus, the significance of the interactions and linkages among these actors can be seen through translating the related inputs into innovation outputs and other technological achievements. In this regard, Figure 2.1 shows the possible linkages and interactions between NIS's elements.

Figure 2.1 Linkages among institutions, technologies, knowledge and incentives in NIS



Source: (Baskaran and Muchie, 2008: 4).

In this context, it is important to mention that from practical perspective, a distinction has been made between a narrow NIS concept, which includes the institutions and policies directly involved in scientific and technological innovation, and a broad NIS perspective, which takes into account the social, cultural, and political environment of the country being examined. (Feinson, 2003:25). This is because in reality, these environments strongly impact on actors, institutions and linkages that make a system of innovation function, as well as the flows of information and resources within the system itself and between the system and its environment. At any rate, weak linkages, interactions and action between and amongst all the relevant actors in the NIS, results in poor information flow and learning, slowing down the rate of technology acquisition and the emulation of

best practices. In addition, the issue of governance can be raised, in relation to the processes associated with a NIS. Smith (2010: 284- 287) demonstrates that NISs tend to exhibit three types of governance mechanism: corporate, political and network governance.

The corporate governance describes the mechanism surrounding the exercise and control of corporate ownership. Political governance refers to the role of government in fostering innovation. This role centres around two functions: policy function and regulating function. Clearly, if the rewards for genuine innovation appear to be low, this will discourage innovation and a country's overall performance will be poor. Network governance recognises that increasingly innovation takes place through firms working together with other organisations. These organisations are likely to include many of institutions that play an important role within NISs such as universities, educational establishments, research bodies and financial institutions.

Baskaran and Muchie (2008: 6) conclude that when a country's NIS is stronger and efficient, it possesses:

- The ability to change continuously its policies and objectives towards FDI
- High level of human capital (both in quantity and quality)
- High level of physical and technical infrastructure
- A high degree of institutional linkages (among financial institutions, technology institutions and industry sectors)

Thus, this approach can lead to understanding the influence of a NIS on the impact of FDI in general and FDI involving R&D in a national economy in particular. Generally, when a country's NIS is stronger and efficient, it is likely that FDI will have greater positive impacts and outcomes in terms of technology and knowledge transfer, R&D activity, developing competitiveness of domestic firms, and a high level of activities in manufacturing and service sectors and less intensive or no activity in natural resource sectors. On the other hand, when a country's NIS is weak and inefficient, it is likely that FDI will have less or no positive impacts and outcomes in terms of technology and knowledge transfers, R&D and design activities, developing competitiveness of domestic firms, and it is likely to witness high level of activities in natural resource sectors or primary commodity export sectors than in manufacturing and service sectors (Baskaran and Muchie, 2008: 6). Based on these implications, it is becoming clear that if countries want to attract and benefit from FDI involving R&D, they should build a strong NIS and

create mechanisms, by which can ensure good linkages and networks at the national and international levels.

2.4 Globalisation of R&D Activity Context

2.4.1 Introduction

Although globalisation concept has been around for some time, the globalisation of R&D did not become a topic of serious discussions among academics until the late 1990s. A key possible reason for this is that R&D activities involve the latest economic activities to have been internationalised. Recently, one of the expanding frontiers of international business thought is the study of the globalisation of R&D activity. This area of study has been stimulated by the growing expansion of overseas R&D activities of various TNCs throughout the world. Given the growing importance of this phenomenon, there are many different variables and elements involved. Therefore, no single perspective is able to deal with and provide a comprehensive analysis to study topics related to this subject. This has led some experts in this field- like Kuemmerle (1999a: 192) - to state that 'the R&D globalisation process is an extremely complex one that is driven by a large number of company specific variables and that rewards more research attention'.

Based on this consideration, there is fundamentally the need to survey at least the international business, technology and innovation management and R&D management literatures and then develop a framework for the analysis of different aspects of this phenomenon. In this context, Archibugi and Michie (1995) and Archibugi and Coco (2001) divide the R&D globalisation process into three different categories, where each category might have different impacts and among different levels, firm, clusters, countries, regions and globe. The following represents these categories:

- International exploitation of technology and innovative know-how, which is produced on a national basis through means to trade, granting of licenses and patents, reverse engineering and etc.
- Global generation of knowledge and innovations, which means that companies are conducting corporate R&D activity on a global scale by building up research networks including different forms, from FDI involving R&D to offshore and outsourcing R&D. The traditional forms were the establishment of new R&D units in the host country or the acquisition of foreign R&D units.

- Global technological collaborations, which may base on joint R&D projects between countries or companies from different countries and any other kind of international S&T cooperation, whereby each partner can keep its own institutional identity and ownership remains unaffected.

With the recent trends of R&D globalisation, Karlsson (2006: 29) summarises the new dynamic of its process, which he thinks that may be characterised as follows:

- *Knowledge and technology generated in one country will be utilised more internationally.*
- *International science and technology collaboration between government, industry and academia in different countries will continue to increase.*
- *Many companies will source knowledge and innovations globally, and many will locate their innovation activities wherever it is most advantageous.*
- *An international division of labour in R&D will emerge. Both public and corporate R&D efforts will continue to specialise. Particular areas of technological activity may become concentrated in relatively few locations across the world.*
- *New world centres of technological activity will emerge. Especially countries in developing Asia will grow stronger as global players.*
- *Intensified global competition will heighten the importance of maintaining national conditions for attracting R&D, absorbing knowledge and technologies developed elsewhere, and creating opportunities for production of innovative products and services.*

However, in this research, the globalisation of corporate R&D activity is studied with a more focus upon industrial R&D and international R&D by TNCs. This part reviews the theories and perspectives relevant to the R&D globalisation. It also sheds light on the main trends and drivers of it and relevant challenges and obstacles to its process. Moreover, patterns and nature of international R&D business are discussed. Finally, it highlights the effects of overseas R&D activity on home and host countries. In this context, it should be mentioned that there is a notable use of an influential and leading reference in the review of this literature. It is UNCTAD (2005a)[1]. This is an essential source for this research topic. This report represents a major research study on the globalisation of R&D that:

- Specifically focuses on TNCs, their foreign R&D activities and comprehensively covers most of the aspects of R&D globalisation from different perspectives
- Is widely quoted by other studies, which implies that it represents probably the best knowledge available on the determinants and implications of global R&D activities

[1] For more relevant information, see appendix (No.5) on pp. 274.

- Is produced by a very authoritative source (i.e. the United Nations (UN))
- Comprises of comparative data on all regions of the world and special parts on developing countries.

2.4.2 Globalisation of R&D: a general overview

Rapid technological developments especially in information and communication technology (ICT) have facilitated the performance of economic activities globally. In the light of these developments, there have been changes in nature of the service sector and increases in the globalisation of service. In this context, trends show that the globalisation of corporate R&D activities is growing and tending to be like any other global economic activity (OECD, 2005a; OECD, 2006b; OECD, 2008b). Hagedoorn, *et al*. (2000) find that trends on the globalisation of R&D indicates a rising number of co-operative agreements or alliances since the 1980s between partners residing in different countries, a trend which is stable across countries and sectors. There has also been a relative shift from manufacturing-centred R&D towards more service-oriented R&D (see Howells, 2008: 245- 246). These studies and others have arrived at evidence that although much international R&D is still heavily concentrated in a few countries, the globalisation of R&D is a gradually increasing trend.

Reviewing the literature on global R&D activities reveals that the early recognition of performing some R&D activities abroad by TNCs was highlighted in some surveys on TNCs' operations in some industrialised host countries. Most of these surveys analyse the performance of R&D by subsidiaries in host countries. This features the role of FDI involving R&D and its impact on host countries. Among these earlier surveys are: Dunning (1958) for the UK, Brash (1966) for Australia, Safarian (1966) for Canada and Stubenitsky (1970) for the Netherlands. Most studies in the 1970s addressed the beginning of internationalising R&D activities by TNCs and provide primary insights into the driving forces behind conducting R&D activities outside the home country. Among the studies are: US Tariff Commission (1973), Terpstra (1977), and Ronstadt (1977). Others focus on international locations of R&D activities by TNCs, such as: Lall (1979) and Mansfield, *et al*. (1979).

Up-to the 1980s, the internationalisation of R&D was a marginal or rather neglected topic of research, not only for economic and business theory, but also for governments, the national statistical agencies in developed countries, and even the specialist international

organisations (Cheng and Bolon, 1993; Niosi, 1999a). This may be attributed to R&D activity being treated as the latest economic activity that has been internationalised by TNCs (UNCTAD, 2005a). In this regard, Howells (1990) confirms that since the 1970s, firms have only commenced performing R&D abroad in a significant way. The tendency of TNCs to keep most their R&D activities in home countries at that time had attracted some scholars to study this issue. For example, valuable research has been done by Terpstra (1977), providing the primary platform about the factors that may lead to the centralisation of R&D activities in home countries, and the factors that may influence the decision to decentralise R&D activities overseas. Behrman and Fischer (1980) examine the factors that motivate foreign R&D investments and they compare American and Europe companies. According to Reddy (2000), studies in the1970s and early 1980s show that most of foreign R&D activities were limited in magnitude and nature, and most of them were conducted either to facilitate technology transfer by adapting the parent's technology to local operating conditions or developing products to meet the requirements and expectations of local markets.

In the late 1980s and the early 1990s, studies contributed to a better understanding of the determinants of overseas R&D activities by TNCs (see Hakanson and Zander, 1988; Herbert, 1989; Granstrand, *et al.* 1993). By the late 1990s, the internationalisation/ globalisation of R&D had emerged as an important subject of inquiry and this subject attracted some scholars from North America, Europe, and Asia (particularly Japan) to publish several articles and research it (Serapio and Hayashi, 2003). Studies in the late 1990s provide more explanation as to the nature of the R&D internationalisation process and how overseas R&D activities can be globally managed and organised. Key findings from these studies reveal that there is an increasing growth in cross-border R&D investments among developed countries, overseas facilities have played significant roles in higher value-added R&D activities, the internationalisation of R&D remains a key management challenge for the next years, and the conventional organisation of firms is inadequate for the requirements of modern global R&D (Gassmann and Zedtwitz, 1998).

In the 2000s, studies focus on new dynamic changes in the practices of corporate R&D activity, applying the open innovation and R&D approach through offshore and outsourcing R&D. The role of policy in attracting foreign R&D activity was also a topic under discussion (see Karlsson, 2006; Edler, 2007; Zanatta and Queiroz, 2007; OECD, 2008b; Kang and Kang, 2009; Enkel, *et al*., 2009; Mortara, *et al*., 2009; Dunning and

Lundan, 2009). These studies provide good insights and valuable ideas into understanding, determining and analysing many issues on the internationalisation of R&D activities. However, they have failed to provide a clear picture of aspects, implications and dimensions of R&D globalisation. Because they were generally conducted on the firm at industry level or country level, excepting some studies that focused showing the effects of foreign R&D activities on the host and home countries (see for example: Dunning, 1993). In addition, most studies examine the phenomenon in developed countries of R&D activities of firms from developed countries. A study by Miller (1994) is an exception from that, as it includes and compares the R&D activities of some European, US, and Asian firms. This is because a lack of data may be a contributory factor. In this regard, Karlsson (2006: 15) points out that findings regarding trends, scope and strategies behind the internationalisation of corporate R&D are heterogeneous and still generally limited. He confirms that available data on these topics is often incomplete, difficult to compare between countries, difficult to interpret, and only available after a considerable time lag.

From the review of the literature, it can be noted that just a few empirical studies have recently focused upon foreign R&D activities by TNCs from developing countries and the internationalisation of corporate R&D in developing countries (see Erdilek, 2005). Generally, in the last decade, there has been a shift in the internationalisation of R&D activities. Some developing countries like China and India have become a favoured destination for several TNCs to establish R&D labs there, and TNCs from developing countries have begun to conduct R&D activity on a global scale (UNCTAD, 2005a). The study by Huggins, *et al*. (2007: 437) analyses the flows of FDI involving R&D for some years, and finds that 'while North America has been the source of one-half of all FDI involving R&D between 2002 and 2005, Asia Pacific, especially China and India, have been the overwhelming destination for most FDI involving R&D, accounting for more than one-half of all investment and almost three-quarters of the jobs created'. Similarly, a survey by Potocnik (2005: 4) identifies that China, India and Brazil as respectively the first, third and sixth choice destinations for increased FDI involving R&D. In line with this evidence, Vickery and Wunsch-Vincent (2009: 95) indicate the rise of emerging economies such as (China, India, Brazil, Russia, and South Africa) in the S&T fields. In this regard, Duga, *et al*. (2008: 4) state that 'liberalisation of economics, breaking of barriers, movement from suppliers of material parts to suppliers of intellectual inputs, and aggressive investments in S&T capacity by both government and industry have all

contributed to a major shift in the global R&D picture'. Simply, the recent changes represent the beginning of a fundamental shift in the global production of corporate R&D.

With this shift, some studies focus on new aspects and dimensions regarding the involvement of developing countries in global R&D networks. These studies shed light on the driving forces which were behind it, and study the pattern of corporate R&D activities, dimensions and implications of this phenomenon, and its effects on some case studies of developing countries (see Reddy 1997, 2000, 2011; Bowonder, 2001; Damijan, *et al.*, 2003; Helble, 2004; Gassmann and Han, 2004; Erdilek, 2005; UNCTAD, 2005a,b; Falit, 2010). Others studies focus upon the role of national policy in attracting FDI involving R&D (see OECD, 2007b; Zanatta and Queiroz, 2007). Further, there has been an emphasis upon the globalisation of R&D from a dynamic context of innovation and knowledge exchange across borders, and the TNC as a learning organisation (OECD, 2007a).

Few studies of developing countries attempt to provide a road map of which developing countries may follow to improve their technological capabilities by joining global R&D networks (see UNCTAD, 2005b). Recent studies illustrate the directions in which the wind of R&D globalisation is blowing and under what conditions (see UNCTAD, 2005a; Duga and Studt, 2007; Jaruzelski and Dehoff, 2008). Although these studies provide new good insights, it seems that they neglect the implications of this phenomenon for technologically underdeveloped countries. Thus, there is as yet a lot of research to be done in broadening and deepening our understanding of recent developments and their impact especially upon so called developing countries in general and technologically underdeveloped countries in particular. At the current state of knowledge, the recent literature cannot enrich our understanding of directions and possible developments in this phenomenon, and the possible obstacles to its process especially in technologically underdeveloped countries.

The concern can come from that there are some things like serious natural disasters, environmental issues, emerging/ re-emerging infectious diseases and developmental issues that have raised and are increasingly influenced on daily life. Thus, there might need to place more emphasis on the nature of R&D globalisation and to redirect its efforts in order to resolve and overcome those problems. Unfortunately, most of these issues are linked to technologically underdeveloped countries' context (Webber and Kremer, 2001). In this respect, previous experiences show that long-term research projects such as 5th Generation Computer, the Human Genome, and the Intelligent Manufacturing System projects, which

involved remarkable world cooperation, have not considerably involved research centres or universities outside developed countries. For example, the ambitious biology project of the mapping of the human genome, which was launched by U.S. government in the1990s, involved more than 350 laboratories around the world, and most of them were in developed countries (Enriquez and Goldberg, 2000: 96).

Overall, technologically underdeveloped countries' context is largely ignored at both the practice and study level in the R&D globalisation's phenomenon. Its process in these countries is not well understood. To some extent, it is even contradictory established views on international R&D research. The technological development and innovation capacity of technologically underdeveloped countries has been largely neglected. In this regard, Zedtwitz (2005: 1) points out that 'Data, research on R&D in developing countries is scattered and limited. Only a handful of countries outside the advanced economies receive some research attention, among of them are Singapore, South Korea, India, and, most recently, P.R. China'. Zedtwitz (2005: 2) reviews a wide range of the relevant research on these countries, and finds that most research has concentrated upon technology transfer to these countries and their capacity to absorb advanced technologies from abroad.

2.4.3 The theories and perspectives applied to R&D globalisation process

Firms traditionally tend to confine R&D activities in their home country. This is on the basis that these activities generate technological knowledge (or innovations) that provide them with a competitive advantage. It could be exploited in foreign markets and at that time this competitive advantage could be derived from the domestic environment (Vernon, 1966; Hymer, 1976). Thus, it may be for security reasons, R&D activities are closely kept to the home-base, but for example, Terpstra (1977) finds further relevant reasons. These reasons are critical mass and economies of scale in R&D, better and easier communication and coordination of centralised R&D, better protection of know-how, more leverage with host governments, and a more experience with the home country market. Mansfield (1974) clarifies that the difficulties involved with supervision and control were a main reason behind firms not internationalising strategic R&D activities in the 1970s. From another perspective, Trott and Hartmann (2009: 720) point out that 'one of the more challenging issues for R&D managers is when to outsource R&D activities due to the inherent risk of giving away critical core competencies to others'. However, the tendency to keep R&D activity in the home country has been changing and the trends show that this development is increasing. This change into conducting overseas R&D activities has been

conceptualised by scholars according to the stages of these developments. Research on the globalisation of R&D is originated from a number of theoretical perspectives. Three approaches can be used to interpret the R&D globalisation phenomenon and the implications for international R&D; international product life cycle theory, FDI theories, and transnational knowledge learning perspectives.

2.4.3.1 Perspectives of product life cycle theory

A review of the literature on international R&D business by firms reveals that the earlier studies (i.e. those published in the late 1970s up-to the early 1980s) frame the internationalisation of R&D in the context of the international product life cycle theory. Originally, the product life cycle theory was proposed by Vernon in 1966 and later he developed his theory on an international level in 1974 to determine the linkages between the location of production, multinationality and oligopolistic structures. Generally, this theory states that TNCs invest abroad as a part of the international life cycle of products or processes, where new product innovations tend to occur in the advanced industrialised nations and are initially marketed there (Taoka and Beeman, 1991: 50). The general argument of Vernon is that firms develop products in response to home market needs and that products are initially manufactured locally to supply these markets.

The traditional view of international R&D, which is associated with this theory, suggests that foreign R&D is concerned with the support of local manufacturing units and the adaptation of products to local markets (Kuemmerle, 1999a). Based on this perspective, the first location of production of new products is likely to be the country where R&D activity takes place, and it is usually the home country (Reddy, 2000). The model derived from this theory views foreign R&D activities as primarily following transplanted production to facilitate implementing the company's strategy during the latter stages of the product cycle (Pearce, 1989). Especially, as some TNCs attempt to compress the speed to market through reduced product development and product life cycle (Archibugi and Iammarino, 1999).

Thus, overseas R&D facilities have been viewed as vehicles for transferring parent company technologies to overseas subsidiaries. In other words, 'local R&D units are set up to support overseas manufacturing operations, but are primarily concerned with adapting products to local tastes and standards. Moreover, process based innovation is common and is often regarded as subordinate to research in the home nation' (Halme, *et al.*, 2004: 8). Overall, this theory maintains that overseas R&D units are initially established to adapt the

TNC's products or processes to the local market. Generally, although that could explain the behaviour of international R&D linked to international production, however, it cannot fully reflect the reality any more. This is because of the changing attitude of TNCs to expand their operation world-wide combined with the pressures from host country governments that have led to the product life cycle becoming highly compressed (Giddy, 1978: 92). Indeed, Vernon (1979: 255) himself admits that product life cycle theory has become less applicable, especially after the tendency to more global standardisation of some products, such as computers, TVs, and pharmaceuticals. In this regard, Bennett (1999: 23) states that there are a number of attendant fundamental problems to this theory. He points out that the length of life of a new product cannot be reliably predicted in advance, and many products cannot be characterised in life cycle terms (e.g. basic foodstuffs and industrial materials).

A criticism to apply product life cycle theory on international R&D has been provided by Pearce (1989), as he points out that in some industries, resembling a situation of near simultaneous innovations worldwide in several major markets, making international R&D consistent with this theory. In line with this, Cantwell (1995) provides evidence - drawn from 100 years of US Patent Office data- that the innovations are not almost always located in the home country of the parent company. He also finds that internal international networks have been developed to exploit the locationally differentiated potential of foreign centres of excellence. This implies that the behaviour of TNCs with regard to the international R&D activities is tending to follow a process of knowledge learning rather than the product life cycle process.

The recent evidence tends to refute the application of this theory on the international R&D business. A simple example that provides some evidence of this is that several TNCs have recently established R&D laboratories in some countries where it is not necessary as they have manufacturing units in those locations (UNCTAD, 2005a). At any rate, 'R&D activities have not simply followed in a proportionate manner to production or marketing activities' (Brockhoff, 1998: 2). Moreover, this theory usually applies to individual products and even to industries but only marginally to firms (Almor, *et al*., 2006: 510), and the literature on the nature of international R&D units reveals that tasks and purposes of foreign R&D units are beyond this scope (see Section 2.4.5).

This theory seems to categorise foreign R&D activities as a support function, while it appears that many TNCs are establishing foreign R&D units in response to the increased competition rather than for supporting foreign production units. UNCTAD (2005b: 213) indicates that in the recent internationalisation of R&D, 'one key driver is the increased competitive pressure created by liberalisation and technological progress'. Consequently, perspectives drawn from this theory may be appropriate for a stable industry situation but are not suited to the business environment in which TNCs face strong competition with an accelerated technological development and a lack of knowledge capital at home.

As a result of changing the trajectories of technological development, a number of major changes in the nature and scope of overseas R&D activities have been taking place since the 1980s (Reddy, 2000). Studies published in the 1990s cast the internationalisation of R&D using multiple frameworks. This is in addition to product life cycle considerations; it demonstrates that supply factors, such as employing scientists and engineers and accessing emerging technologies in the host country, are also important drivers of international R&D (see Serapio and Dalton, 1999; Florida, 1997; Niosi, 1999a). These studies maintain that transfer of technology is not just one way, namely from the parent company to the subsidiary, it also flows from overseas R&D facilities to that of the parent company and subsidiaries located in developed countries. Based on these changes, the product life cycle theory alone is inadequate to explain the behaviour of international R&D by firms.

2.4.3.2 Perspectives of FDI theories

There was a belief in the 1970s that 'foreign R&D follows FDI and tends to be associated with manufacturing operations. Foreign manufacturing is the first presence of the firm abroad, usually after some export experience. Later in the firm's international development may come foreign R&D' (Terpstra, 1977: 31). Generally, three theories have been basically used to explain FDI operations. These are, the classical theory of international trade, new trade theory, and transaction cost theory. However, as there are specific aspects of internationalisation related to FDI involving R&D, the possible explanation to this process can be through applying the 'OLI paradigm' (i.e. ownership, location and internalisation) to foreign R&D activity (see Dunning, 1992, 1993, 2000). This paradigm developed by Dunning in the 1970s, when he argued that no single approach is able to fully explain the international activity of TNCs. Then, he attempted to synthesise different theories of international production in a general framework of analysis that accommodates both trade and investment theories.

In the OLI paradigm, Dunning distinguishes three factors, which enable and can explain the engagement of a firm in international activity. These are, 'ownership-specific advantages' (O); 'location-specific advantages' (L); and 'internalisation advantages' (I). In brief, O advantage refers to firm-specific ability and assets to exploit the investment opportunities abroad. L advantage refers to country-specific conditions, which makes it more attractive to FDI. L advantages may include availability of natural resources, input prices and quality, infrastructure quality, investment incentives, economic system and strategies, etc. I advantage refers to the benefits that can be derived from internal markets and that allow the firm to prevent its assets from being replicated by competitors or selling them in external markets and reducing transactions costs associated with.

Based on assumptions of the OLI paradigm, the factors of locational and ownership advantage can be applied to partially explain the process of R&D globalisation. For example, a country's specific locational advantage, when it has a high availability of scientists and engineers or excellent universities or research institutions in some specific fields, may contribute to attracting FDI involving R&D. For a firm, if it has ownership advantages in organising and controlling R&D activity through global networks, it may combine this advantage with these locational advantages and this will motive it to conduct R&D activity in that country. However, with different factors required and the different driving forces for locating different types of R&D functions abroad, this paradigm has a limited application to explain the R&D globalisation process (Reddy, 2000).

Based on these aspects, Dunning and others have developed the OLI paradigm to explain foreign R&D activities (see Dunning, 2000; Cantwell and Narula, 2001). These developments in the OLI paradigm add that the 'I' advantage can be realised through merger and acquisitions (M&As) or by other forms of foreign R&D activities such as R&D cooperation and alliances to internalise market transactions. Then, transactions costs on the imperfect markets, for knowledge and technology can be reduced, appropriability problems can be mitigated and access to knowledge sources can be facilitated (Arvanitis and Hellenstein, 2010: 6). This explanation is more explicit and convenient, as the one of the major driving forces for the internationalisation of R&D seems to be the competition for accessing S&T resources and with this process, firms attempt to create or acquire O advantage (Reddy, 2000). Indeed, the recent version of OLI paradigm can be applied to explain the propensity of firms to invest in R&D abroad (Arvanitis and Hellenstein, 2010).

During the late 1980s and 1990s, a number of scholars offered various models for distinguishing the motivation and scope of operations related to overseas R&D facilities. Among the central debates in the literature is that in which centripetal versus centrifugal forces influence international R&D (Gammeltoft, 2006: 148). In this regard, Pearce (1989) distinguishes between centrifugal and centripetal forces in influencing the decision by TNCs to engage in FDI involving R&D. According to Pearce, centrifugal forces are factors that pull R&D away to peripheral sites. In contrast, centripetal forces are factors that support a tendency to centralise R&D at a dominant laboratory.

Granstrand, *et al*. (1993) discuss the issue of motivation in terms of centripetal and centrifugal forces. They conclude that the centripetal factors driving firms tend to keep R&D activity in the home country are: the need to protect firm-specific technology, home market conditions, economic of scale in R&D, and the minimisation of coordination and control costs. While centrifugal factors can be divided into two groups: demand-oriented and supply-oriented factors. The first one includes: providing a technical support for production or/ and marketing activities and government regulations that are associated with encouraging FDI involving R&D. The latter one includes: existing opportunities to tap into the scientific and technical infrastructures of the host country and the lower cost of researchers and scientific facilities abroad compared to the home country. In addition, they note that there are some company specific determinants that can be influenced firms' decisions to establish R&D activity abroad. These include; the share of overseas production conducted by the firm, firm's size, its age, and stage of the firm's development.

In this context, Cheng and Bolon (1993) review the literature on international R&D and discuss the most important factors that lead to increase the internationalisation of R&D activity. They think that these factors can be divided into three groups; condition, motivation, and precipitating circumstance factors. According to them, condition factors include: improvement in transportation and telecommunication infrastructure, in IPRs protection, and in the social, economic and technical conditions. While motivation factors include; the desire to tap into foreign scientific and technical organisations, obtaining an access to new knowledge and information, improving responsiveness to local market needs, and taking advantages of foreign governments incentives. In further illustrations, they describe precipitating circumstance as triggers, and categorise these triggers into firm-related and country-related factors. The first one includes; increased production overseas

and following other leader firms' pattern. The other includes: the shortage of scientists and engineers in home country, the increasing technological excellence of foreign countries in some certain technical fields, government aggressiveness in attracting or even requiring R&D facilities and the fear of being frozen out of technical communities.

Kuemmerle (1997) differentiates between home base exploiting and home base augmenting FDI involving R&D. In this regard, it is useful to mention that these types of R&D sites are termed by Dunning and Narula (1995) as 'asset-exploiting' and 'asset-seeking' R&D activity respectively. According to Kuemmerle (1997), the first one facilitates the transfer of competitive technology from the parent to overseas subsidiaries; the latter enhances the parent company's competitive position by accessing key technologies from abroad. Precisely, home base exploiting is made to capitalise on advantages that were created at the home base and that the firm could not exploit better through other means than FDI (exports, licensing, etc.). It is where overseas R&D activities are established for adapting technologies and products developed at home to local market conditions and /or providing technological support to TNCs' subsidiaries at host countries. While, home base augmenting is usually made to add new knowledge and skills to the firm's home base to ensure long-term survival and sustained growth. It is where overseas R&D activities are established for tapping into external knowledge and technology sources, with more proximity to excellent knowledge created bodies wherever. This tends to emphasise the creation of core products, the sourcing of specific core products support and the creation of new processes (Gammeltoft, 2006: 188).

Le Bas and Patel (2007: 1) explore the factors that can explain the choice faced by TNCs between the two main location strategies mentioned above. According to their findings, the factors increasing the probability of choosing the home base-augmenting strategy are: 1) the volume of technological activity (indicating that the effect of this factor is very weak), 2) the degree of technological specialisation (the opposite of technological diversification), and 3) nationality of the firm.

For the country level, the survey by EIU (2004: 7) finds out that the most important aspect of a country's business environment that can be a target destination for foreign R&D is the quality of the local education system. Related to this, proximity to major universities and research labs remains an important advantage for many types of R&D activity. The study mentions that the ability to exploit pools of skilled labour as a key benefit to globalising

R&D. Some part of these findings supports what Kuemmerle (1999a: 192) expects that in countries that lack strong institutions of tertiary education and do not have large domestic markets the level of FDI involving R&D will probably remain low.

The more coherent classification on motivation for internationalising R&D has been provided by Gammeltoft (2006). He summarises the motivations of FDI involving R&D into six categories. His work is based on a variety of motivations that have been suggested in the literature by previous studies, which most of them have been already mentioned above. Table 2.5 shows characteristics of those motivations:

Table 2.5 Motivations and drivers behind FDI involving R&D

Kind of Category	Implications
Market-driven	Exploit existing company-specific assets more widely; motivated by market size and proximity; support local sales, closeness to lead customer; improve responsiveness in terms of both speed and relevance.
Production-driven	Supporting local manufacturing operations.
Technology-driven (Pull)	Tapping into foreign S&T resources; technology monitoring (especially competitor analysis); acquire/monitor local expertise, knowledge and technologies.
Innovation-driven (Push)	Generating new company-specific assets; attaining a faster and more varied flow of new ideas, products and processes; capitalize on location-specific advantages through an international division of labour between R&D labs.
Cost-driven	Exploiting factor cost differentials.
Policy-driven	National regulatory requirements or incentives, tax differentials, monitoring and exploitation of regulations and technical standards.

Source: Based on (Gammeltoft, 2006: 186).

Beyond the coherent analysis of these motivations, it has been mentioned that cost and policy factors are important motivations for FDI involving R&D. In this context, the literature suggests some drivers, where the policies may be directly influenced on the decision by TNCs to locate FDI involving R&D (Guimon, 2008: 3):

- *The availability of researchers and capacity to attract skilled engineers and scientists.*
- *The quality and repetition of scientific institutions such as universities, research centres, science and technology parks and other research infrastructure.*
- *The tendency to collaborate of different agents of national/regional innovation system (i.e. the dynamic of the innovation system).*
- *The presence of lead markets in key technology areas.*
- *Fiscal and financial incentives to corporate R&D.*
- *A clear and enforcement able intellectual property rights regime.*

It is worthy to mention that although there is a consensus about the importance of policy factors in determining the location decision of corporate R&D activity, it seems to be that public policies with regard to R&D globalisation still have a limited evidence base (Schoen, *et al.,* 2009). Different reasons have contributed to this situation. OECD (2008b) addresses that the analysts in policy and academic circles are still far from understanding

properly the dynamics of globalisation of industrial and business R&D. Furthermore, JRC-IPTS (2007) indicates that there is a lack of available data on the internationalisation of R&D, and even when it is available, its quality remains weak.

In both developed and developing countries, the process of FDI involving R&D takes several types. But, from reviewing the literature on FDI involving R&D, it reveals that the main form that TNCs have taken to build their R&D networks across borders is the establishment of new R&D units in the host country 'Greenfield FDI' (see Kuemmerle, 1999a) and then the acquisition of foreign R&D units. However, where Greenfield investments presuppose rational decision criteria, M&A is a major means to assimilate overseas R&D units (see Boutellier, *et al.,* 2008). The choice to use one of these forms would depend upon several factors. Narula and Duysters (2004: 210) argue that:

'Whether the advantage being sought is firm or country specific, the establishment of a Greenfield laboratory is a feasible option, but involves high costs of start-up, and considerable time. In fields where innovation is rapid, it may not provide a fact-enough response. The use of M&A is even less attractive where the area and the complementary resource sought only cover a small area of the form's interests. Even where a firm wishes to acquire an R&D facility, it is generally not possible to do so, except in rare circumstances'.

They suggest that R&D alliances can be considered as a first-best option in many instances. However, there are strategic limitations to the use of alliances. For example, they may not be suitable in a turbulent technological environment (or even a change in technological trajectories), because having ties to a wide group of firms, including firms that have yet to demonstrate their value, represents a higher learning potential (Narula and Duysters, 2004: 210).

Overall, based on the FDI literature about the necessary conditions for FDI to take place, one can relatively argue that these conditions can be applied to FDI involving R&D. Several different drivers and motives lie behind it and they tend to change over time. Thus, there is a need for more empirical studies about the behaviour of FDI involving R&D to know why it goes here or there and what the implications are. The study by Johansson and Loof (2006: 3) indicates that 'although there is a considerable literature on FDI and outsourcing, much of it has focused upon production perspective. The effects of a growing globalisation of R&D have been less scrutinised'.

2.4.3.3 Transnational knowledge learning perspectives

Given that the globalisation of R&D is increasingly recognised as an important phenomenon. This importance increases particularly in generating and diffusing knowledge at all levels. It is becoming clearer that the dynamics of knowledge creation suggests that this process has been increasingly taking place at the global level. Based on these developments, Boekholt and Edler (2001: 314) argue that 'neglecting the specific demands and chance of the international flow of knowledge and R&D capital is no option for S&T policy-makers'. This is especially since there are a growing number of firms turning to external partners for innovative ideas and new knowledge (UNCTAD, 2005a).

Moreover, no country can produce all knowledge which it needs (Dunning, 1993) and this assumption can be certainly applied to any TNC. This can imply that to complement needed knowledge and technology, TNCs can search on them from external sources of knowledge. Enkel, *et al*. (2009: 311) mention that Koschatzky (2001: 6) found that 'firms which do not cooperate and which do not exchange knowledge reduce their knowledge base on a long-term basis and lose the ability to enter into exchange relations with other firms and organisations'. Indeed, while the technological sophistication of most TNCs is well established, there is recently increasing recognition that technological capability is spreading throughout the globe (OECD, 2008b). TNCs are forced to expand outside their own boundaries in order to tap into the expanding knowledge base around the globe (UNCTAD, 2005a). One of the marked trends is the extension of R&D activity and competence portfolios on a global scale (Pearce, 1999) to augment the knowledge base of the firm (Kuemmerle, 1999a, b).

Based on developing the dispersion of technological knowledge throughout the world, TNCs may find themselves having to seek new technological knowledge and skills not only outside their own companies but also outside their home country (Penner-Hahn, 1995). It is not surprising to note that there has recently been a growing involvement among different industry sectors in collaboration with excellent academic institutions and research centres, adopting strategies to attract and employ the best scientific and engineering personnel on a global scale (Kaounides, 1999; Lam, 2001). In this context, some scholars like Cantwell (1995); Florida (1997); Kuemmerle (1999a, 1999b) confirm that foreign R&D activities have been driven by firms' needs to acquire new knowledge and capabilities, and to obtain access to unique knowledge capital resources. This means that the fundamental processes to do so are based on a learning process.

From another perspective, the reflection of the open innovation approach can be realised in this context from the fact that open innovation basically emphasises the importance of using external source of knowledge in a firm's innovation processes (Chesbrough, 2003a). There are a growing number of firms whose have learnt how to successfully use and capitalise on knowledge generated by others (West and Gallagher, 2004). In this regard, Gerybadze and Reger (1999) point out that the motives and aims underlying R&D location are decreasingly related to the exploitation of cost advantages, and instead emphasise the effects of international learning. This evidence is supported by Dunning (2000) as he finds that asset-seeking 'knowledge oriented motive' has become much more prominent for FDI involving R&D. FDI can serve as 'a vehicle for carrying tacit knowledge and assisting enterprises at frontiers of world technological learning' (Liu and Wang, 2003: 945).

Recently, there have been some changes in corporate R&D function at TNCs. 'With the recognition of the importance of knowledge and its development within companies, the total demise of a central research function is now realised to have been wrong and many companies are revitalising their corporate R&D efforts' (Bamfield, 2006: 73). Consequently, there is an increased emphasis on application-oriented R&D and basic research has tended to be squeezed off the corporate R&D agenda. These changes have led to more dependency on external knowledge sources in the corporate R&D operation by firms (The Economist, 2007). This is especially since knowledge creation and innovation are becoming increasingly multidisciplinary. In addition, 'the need for critical mass and large-scale infrastructure for advancing research in many areas increasingly call for strong international partnerships' (European Commission, 2007c: 6). For TNCs, this shift can mean that they exploit the NISs of countries in which they are operating. In this regard, Gerybadze and Reger (1999) argue that the proliferation of NISs and knowledge-created bodies at several places throughout the world has strengthened the incentives for TNCs to exploit the global knowledge sources. Their findings indicate that a decision by TNCs to establish or expand tasks of R&D units abroad has been motivated by the wish to obtain access to sophisticated resources that cannot be found in other locations.

Evidence suggests that a key element in the global knowledge learning strategies of TNCs has been the increasing growth of collaborative R&D activities (Lam, 2006). This transnational collaborative relationship could be with another TNC or knowledge-created institutions. This trend is prominent particularly in science-based industries in general and

in knowledge-intensive industry sectors in particular (Narula and Duysters, 2004). It is based on the fact that a creation of close linkages with knowledge-created institutions helps to speed up innovation and also broaden the boundary of knowledge exploration. Furthermore, Narula and Duysters (2004: 199) clarify that 'the increasing similarity of technologies across countries and across-fertilisation of technology between sectors, coupled with the increasing costs and risks associated with innovation have led firms to consider R&D alliances as a first-best option in many instances'. Based on these implications, it can be argued that in dynamic technological fields, competitive advantage increasingly depends on tacit competence and unique configurations of knowledge resources, where overseas R&D activities are considered as knowledge incubators (see Lam 2001, 2006). Thus, it can be recognised why firms seek to establish strong linkages with external knowledge resources, such as universities, research centres, domestic companies and even competitors. One of the main motives of this process is to tap into new clusters of knowledge located abroad (see Huggins, *et al*., 2007; Hollenstein, 2008).

More recently, with more emphasis on supply factors in the R&D globalisation process, this process can be explained by firms seeking to utilise immobile assets, which may be either firm specific that is often associated with clusters of firms or exhibiting location specific characteristics (Narula and Duysters, 2004: 209). This brings in a possibility to apply an institutional perspective, especially it stresses that there is a strong influence of home-based institutions on structure and behaviour of firms. Indeed, Kotabe and Mudambi (2003: 216) stress that 'institutions affect the capacity of firms to interact and therefore affect the relative transaction and coordination costs of production and innovation'. Nonetheless, empirical evidence provided by Pearce and Papanastassiou (1999) supports these perspectives. They study the evolution of foreign R&D units in the UK and found that internationally interdependent units have emerged as the most prevalent type of TNCs' R&D units there. They suggest that supply side factors such as the technological capability and research infrastructure of the UK, and the availability of local scientific personnel, are most important in affecting the technological development of these units.

The studies have increasingly focused upon the internationalisation of R&D from a dynamic context of innovation and knowledge exchange across borders, and the TNC as a learning organisation. Feinberg and Gupta (2004) maintain that past research on the internationalisation of R&D has largely overlooked the potential to capture and utilise knowledge spillovers from competitors in examining why and where TNCs engage in FDI

involving R&D. Their study shows that TNCs anticipate knowledge spillover opportunities and are discriminating in assessing these opportunities, not only across locations but also across categories of competitors within the same location. Further, they argue that such knowledge spillover-seeking investments tend to provide stronger support to predictions regarding the global rather than local utilisation advantages of FDI involving R&D.

'The challenge is to utilise local technological and knowledge learning in geographically dispersed sites by communicating and integrating it into the firm's global organisation and leveraging it in other markets' (Belderbos, 2003: 237). In the processes of technology transfer to and applying new technology in TNCs' subsidiaries, there is 'an emphasis upon the importance of the firm's capability to learn from each transfer abroad and accumulate knowledge on how to apply tacit knowledge in different geographic locations' (Belderbos, 2003: 241). Given that there is a need for diversity in producing knowledge, the challenge may arise as to how to determine the optimal level of openness and reliance on knowledge produced in inter-firm settings, which thereby contribute to a more complete understanding of a firm ability to engage in R&D cooperation and knowledge networks (Enkel, *et al*., 2009).

Overall, all perspectives mentioned in this section widely agree that corporate R&D activity not only generates new knowledge, but can also enhance the firm's ability to access, absorb and exploit external knowledge sources. These perspectives suggest that there has been a shift towards foreign R&D activities, not just in adaptive activity to the host country's market for innovations, based more on development activities, but also in vital innovations, creating basis generic know-how. In addition, it is for the absorption of external knowledge that might spillover from other firms undertaking R&D in that country. This process needs a good absorptive capacity, which is defined as 'the quality of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends and saw it as largely a function of the firm's level of prior related knowledge' (Cohen and Levinthal, 1990: 128). The absorptive capacity is essential for firms to find and use new knowledge and this ability can determine where, when and how firms make use of external knowledge to grow (Tidd and Bessant, 2009: 257).

2.4.4 Determinants of the global R&D activities' location and their drivers

This section illuminates the main determinants of FDI involving R&D and localisation decisions by companies. In other words, it can reflect why a given country is considered by

companies to be a favourite destination for undertaking a corporate R&D activity. In addition, the drivers behind conducting corporate R&D outside the home country are discussed. The literature review reveals that some studies focus significantly on these issues and provide good insights into these determinants. For instance, Thursby and Thursby (2006) find four significant factors which essentially reflect the R&D location decisions that can be based on. These essential factors are: output market potential, quality of R&D personnel, university collaboration and intellectual property protection. These factors are slightly varied, depending on which country R&D activities will be located. They find that for companies locating in emerging economies, the most important factors to have been considered are the growth potential in the market and the quality of R&D personnel. While when companies are located in developed countries, the most important factors are the quality of R&D staff and intellectual property protection.

Regarding the location disadvantages, Hollenstein (2008: 7) represents the obstacles to innovation activities that may drive firms to perform R&D at foreign rather than at domestic location. His study is on Swiss locations and he identifies ten relevant obstacles as assessed by firm themselves. These obstacles are high taxation; insufficient supply of R&D personnel, of other highly qualified workers; restricted access to EU market; excessive regulation of domestic markets; entry barriers for foreigners on the Swiss labour market; lack of public research programmes, of R&D subsidies; environment protection; and restrictive regulation of land use. It is a good attempt to consider firms' perspective on obstacles that they push them to decentralise their R&D activity outside their home country. In this context, although it seems to be crossing with this research, in fact, this research looks at identifying TNCs' perspective on the obstacles that they may face in specific locations to undertake corporate R&D activity outside their home countries. Regarding foreign location matters, there is a lack of clear and persuasive information about this issue. UNCTAD (2005a: 157) states that 'TNCs are reluctant to locate R&D abroad when they want to maintain greater control over innovation process and its outcomes. Due to the risk of technology leakage, they are also reluctant to place R&D in locations where there are weak intellectual property rights regimes. The size of firm and the industrial structure also matter'.

However, the study of host country's determinants of R&D location is quite helpful to primarily predict what kinds of obstacles may hinder TNCs to expand or undertake some of their corporate R&D in that host country. The best knowledge available on these

determinants is UNCTAD's world investment report 2005. After relying on survey evidence upon developed countries and qualitative evidence from so called developing countries, UNCTAD (2005a: 161) summarises these determinants as follows:

- *The general investment climate – comprising, for example macroeconomic and social stability, security, transparency, administrative rules and regulations – is important for R&D location as it is for FDI in general.*
- *The type of R&D that may be attracted depends on the economic structure of the location, including the industrial structure, market size and growth, culture and language, natural resource endowments, living conditions and physical infrastructures.*
- *Host country policies play a significant role in determining a country's ability to participate in the international restructuring of R&D activities by TNCs.*

From another perspective, Zedtwitz and Gassmann (2002) provide new insights into reasons behind the decisions to locate research activity and/or development activity in a particular country. For the research activity, the most important reasons are proximity to local universities and research parks, tapping informal networks, proximity to centres-of-innovation, limited domestic science base, and access to local specialists/recruiting. For the decision to locate development activity, the most important factors are local market requirements, global customers request local support, customer proximity and lead users, and cooperation with local partners and market access. Thus, it can be concluded that several different factors contribute to determine the location of foreign R&D activity. Some of them are related to the host countries and others to firms themselves. Supply-side factors are dominated these determinants. But the determinants may differ from research to development. This leads to indicate the importance of these factors and the consideration should be given to the type of foreign R&D activities intended to be internationalised.

For drivers of the globalisation of corporate R&D, Falit (2010: 3) provides good insights into the determinants of foreign R&D activity, based on an approach of demand and supply oriented motives. His thought is mainly centralised on product adaptation motives as opposed to traditional research considerations are more often behind the decision to internationalise. In general, demand-oriented motives predominate in cases involving product adaptation, including:

- *Proximity to customers: TNCs often list proximity to large, growing markets and local customers in foreign countries as the key reason for locating R&D hubs in specific LDCs.*

- *Cooperation with local partners: related to customer proximity, cooperation with local partners, including the potential desirability of co-locating manufacturing and R&D operations, also tops TNCs' lists for reasons to internationalise.*

While supply-oriented motives predominate in cases with traditional research, including:

- *Proximity to best talent: TNCs are willing to travel away to access the best human capital.*
- *R&D agglomeration: proximity to other R&D institutions and corporate hubs is important for the purposes of monitoring and technology imitation and adaptation.*

From another perspective, Hollenstein (2008: 2) summarises the linkage between TNCs' motives behind conducting R&D activity abroad and Dunning's OLI paradigm as follows:

- *Ownership-specific advantages (O) capture market-seeking as well as knowledge seeking.*
- *Location-specific advantages (L) represent the cost-reducing/efficiency-seeking motive.*
- *Internalising advantages (I) are not directly linked to a certain motive for performing R&D*
- *Internalising transactions in imperfect markets for knowledge may explain FDI involving R&D, but it can be realised only if a firm disposes of specific O-advantages (i.e. particular expertise in international knowledge management and firm internal knowledge transfer).*

Based on this analysis, the motives for overseas R&D activities may relate to three motives: knowledge seeking, market seeking, and efficiency seeking. Accordingly, the knowledge seeking strategy aims at exploiting a host country's possible knowledge spillover, even from competitors by companies in order to augment their existing knowledge assets, where the conditions may be an existence of certain level of research capacities or technologies. Thus, the establishment of R&D units abroad can facilitate access to tap into external knowledge (see Cantwell and Piscitello, 2005). Here, there is a need to have a certain level of absorptive capacity to augment this external knowledge and integrate relevant knowledge sources (see Cohen and Levinthal, 1990). Arvanitis and Hollenstein (2010: 1) mention another dimension in the knowledge seeking. They think that 'a more specific aspect of knowledge-oriented foreign activities is the search for knowledge incorporated in personnel that is specialised in specific fields of S&T'.

The market seeking strategy often aims to access foreign markets and increase the marketing share. TNCs here would exploit their existing knowledge assets, where R&D efforts target to adapt technologies or products to the local environment condition of the host country market. This means that R&D is considered to support local production and sales (see Pearce, 1999; Pearce and Papanastassiou, 1999; Le Bas and Sierra, 2002; Le Bas

and Patel, 2007; Hollenstein, 2008). The efficiency seeking strategy aims to reduce the cost of R&D activities by conducting these activities in countries where possibility of low prices of innovation inputs. It targets to access a sufficient supply of R&D personnel and skilled human capital in general (Hollenstein, 2008). Moreover, it can identify another motive, which is established on the technology seeking strategy. This is 'when TNC seeks to offset areas of weakness in the home country innovation system by setting up R&D facilities or acquiring local innovators in countries with complementary strengths' (UNCTAD, 2005a: 139).

In this context, it is worth mentioning that a study by Maskell, *et al*. (2007: 250) on learning paths to offshore outsourcing reveals that motives for offshore outsourcing have changed from cost reduction to a tendency to knowledge seeking. They find that although operational costs remain significant, motives related to the acquisition of knowledge increase in importance. This reflects the knowledge-oriented motives, where the desire to get access to new knowledge and technology is highly dominated.

At the global level, the globalisation of R&D is driven in part by the external pull forces of access to markets and new technologies, and in part by internal push forces of cooperation and competition, and global integration and local autonomy (Boutellier, *et al.*, 2008: 31). Based on this perspective, there are specific driving factors related to the internationalisation of R&D by TNCs in developing countries. Table 2.6 shows these driving factors:

Table 2.6 Main drivers of corporate R&D by TNCs in candidate developing countries

Nature of Factors	Elements of the Factor
Pull factors	* Growing market availability of large talent pools at favourable costs. * Emerging some global production bases in some industries.
Push factors	* Shortening skills in some specific categories in home countries. * Rising costs and complexity of R&D activity. * Greater competitive pressure that forces TNCs to innovate more without increasing costs.
Policy factors	* Host-country efforts to strengthen their NISs. * Improving education systems of host country. * Adopting policies to promote and attractive FDI involving R&D. * Incentives to R&D activity.
Enabling factors	* Technological advance in ICT. * Promoting FDI and trade liberalisation.

Source: Based on (UNCTAD, 2005a: 172).

As can be seen from Table 2.6, many of these elements can be linked to locational advantages, institutional factors and other framework conditions. From TNCs' perspective most elements of these factors can be linked to home based augmenting strategies, while push factors can be linked to the cost reduction strategy. This may especially be an important motivating factor for companies planning to offshore R&D facilities.

Furthermore, it is clear that pull and push factors represent demand related motives, while policy and enabling factors represent supply related motives. In this regard, Reddy (2000: 35) provides some motives for location R&D activities abroad can be applied to developing countries context. These motivations are: market-related factors (size, proximity, and importance); technology-related factors (to tap into foreign S&T resources); cost-related factors (to exploit cost differentials); technology monitoring factors (to monitor new developments in S&T and technology competitors' analysis, etc.) and non R&D-related factors (pressure by national governments, improving the firm's image, etc.).

Overall, the literature tends to confirm that both demand and supply related motives are equally important behind conducting R&D activity outside the home country. However, studies by Dunning and Narula (1995); Kuemmerle (1997); UNCTAD (2005a); Maskell, *et al*. (2007) suggest that there is a gradual move away from home based exploiting strategies towards home based augmenting strategies. In addition, technology-sourcing motives are on the rise. This has come as a result of many companies having recently tended to follow the open innovation approach. Generally, Reddy (2000: 35) thinks that the motives for location R&D activities abroad can be differed from firm to another and a TNC may locate R&D activities abroad for more than one motive.

2.4.5 Nature and patterns of international R&D by firms

In order to understand patterns of the international R&D activities by firms, it is important to determine the nature and purpose of these operations. The classification of international corporate R&D units can reflect the strategy of TNCs toward decentralising R&D activity. It can also help to analyse potential impacts on the level of internationalisation and the size of operations relevant to R&D activities. Overall, it can reflect the different technological and research functions assigned to TNCs' subsidiaries in the host countries.

There have been several attempts to determine these patterns. With a spread of R&D activities at the international level, Ronstadt (1978) defines international R&D operations as typically being one of four types: transfer technology, indigenous technology, global technology and corporate technology units. Another attempt has been made by Hood and Young (1982). They identify three types of international R&D labs: support, locally integrated and internationally interdependent laboratories. Furthermore, Reddy and Sigurdson (1994) identify another type of international R&D operations in addition to the types identified by Ronstadt. These are regional technology units. They clarify that this

type has emerged to cater markets of some regional clusters that have emerged with share some common features and needs for specialised products i.e. pharmaceuticals (drugs for regional diseases). Respectively, all these units are established to achieve specific purposes. Table 2.7 shows the nature and purpose of theses international R&D operations:

Table 2.7 The nature and purpose of international R&D units

Nature of Unit	Purpose of Unit
Technology Transfer Unit	To facilitate and help the transfer of parent's technology to subsidiaries, and to provide technical services in these markets.
Indigenous Technology Unit	To develop new and improved products for some foreign markets, drawing on foreign technology in those markets.
Global Technology Unit	To develop new products and processes for markets worldwide.
Corporate Technology Unit	To generate basic technology or provide research of long-term or exploratory nature for use by the corporate parent.
Regional Technology Unit	To develop new and improved products for regional markets.
Support Laboratory	To make subsidiaries able to assimilate and utilise existing technology derived from subsidiaries of the multinational.
Locally Integrated Laboratory	To provide R&D services to local subsidiary and offer a less dependence on other parts of multinational.
Internationally Interdependent Laboratory	To provide R&D service to all parts of multinational.

Source: Based on (Ronstadt, 1978; Hood & Young, 1982; and Reddy & Sigurdson, 1994).

Different classifications provided by different authors in different time periods. However, some distinctions seem broadly to be similar. For example, technology transfer units and support laboratories, both of them are established to allow subsidiaries to benefit from available technology and support them by technology transfer, where the subsidiaries adapt technologies in order to support operational process and make existing technologies work more efficiently in new environments. Indigenous technology units and locally integrated laboratories are established to maximise the utilisation from local existing technology, to reduce dependence on headquarters in providing R&D activities and to provide R&D service for local and regional markets. These can also work as scanning or monitoring technologies. These tasks can also apply to regional technology units in terms of providing R&D service to regional markets. For other types; global technology unit, corporate technology unit and internationally interdependent laboratories, although they are quit dissimilar in their tasks, all of them they are established to conduct R&D activities that can be globally exploited by the parent company and use for markets worldwide.

Another typology based on the technological objectives of the parent company has been provided by UNCTAD (2005a: 138). It is established upon two main motives:

- *Home base (or asset) exploiting FDI involving R&D: Where the main functions of the R&D are to absorb and adapt technologies transferred by the parent company so that the TNC can effectively exploit its technology assets.*
- *Home base (or asset) augmenting FDI involving R&D: To access foreign technological assets and further, to capture the externalities created by host-country technology clusters.*

This is where TNCs undertake R&D in technologies in which they are strong at home and where the host country also has strengths.

There are other ways to classify foreign R&D activities. For example, researchers of R&D management have developed different taxonomies for international R&D units. It is worthy mentioning here an extensive review of international R&D units' taxonomy, which has been provided by Medcof (1997: 360). This taxonomy has been already presented in this chapter, in Section 2.3.2. In this context, Chiesa (2000) provides a more comprehensive view of the global R&D organisation. His taxonomy is drawn from a result of an empirical study on twelve MNEs, operating technology-intensive businesses in different industrial sectors, from the Triad. He finds that there are two major categories of global R&D structures; specialisation- based structure and integration- based structure. These can be presented as follows (Chiesa, 2000: 345):

- The first one is 'where one foreign laboratory (the firm's centre of excellence) is assigned the full responsibility for developing a new product/ process/ technology on the basis of a global mandate';
- The second one is 'where different units contribute to technology development programme and global innovations are a result of the joint work of these units'.

More precisely, in each category, two sub-cases have been found. Among the specialisation based structure types there are:

(1) The centre of excellence structure, where the centre is the only one of the firm to do R&D in certain field and acts as the centre of excellence or centre of competence of firm in that field;

(2) The supported specialisation structure, in case of where the centre of excellence is assigned the global responsibility of the R&D works in a certain area and there are a number of small units supporting the centre.

Whereas, among the integration- based structure types there are:

(1) The network structure, in case, where various foreign laboratories work and perform innovations in the same technological field or product area.

(2) The specialised contributors structure, where it is based on a structural division of labour among units, which leads to specialise each unit in a certain technological discipline or product component.

Overall, this distinct stream of international R&D literature on typology development is in terms of concerned with analysing these typologies in terms of function performed and the

degree of diversity. This can mean that all perspectives provided were established upon two main factors (purpose and motivations of R&D units) as determinants of the nature and patterns of corporate R&D activities. The general observation that can be made is that these typologies demonstrate a significant variation in the mission of different units. In addition, the role of foreign R&D units play in the innovative process may depend on their level of technological capabilities and the significance of host market.

These typologies represent attempts by scholars to categorise foreign R&D units according to two essential dimensions: geographic scope, and the nature and structure of technological and innovative activities. As has been shown above some types of units serve very limited geographic areas. They might be established to transfer technology from the home base to the foreign affiliates, to adapt process technology for a particular offshore manufacturing facility, or to modify, develop and improve products to satisfy the distinctive demands of a host country market. Others serve a regional need, when they may source inputs from and provide outputs to more than one close national market. Whereas others may assign a global responsibility for developing specific product lines/ processes or improving products/ services, or acquiring specialised knowledge assets. Another dimension reflects three phases, a market seeking, a technology seeking, and an asset seeking strategy, that TNCs may adopt.

2.4.6 Effects from R&D globalisation process on host and home countries

There is no doubt that corporate R&D can enhance host countries' technological and innovative capability and support their competitive position in the global economy. According to (Blomstrom and Kokko, 1997), the desire to acquire modern technology may have become the most important reason why most countries attempt to attract FDI in general and FDI involving R&D in particular as the flows of new technology and technological knowledge. The relevant literature suggests that countries with strong technological capability and well integrated NIS are likely to benefit from the trend toward technology sourcing motives for the globalisation of R&D. This is because they are more likely to attract FDI involving R&D in the first place (UNCTAD, 2005a).

However, the challenge for countries is how they can strike a balance between potential benefits and the costs they bring with them through involvement in global R&D networks and operations. Table 2.8 shows the possible benefits and costs related to the globalisation of R&D on both, host and home countries:

Table 2.8 Potential implications of international R&D by TNCs for countries

Countries	Potential benefits	Potential costs
Host country	* Improved structure and performance of the NIS * Contribution to human resource development (R&D employment, training, support to higher education, reverse brain drain effects) * Knowledge spillover * Contribution to industrial upgrading	* Downsizing of existing local R&D or losing control of technology * Unfair compensation for locally developed intellectual property * Crowding out in labour market, potential harm to basic research * Technology leakage * Race to the bottom and unethical behaviour
Home country	* Improved overall R&D efficiency * Reverse technology transfers and spillovers * Market expansion effects	* "Hollowing out" of domestic R&D base * Disappearance of certain R&D jobs * Technology leakage

Source: (UNCTAD, 2005a: 180).

According to Table 2.8, the impact of TNCs' foreign R&D activities on host and home countries can be contradictory, with the potential for both positive and negative effects. One of the important implications is that there is a good opportunity for host countries to benefit from these operations to build, develop and upgrade their technological capabilities. But this important question should be considered from a policy perspective, in particular, whether these countries have the ability to attract different forms of foreign R&D activities or not and what policy measures can be applied to reduce the costs which may arise with the presence of these activities. For home countries, although there are benefits and costs, with the tendency of TNCs to keep core technological competencies at home, they are likely to be in a better position to benefit than host countries.

2.5 Conclusion

The tendency for some corporate R&D to be undertaken by TNCs outside their home country became significant in the mid-1980s, following the increased internationalisation of production operations in the 1970s. It was widely accepted that the internationalisation of production usually (but not necessarily) takes place before the internationalisation of R&D among TNCs activities (Reddy, 2000). Since then, this trend has expanded into knowledge-intensive services and more systematic R&D activities during the 1990s. Until the mid-1990s, the overseas R&D activities were confined to the Triad, but after that they have been expanded into other regions. Some called developing countries have been highly involved in the R&D globalisation process and some selected ones such as China and India are rapidly becoming important players in the global R&D landscape. Additionally, some TNCs from developing countries have begun to conduct corporate R&D activity on a global scale. These developments have helped change the opportunity sets of both TNCs and host countries (Narula and Dunning, 2000). Furthermore, TNCs started conducting some sort of corporate R&D activity in specific industry sectors in few technologically underdeveloped countries. Overall, observations suggest that the globalisation of corporate

R&D is an increasing trend. It opens the door not only for the transfer of technology that has been created elsewhere, but also for the enhancement of the technology creation process itself. In this regard, evidence suggests that building a strong NIS in a country can serve to maximise the benefits from the R&D globalisation process and reduce the possible costs associated with it.

From this review of relevant literature, it seems to be that the literature offers three main theoretical perspectives (perspectives on product life cycle theory, perspectives on FDI theories and transnational knowledge learning perspectives), from which can be derived the perspectives to explain the behaviour of the globalisation of R&D phenomenon. The attempt was made to clarify to what extent this phenomenon falls within the boundary of these perspectives. In this context, one can realise that the explanation of international R&D by firms at different stages as it stands today is mainly the outcome of these three perspectives.

The global R&D landscape reflects the fact that the logic of R&D globalisation has changed. This is partially due to companies spreading their businesses across the globe to achieve greater market access and partially due to the increasing dispersion of knowledge leading to competence centres emerging in various locations across the globe. The changed logic is also mirrored in where firms decide to locate their foreign R&D activities, which is more influenced by accessing to local scientific and technological capabilities and connected with NISs. The motives of overseas R&D activities have tended to ensure knowledge integration irrespective of where this knowledge is located. Tapping into external knowledge has become a strategically important driver to the R&D globalisation process. Based on transnational learning perspectives, the knowledge seeking strategy can become a dominant strategy behind conducting foreign R&D activity for many TNCs. However, other strategies such as the market seeking, technology seeking and cost reduction are still important in many cases. As adopting a specific strategy can determine the nature and pattern of the units of overseas R&D activities, it is clear that the different types of foreign R&D units can serve these strategies. The patterns of R&D facilities in these units would depend on the nature of the R&D activities conducted.

In the light of reviewing the conceptual background and theoretical aspects of the research topic, it is significant to highlight key emerging themes that have appeared from the literature. Table 2.9 shows these themes and the most important issues associated with:

Table 2.9 Key emergent themes in the literature being sourced

Key Emergent Themes	Underlying Discipline and Issues Associated
Corporate R&D activity	Historical background, characteristics of R&D activity, concepts and related terms,
Globalisation of R&D	Relevant theories and perspectives, the R&D globalisation process, its determinants and nature, type of foreign R&D activities and three main actors (TNCs, home and host countries)
FDI involving R&D	Home base (or asset) exploiting and home base (or asset) augmenting FDI involving R&D
National Innovation System	Actors, institutions, linkages, interactions and national public policies
Drivers behind foreign R&D	Pull, push, enabling and policy factors; marketing, knowledge, technology and efficiency seeking strategy; cost reduction

It can be seen from Table 2.9 that several key emergent themes in the literature address the topic of this research. Within each theme, several different associated issues have been highlighted and discussed in order to provide deeper knowledge of the theme. These themes are interconnected and can be linked to a number of academic disciplines. These include for example, international business (for globalisation and FDI involving R&D), innovation and R&D management (for corporate R&D activity, NIS), economic development (for host countries polices and etc) and international strategic management (for drivers of global R&D activities). These themes have covered in details various aspects of the R&D globalisation process and from different perspectives. These perspectives include special references to the internationalisation of R&D by TNCs, undertaking foreign R&D in host countries and the role of host country policies and NIS capacity in attracting FDI involving R&D.

Finally, it has found out that the literature provides deep insights into why and how specific firms engage in international R&D and the extent in which international R&D business has developed historically. At the basis of this chapter lies a careful survey of existing knowledge of the R&D globalisation process. While there is a considerable amount of literature on this phenomenon in developed countries, studies looking at it in developing countries and particularly in technologically underdeveloped countries context are clearly lacking. Relevant available data on developing countries still generally tend to be incomplete, not fully comparable and subject to differing interpretations. Thus, given the fact that several scholars have published extensively in the field of international R&D, it is perhaps surprising that there is lack of studies of the obstacles to the globalisation of corporate R&D activity and implications of this phenomenon within technologically underdeveloped countries context. Therefore, this research endeavours to relatively fill this knowledge gap by providing a primary analysis of possible obstacles that may hinder the R&D globalisation process in such countries and other relevant important issues.

Chapter Three

Research Strategy and Methods

3.1 Introduction

The research questions and objectives have been outlined in Sections 1.5 and 1.6. Thus, the purpose of this chapter is to outline the research philosophy this research bases on. This is through providing an overview of the research methodology in general and then explaining, justifying the research strategy and methods adopted and applied in this research. It is also to clarify in detail the research design and the process of empirical work conducted. In doing so, this chapter is divided into key sections discussing these themes and other related issues in context of this research.

3.2 Research process and philosophy

This study is conducted in order to assess the obstacles to the globalisation of corporate R&D activity in technologically underdeveloped countries. The focus of the assessment is to have TNCs and the host country perspectives on these obstacles and other relevant issues. In order to gather the necessary data, it utilises qualitative and quantitative approaches as a base of research design. Thus, the purpose of this section is to present the philosophical assumptions underpinning this research strategy and methods chosen as part of this strategy. Three major research philosophies have been identified in the epistemological research process, namely positivism, realism and interpretivism.

There are several distinctions between these three philosophies. Positivists and realists assume that the researcher is independent of and is not biased by his/her research matter and that independent causes lead to observed effects. They focus upon quantitative methods and the analyses of data obtained are mostly emphasised in an attempt to identify common patterns or processes, with the objective of generalisability. On the other hand, interpretivists assume that the researcher is not independent of the phenomenon under investigation and that reality is not objective. They mostly use qualitative methods, with the models of descriptive analyses, where the generalisability is not of crucial importance (see Bryman and Bell, 2008, pp. 16- 21; Saunders and *et al*., 2007, pp. 102- 107).

Considering the conditions of this research, interpretivism is basically adopted as the research philosophy. Accordingly, I follow the point of views of phenomenologists. Based

on that, it has used in a large part the inductive approach. This approach is suitable for this kind of research (exploratory research). As Easterby-Smith, *et al.* (2002) note, there are important reasons which make the researcher chooses this process. For example, if the researcher is particularly interested in understanding of why something is happening, rather than being able to describe what is happening. It can also be when there is a lack of prior knowledge of the subject. In general, 'the interpretivist perspective is highly appropriate in the case of business and management research and particularly when business situations are complex and unique. In addition, where they are a function of a particular set of circumstances and individuals' (Saunders, *et al*., 2007: 107). This research studies a complex and unique phenomenon and with a particular set of circumstances, as the research focus upon the phenomenon of R&D globalisation in technologically underdeveloped countries.

The research strategy adopted in this research is based on case study, with using of quantitative and qualitative data collection techniques and analysis procedures. In comparison between qualitative and quantitative methods, Wright (2004: 49- 50) stresses that 'one method is not a priori better than the other. Both have merits and both have weaknesses'. He thinks that the most significant question that should be asked would be how do we use both methods together to strengthen them? At any rate, this will lead to garner more reliable results. However, the qualitative method is highly advocated, when the research intends to contribute in theory building. In this regard, Wright (2004: 52) points out that 'theory generated from data (i.e., inductive) has greater staying power than theory generated from deductive hypotheses, because, even though it may be modified by input from later data, it is very unlikely to be proved totally wrong'.

Wright (2004: 57) indicates that qualitative research affords the opportunity to examine the processes "why" and "how," not just "what," and to explore the complex, interdependent issues that constitute international business and management studies. The rationale for using qualitative methodology is, for example, when the researcher wants to have better understanding on any phenomenon about which little is yet known. This research is studying the globalisation of corporate R&D in technologically underdeveloped countries, which is a new phenomenon and very little is known about it. The qualitative research methodology can also be used to gain new perspectives on things, or to gain more in-depth information that may be difficult to convey quantitatively (Hoepfl, 1997: 49). Indeed, this research intends to provide two fresh perspectives (TNCs and host country perspectives)

on the obstacles to this phenomenon, where given the novelty of the research's topic, most of the data and information that have been compiled for the first time in this research – especially about TNCs- are not easy to be quantitatively conveyed.

Regarding TNCs' perspective, it has been realised that quantitative measures cannot adequately describe or interpret the situation of their conductions to corporate R&D in technologically underdeveloped countries. This is due to the limitation of TNCs undertaking such activity there, and there are no previous identified variables on this situation that might be quantitatively tested. Furthermore, Hoepfl (1997: 49) points out that the qualitative methods are appropriate in situations where 'research problems tend to be framed as open-ended questions that will support discovery of new information'. As presented in Section 1.5, the research problem of this research has been formulated as open-ended questions. Nevertheless, in this research, qualitative and quantitative research methods have been used in order to combine the advantages of both methods and to eliminate the disadvantages of a single method research design.

3.3 The research issue and analytical framework

This research is an exploratory study, investigating the possible obstacles to the globalisation of corporate R&D activities in technologically underdeveloped countries. In studying this issue and others related to, it has been considered to focus on more than one perspective. In this regard, TNCs and host country perspectives have been equally identified and discussed. The overall unit of analysis is Libya as a technologically underdeveloped country. Thus, the analytical sub-units are represented in two subsidiaries of TNCs working in a host country (Libya) to identify the TNCs' perspective and 10 Libyan organisations (represented in five research centres and five industrial firms) to identify the host country's perspective. It has used these perspectives to obtain more coherent knowledge about the nature of these obstacles from two main actors in the globalisation of corporate R&D. The objective is to have a more comprehensive picture of these obstacles and their implications upon the possible growth of this phenomenon in such host countries.

The empirical work was done during 2008, where the main data collection techniques used were the interviews and questionnaire. The empirical part of the thesis was undertaken in four stages. In the first stage, the archival analysis of the relevant documentary data upon Libya, which as about the structure of the Libyan economy, such as FDI policy,

institutional mechanisms and legal issues, recent economic development, and industrial and S&T policy. In the second stage, a small scale survey was conducted upon a sample of 10 R&D related organisations in Libya, five industrial firms and five research centres. A self-administrated questionnaire was used to collect data from these organisations, and they were distributed upon three people (senior manager, R&D unit manager and laboratories manager) within each organisation, who had relevant experience in the practices of R&D across their organisations. Thus, total of 30 questionnaires were distributed, with 100% response rate as anticipated because of government sponsorship. After two months, all questionnaires were collected by hand with a face to face meeting to ensure that all questions were answered and clarity provided with issues raised by the questionnaire.

In the third stage, two TNCs were selected as case studies. As part of the case studies, semi-structured interviews were conducted at these two TNCs with three levels of the decision makers who were responsible for; corporate strategy, R&D activities and laboratories in these organisations. In addition, archival data on corporate R&D was utilised. These included technology agreements and management reports.

In the final stage, the descriptive statistics were used for the quantitative analysis and a thematic analysis was used to analyse the qualitative data. In this respect, both deductively-based and inductively-based analytical procedures were adopted for the analysis. For analysing quantitative data, the percentages and frequency were mainly used. They are suitable method for this exploratory research with consideration to the nature of many questions that participants were asked to answer. All contingency tables used for analysing the quantitative data include more than one variable. In this regard, Bryman and Bell (2007: 361) indicate that 'contingency tables allow two variables to be simultaneously analysed so that relationships between the two variables can be examined'. And they add that it is normal for contingency tables to include percentages, since these make the tables easier to interpret (Bryman and Bell, 2007: 361). For open questions, the analysis of data has been done by thematic analysis, through which grouped together pieces of conversation related to a particular theme (Bryman and Bell, 2007: 406).

The analytical framework covers analysing the relevant collected data on the host country (Libya) and analysing data on each selected case (TNC), plus cross case analysis. It should indicate that during the subsequent stages in writing this research, several different forms of secondary data has been analysed and utilised to supplement data empirically collected.

3.4 Research methods

The research strategy adopted in this research is basically based on case study, with using of quantitative and qualitative data collection techniques. This part represents this research strategy and data collection methods used in this research:

3.4.1 Case study

A case study can be used for qualitative and quantitative research. The case study, according to Yin (1994: 13), is 'an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident'. This research studies new phenomenon (the globalisation of corporate R&D in technologically underdeveloped countries) is completely suited with this definition. In general, Yin (1994) stresses that case study is a preferred approach when how or why questions are to be answered. Furthermore, Eisenhardt (1989: 548) argues that case study is 'particularly well-suited to new research areas for which existing theory seems inadequate. This is useful in early stages of research on a topic or when a fresh perspective is needed'. Therefore, given there has not been much research on this topic, and on the basis that a form of the main research questions are of the why and how type, and fresh perspectives (TNCs and host country perspectives about obstacles to this phenomenon) are desirable, using case study research is logical.

Woodside and Wilson (2003: 493) provide a broader definition. They state that 'case study research is inquiry focusing on describing, understanding, predicting, and/or controlling the individual (i.e. process, animal, person, organisation, group, industry, culture, or nationality)'. This definition can be applied to this research, as it aims to describe the patterns and forms of corporate R&D activity in technologically underdeveloped countries and understand the possible obstacles to R&D globalisation process in these locations. Eisenhardt (1989: 534) adds that case study is 'research strategy which focuses on understanding the dynamic present within single settings'. In this research, the single setting is Libya as an example of technologically underdeveloped countries. The unique of Libya as a case study can be derived from several aspects. Given the fact that with the ending of the various sanctions which imposed on Libya by US and UN, it could no longer cite international isolation as the cause of the country's many deep seated socio-economic ills (Pargeter, 2006) and a lack of technological development. Thus, discovering the aspects of technological development and the international R&D activities in Libya is very significant in this context. This is especially that Libya belongs to MENA and this is a

region that has not been widely studied/ researched in terms of the technological development. Additionally, there has been some research on countries subject to 'resource-dependency' (i.e. oil rich ones) and the problems they have in achieving good economic growth and development, and this study makes a contribution to this issue. Furthermore, Libya is at the 'cross-roads', between a highly developed region: Europe and a relatively underdeveloped region: Africa, but it is still amongst countries with a low level of the technological readiness and capacity for innovation (Porter, *et al*., 2007; Porter and Schwab, 2008; Schwab, 2009), which leaves the country exposed to criticism and more significant to be as case study. Finally, 'with the Arab Spring of 2011', one could argue that economic development in the Middle East is at an important turning point and a study of a country like Libya is therefore most appropriate.

Overall, a case study was used as a methodological approach for our empirical analysis, as suggested by a number of scholars; it is indeed the most appropriate method for building a rich understanding of complex phenomena (Eisenhardt and Graebner, 2007). It has been mentioned in Section 2.4.1 that the globalisation of R&D is a complex phenomenon. In particular, this research studies corporate R&D activity in different industries and sectors where their boundaries are not clearly defined, because there are different levels of the technological advance in these industrial fields and sectors. Considering these conditions, taking Libya as a case study will add to the current literature in this difficult research area. Consequently, the case study approach is very appropriate as a way of obtaining in-depth insights into the research questions this thesis addresses and providing a holistic approach to study corporate R&D in technologically underdeveloped countries. 'Achieving deep understanding in case study research usually involves the use of multiple research methods across multiple time periods' (Woodside and Wilson, 2003: 498). Based on the recognition that different methods lead to superior results, better than those provided by one method, this case study approach is complemented by a small-scale survey of 10 organisations. Overall, based on the conditions of this research and the justifications to use a case study strategy mentioned above, it is safe to conclude that using a case study strategy in this research is better than other strategies such as a large scale survey or focus group etc.

3.4.1.1 Advantages and disadvantages of case study research

There are some weaknesses related to case study's research method. In this regard, Eisenhardt (1989: 547) points out that case study can result in overly complex theory due to the large amount of data or in excessively narrow theory because the case study research

is very specific. Case study research only allows theoretical generalisation, but no empirical generalisation. This is because case studies are often and typically restricted to a single organisation or unit and it is difficult to generalise findings since it is hard to find similar cases with similar data that can be analysed in a statistically meaningful way. Gable (1994: 113) indicates the difficulty to manipulate independent variables in the case study research, which has influenced on the possibility to establish causality in such research. Other problems may appear in the case study research are, the risk of improper interpretation and the lack of ability to randomise cases (Gable, 1994: 113). The same data may differently interpret by different researchers.

On the other hand, the case study method may offer unique strengths. In this regard, Yin (1989: 14) stresses that the case study method allows the researcher to comprehend the nature and complexity of the research matter under investigation. Moreover, the research based on case study is very likely to generate new theory, to be testable and to be highly empirically valid (Eisenhardt, 1989: 546- 547), as it is widely agreed among researchers that this method is especially appropriate for new topic areas. Case studies involve an attempt to describe relationships that exist in reality, where the reality can be captured in greater detail by an observer-researcher, with the analysis of more variables than is typically possible in experimental and survey research. Overall, the main advantage of case studies compared to other approaches is that they permit the combination of different sources of evidence (Blumberg, *et al*., 2008: 377).

3.4.1.2 Cases selection

As a part of the case study of Libya, I have chosen to include two TNCs working in Libya as sub-cases within the main case study. The first case is American TNC and the second case is Italian TNC. They belong to the field of oil and gas industry, both heterogeneous sectors (technology services suppliers and exploration and production), where real names have been blinded for confidentiality. These cases have been selected based on their similarities as well as their differences. They should have undertaken some sort of corporate R&D in Libya, and they should also differ on activities, nationality, and work history in Libya. This is applicable as 'theoretical sampling simply means that cases are selected because they are particularly suitable for illuminating and extending relationships and logic among constructs' (Eisenhardt and Graebner, 2007: 27). As a first step, the selection has considered the observation mentioned in UNCTAD (2005a: 148) regarding the sector in which some TNCs conduct corporate R&D in Libya, and with the help of the

National Oil Corporation (NOC), allowed me to identify six TNCs that have been carrying out corporate R&D in Libya . Three of them were American and the others were European. To have different perspective, it has been decided to select one TNC from each category.

With regards to sample size, one issue that could be raised is the limited number of cases. This research employs two case studies. As the purpose of this qualitative research part is to have the TNCs' perspective upon the obstacles to the globalisation of corporate R&D activity in Libya and relevant issues, and it is not to calculate how often these obstacles are repeated, which needs taking a large number of samples, rather the focus is to obtain access to relevant evidence about the phenomenon. Other consideration has been taken into account to be these cases from different home countries, and although they are from the same industry, they are working in different fields. At this point, it is worthy to mention that UNCTAD (2005a) has indicated that it is just in the oil and gas industry field, TNCs have undertaken corporate R&D activity in Libya. Thus, the cases in this research have been chosen based on the principles of access as well as relevance. Overall, the aim of the sample is not to be representative or generalisable as such. Rather, it is chosen based on the availability of required data and relevant information about the phenomenon and willingness to respond to participate in the survey.

3.4.2 Archival analysis

The archival analysis is mainly based on analysing data existing in various kinds of documentation, public records, or other units of analysis. These documents and public records can take many forms, including letters, internal memos and reports, newspaper articles, agendas, and so on (Blumberg, *et al.*, 2008: 378). Dane (1990: 170) defines archival research as any research that deals with public records as unit of analysis. Generally, the archival analysis can be distinguished from other research methods in terms of that information is available through archival analysis before one's own research (May, 1997: 160- 161). In this research, the relevant sources of data were some reports on global R&D activities, which issued by international organisations. The available data from the government charters and documentations about S&T policy, industrial policy, FDI policy, NIS, and R&D joint ventures in Libya were targeted. In addition, relevant reports issued by the TNCs studied and several other reports have been used in order to have some evidence that can help to achieve some objectives of this research.

Based on the form of a formal theoretical inquiry, an archival analysis can create new knowledge based on extant knowledge. This is by means of combining, extending, analysing, and integrating existing research areas, namely an interdisciplinary approach, allows one to gain new insights. Thus, it is useful to use archival analysis in this research, as mentioned in Chapter Two that this research based on a multifaceted subject, where no single perspective is able to provide a complete understanding of the research topic. Source of data including archival sources form a rich source of evidence, which is rarely exploited in other research approaches and plays a crucial role in case study research (Blumberg, *et al*., 2008: 378).

Disadvantages of archival analysis may include the potential considerable age of data and the differences in the unit of analysis used in previous studies and one's own research. To what extent one can depend on the quality of data from previous research is a further problem, as the reliability and validity of data collected by others being difficult to determine (Dane, 1990: 187). Certainly, although the importance of archival analysis to complement other research methods, it is alone not enough to achieve research objectives.

3.4.3 Survey

In general, survey allows data and information to be obtained from participants directly or indirectly, either orally or in a written form, from single or multiple respondents in any setting form level. Using a survey makes it possible to question people and recording their responses for analysis (Cooper and Schindler, 2008: 223). Surveys can be conducted in various types: self-administered survey, telephone survey, and survey via personal interview. Each of these types has advantages and disadvantages (see Cooper and Schindler, 2008: 223). The data analysis depends on the particular study and type of data that needs to be collected. Different types of data variable can be collected: facts, opinions, behaviours, attribute and attitudes (Saunders, *et al*., 2007: 362; Cooper and Schindler, 2008: 215). Thus, the use of surveys allows the researcher to study more variables at one time than is typically possible by other methods, whilst data can be also collected about real world environments.

Saunders, *et al*. (2007: 138) clarify that 'survey is a popular and common strategy in business and management research and is most frequently used to answer who, where, what, how much and how many questions. It therefore tends to be used for exploratory and descriptive research'. Thus, the survey can be an appropriate research method to be used in

this research as the research questions go in line with this orientation and indeed this research is an exploratory and descriptive research. Furthermore, a survey is applicable when no control over behavioural events is required and when contemporary events are examined (Yin, 1989: 17). This consideration can be applied to this research as it studies a contemporary phenomenon. Generally, 'Using survey strategy should give the researcher more control over the research process and, when sampling is used, it is possible to generate findings that are representative of the whole population at a lower cost than collecting the data for the whole population' (Saunders, *et al*., 2007: 138). However, some weaknesses are belonged to surveys. For example it is very difficult to realise insights relating to the causes of or processes involved in the phenomena being measured. There are several sources of bias such as the possibly self-selecting nature of respondents, the point in time when the survey is conducted and in the researcher him/herself through the design of the survey itself.

In survey strategy, the researchers determine the appropriate data collection approach largely by identifying the type of information needed and investigative questions the researcher must answer (Cooper and Schindler, 2008: 214- 215). In this regard, surveys enable the researcher to obtain data about practices, situations or views at one point in time through questionnaires or interviews. In this research, a small scale survey based on a self-administrated questionnaire and an in-depth survey based upon semi-structure interviews have been used to collect primary data from respondents.

3.4.3.1 Questionnaire-based survey

A questionnaire-based survey can be addressed to an important number of informants, the objective being to discover relationships based on a quantitative analysis, relationships that are common across organisations. It aims to provide generalisable statements about the phenomenon under investigation (Gable, 1994: 114). Therefore, it can be used for descriptive and explanatory research (Saunders, *et al*., 2007: 356). The part of regarding the host country (Libya) can be applicable to this consideration, as there are several indicators which survey can establish on.

Evidently, a major strength of questionnaire-based survey is that it can result in reducing time and cost, when respondents in various geographical areas can be easily researched. A further strength of it is that participants can take more time to answer questions, rethink them, and can reply more carefully (Cooper and Schindler, 2008: 304). On the other hand,

the questionnaire-based survey has also some disadvantages. For example, it can be encompassing objectivity and testability might be carried out at the cost of a richer understanding of the phenomenon under investigation (Gable, 1994: 114). The respondents might interpret a question or concept very differently from what the researcher's intends and, hence, may answer a different question (Cooper and Schindler, 2008: 339). The questionnaire based survey may associate with a low response rate, which will affect the generalisability (Saunders, *et al*., 2007: 359).

For this research, the questionnaire-based survey instrument was used as primary source of data collection to achieve some objectivity of this research. This is by gathering detailed relevant data and information. A self-administered questionnaire was distributed to the selected relevant R&D managers in some Libyan targeted organisations. It was sent to them with covering letter explaining the purpose of the questionnaire (see Appendix No. 1). The questionnaire given to those managers was aimed to assess several aspects as mentioned in Section 3.4 in this chapter. This focus of the assessment was based on the principles introduced by various authors.

A self-administered questionnaire was designed for the data gathering process to obtain quantitative data. It is based on closed and multiple choice questions and few ranking, open-ended and open questions format (see Appendix No. 2). The questionnaire has been designed based on Omar's study (2000). However, this is not intended as a replication of Omar's study, instead, it picked up from it and then developed it to add several new parts required for the research topic. Generally, the questionnaire was structured in such a way that respondents will be able to easily answer it. The set of questionnaire was structured using in most parts options format, with choosing as much as appreciated or it can apply to. These options serve as the quantification of the participants' agreement or disagreement on each question item. In this arena, the consideration provided by Cooper and Schindler (2008: 338) was taken into account when designing this questionnaire in order to make it more suitable to collect the appropriate date for this research (see Appendix No. 8).

3.4.3.2 Interviews-based survey

An interview-based survey involves personal or telephone interviews between two or more people. Thus, due to the direct interaction between researcher and research subject, the researcher can immediately respond to the information given, can clarify doubts, can gather supplemental information through observation, can obtain more detailed evidence in

comparison to a questionnaire-based survey, can prescreen to ensure the correct participant is replying and can set up and control interviewing conditions (Cooper and Schindler, 2008: 235- 236). Thus, the use of interview can help researchers to gather valid and reliable data that are relevant to his/ her research question(s) and objectives (Saunders, *et al*., 2007: 310). Furthermore, interview-based research is well suited for exploratory studies, particularly, when researchers study an issue with little or no pre-existing theoretical basis (Daniels and Cannice, 2004). This research focuses upon an issue (obstacles to the globalisation of corporate R&D in technologically underdeveloped countries), which is as a new phenomenon and little is known about it.

Thus, based on such advantages, interviews-based surveys are important for the research questions of this thesis, in order to complement the case study research and hence to obtain more generalisable results about the TNCs perspective on the obstacles to the globalisation of corporate R&D in Libya, the influence of host country policy on evolving R&D subsidiaries and the nature and pattern of corporate R&D conducted there. The goal of the interview based survey is to derive comparable data across subsets of the chosen sample so that similarities and differences can be found (Cooper and Schindler, 2008: 215). Interviews-based surveys are the most widely used source for collecting information for evidence (Blumberg, *et al*., 2008: 378).

According to these conditions, a semi-structured interview method was chosen to gather qualitative data on the issue of this research from two selected cases studies mentioned in previous sections. In semi-structured interviews, researchers will have a list of themes and questions to be covered, although these may vary from interview to interview (Saunders, *et al*., 2007: 312). This is to explore the research questions and objectives. At any rate, a semi-structured interview will be most appropriate for the situation where the questions are either complex or open-ended and where the order and logic of questioning may need to be varied (Saunders, *et al*., 2007: 316). Thus, it is clear that these circumstances are fully applied to this research (see interviews format in Appendix No. 4).

For the case studies, primary data has been mainly collected through direct, personal interviews (face to face), while secondary data was gathered through company reports and documentation related to the research topic. Two to three semi-structured interviews carried out for each TNC (each interview lasted on average one hour and half), with the aim to collect the data and information required to achieve some objectives of the research.

The interviews followed a semi-structured replicable protocol, inspired by the reference format presented in Appendix No. 4. Unfortunately, all interviews were not tape-recorded and transcribed, as all participants were not willing to be their interviews recorded.

3.5 Sampling and respondents of the survey

The respondents of this study can be divided into two categories. The first one is related to the host country context (Libya), and the other one is related to the subsidiaries of TNCs working in this host country. The first category includes three relevant managers of 10 Libyan organisations from two relevant sectors. All participants were selected through selective sampling. This sampling method is conducted where it is not significant to choose them randomly, as it needs some specific knowledge or information identified managers are just had these kinds of knowledge or information. In order to conduct this sampling strategy, targeted managers in Libyan targeted organisations have been defined first, and then they were selected to make the sample.

In this context, Bryman and Bell (2007: 182) define non-probability sample as 'a sample that has not been selected using a random selection method. Essentially, this implies that some units in the population are more likely to be selected than others'. Thus, as the sample is a selected sample, the selective organisations were on the basis of criteria, where the organisations have to be from different research and industrial sectors, and more reliable to conduct a significant R&D activity comparing with other Libyan organisations, and they are more critical for the Libyan economy. 50% of targeted sample was chosen from the technology and research services sector and the other 50% from the manufacturing sector. This is applicable to that the sample is chosen based on the researcher's personal experience and judgement, and also convenience (Hair, *et al*., 2003). In this regard, it is worthy to mention that the sampling technique used for the purpose of this research excluded organisations which were established after the year 2005, as it would be too soon to assess such newly established organisations regarding their experience of conducting R&D activities in general and collaborative R&D activity in particular. It must be mentioned that although given that R&D activity is conducted in three main types of units; company laboratories, government and private research centres, and university laboratories, the later ones have been excluded from this study, as they usually tend to focus only upon basic research and in many cases not for business purpose. Thus, according to conditions mentioned, the sample may be representative to population.

As always, one central issue of any survey is the question of sample and sample size. The questionnaire was distributed to 30 participants at 10 Libyan organisations (five research centres and five industrial firms) on the basis of three questionnaires per each organisation to three participants represent three management levels related to R&D function. Fortunately, thirty completed and returned the questionnaire, which means that the response rate was 100%. However, an objection to this survey could be that the sample is neither large nor wide enough to represent the Libyan organisations as a whole. But, as no one intensive R&D sector is missing, the sample covers an identical group of intensive R&D based-Libyan organisations (respondents belonging to research centres; agricultural and animal research, industrial R&D and benchmark research, petroleum research, renewable energy and water desalination, and biotechnology research. With regard to industrial firms; electronic and telecoms industry field, chemical industry field, assembling of heavy equipment industry field, electric engineering industry field, motor vehicles and trucks industry field). The sample can therefore be considered representative of the relevant Libyan organisations as a whole in terms of breadth. The fact that the participants in the survey are considered relevant responsible people to the daily practice of R&D activity in their organisations – which means that they are the best people to have all data needed to answer the questionnaire questions, with a solid understanding of the issues concerning the obstacles to globalisation of corporate R&D in Libya – makes up in part for the small sample size in terms of quality of the answers. As the objective was not to make a census of what managers in these organisations think, but rather to inquire into what the possible obstacles may hinder the practice of R&D activity and R&D globalisation process in Libya, a small and well-informed group of respondents is preferable to a larger group that may not be as well informed. In addition, the fact that the respondents had access to me for questions while conducting the survey (as the questionnaires collected by hand during a short meeting) also added to the quality of the answers, as any ambiguities or misunderstandings could be avoided. Thus, it must be assumed that all respondents answered the questionnaire on the basis of their actual organisation situation.

In the second category, the selected case studies consist of two TNCs' subsidiaries working in Libya. They have been chosen on the basis of non-probability sample. In this context, Saunders, *et al*. (2007: 207) points out that non-probability sampling is more frequently used when adopting a case study strategy. In general, conducting multiple case studies requires considerable thought on which case to select (Blumberg, *et al*., 2008: 377). The selection was based on indications mentioned in (UNCTAD, 2005a: 148) regarding some

TNCs in the oil and gas industry field have been conducting some sort of corporate R&D in Libya. The selective criteria were as mentioned in Section 3.4.1.2. Accordingly, the two cases were an American TNC and an Italian TNC, which are considered to be among the highest technological sophistication ones in their industry field. The three levels of the decision makers who are responsible for; corporate strategy, R&D activities and laboratories and business development in these organisations were selected as respondents and given a code (BD manager) in interviews. These managers represent the most informative managers about the corporate R&D activities of their companies in Libya. Four interviews have been conducted, two per each TNC. Additionally, to have more coherent information and comprehensive perspective, extra interviews were conducted with other relevant R&D managers in three other TNCs' subsidiaries working in Libya in the field of oil and gas industry. One is from each TNC. These interviews were mainly focused on the issues related to obstacles to the globalisation of corporate R&D process in Libya, from their organisations' experience. This is in order to supplement the evidence deduced from two main cases study. Thus, the total of successful interviews conducted is seven interviews.

3.6 Validity and reliability

Yin (2003) advocates strongly, for qualitative research, the use of triangulation and regular reviews by key informants. It has been done so in line with this perspective, as the research methods applied in this thesis bridge the different research traditions of quantitative versus qualitative research and take advantage of such triangulation. Given that case studies require multiple data collection methods, whose results hopefully converge, in order to establish construct validity (Wright, 2004).

As the matter of external validity, which may concern with 'whether the results of a study can be generalised beyond the specific research context, the issue of how people or organisations are selected to participate in research becomes crucial' (Bryman and Bell, 2007: 42). In this regard, all people and organisations participated in this study were selected according to selective criteria that are very associated with best representatives for providing data and information needed to serve achieving research's objectives.

Based on what Sandberg (2000: 14) indicates regarding reliability, I have strongly avoided my own interpretations, and have explicitly dealt with this issue throughout the research process. In addition, as reliability is particularly at issue in connection with quantitative

research (Bryman and Bell, 2007: 41). All consideration has been taken into account during designing the questionnaire and conducting the relevant survey to maximise validity and reliability, with special consideration to the criterion of measurement validity.

Thus, in order to test the validity of the evaluation instrument which was used for the questionnaire based survey; the questionnaire was tested on five respondents. These respondents as well as their answers were not a part of the actual research process and were only used for testing purposes. After the questions were answered, the respondents were asked for any suggestions or any necessary corrections to improve the instrument further. The content of the questionnaire has been modified based on the assessment and suggestions of the sample respondents. Irrelevant questions have been excluded and any vague or difficult terminologies have been changed into simpler ones so as to make the survey more comprehensive for the selected respondents. Overall, these processes have contributed in pre-testing the survey instruments and as a crosscheck against questionnaire responses, which improved internal validity and the interpretation of quantitative findings.

3.7 Ethical consideration

The ethical consideration has been given within all research design stages about protecting the rights of the participants. This research has designed in the way with which they do not suffer physical harm or loss their privacy. Anonymity and confidentiality have been assured to the participants and their organisations (see attached letters in Appendix No. 1, 3). Regarding the secondary data source, much of it already exists on the organisations' websites. Thus, it is available for public use, and there is no need to the ethical considerations. The research has been adhered to the research ethical standards specified by Nottingham Trent University. An application for ethical approval has been made to the College Research Ethics Committee and all primary data has been collected after obtaining an approval from it. In this context, it is important to mention that all data will be kept in a safe place for one year after the thesis is submitted and defended.

With regard to confidentiality and anonymity, all necessary procedures and steps have been considered to make all data and information obtained and used to be anonymised. It does not identify, directly or indirectly, the individual to whom it relates. It is not just as the name of participants and their organisations are not appeared, rather avoiding any indications can reliably identify them. In the quantitative analysis part, aggregating data has served to anonymise any information related to individuals participated. In the

qualitative analysis part, the identity of interviews has referred to a code as (BD), so it has also helped serve to anonymise it. Furthermore, to ensure a high level of confidentiality for participants, the following points have been considered:

- Confidentiality of data has been maintained by ensuring the separation of data from identifiable individuals and storing the code linking data to individuals securely.
- It has avoided discussing the issues arising from an individual interview with others in ways that might identify an individual.
- What an individual says in the interviews has been not disclosed.
- Individuals and their organisations have been anonymised in the dissemination of the study to protect their identity.
- It has been avoided asking questions which are in any way demeaning to participants.
- During interviews, the time has been arranged to be convenient for participants.

3.8 Conclusion

This chapter has provided an elaboration of the research philosophy adopted in relation to research methodology, and has identified the main elements of research approaches and data collection methods used in this research. It has been concluded that quantitative and qualitative approaches can be suitable in this research, whit a research strategy focuses on the case studies complementing by the archival analysis and surveys as research methods.

Chapter Four

Technologically Underdeveloped Countries Context

4.1 Introduction

The importance of technological development and progress in determining economic growth and development has long been understood and emphasised in economic and other relevant literature. However, the classification of countries on a technological scale is rarely and inadequately mentioned in literature. Furthermore, the concept of technologically developed countries versus technologically underdeveloped countries is not in common use between scholars, where they are more reliable to conceptually reflect the significant differences between countries. As this research focuses on studying the globalisation of R&D, it is significant to adopt these concepts. An attempt is made to follow the roots of the term of technologically underdeveloped countries and study the possible debate surrounding them. This chapter mainly aims to investigate the determinants and characteristics of technologically underdeveloped context, where it highlights the case of Libya to represent the aspects of this context. This is for highlighting and discussing the relevant issues involved in the practice of R&D activities and technological development such as S&T, industrial, FDI polices, NIS and economic development.

4.2 General relevant debate

Why are nations technologically underdeveloped? This question has been plaguing academics and policy-makers for a long time. The differences between technologically underdeveloped countries and developed nations are many. Several of these include, for example, gaps in productivity, education systems, and, in particular, innovation and technology in all its dimensions; producing, acquiring, diffusing, exploiting and using. This is not a temporary phenomenon, as Silberglitt, *et al*. (2006: 4) concludes that nations will continue to vary in their capacity to reap the benefit of technology applications. This can mean that global diffusion of technology applications does not mean universal diffusion. There is a major technological gap between the developed and the majority of the developing countries and this gap has grown over the years (UNCTAD, 2007a: 3). Thus, a question arises as to why these gaps exist, and how they can be corrected. Although economists might agree that sustained increase in economic growth will serve to narrow these gaps, the reality however does not reflect this hypothesis in all cases.

There are some countries that have good economic growth, but they have not got a good level of technological development. As these elements (productivity, education systems, innovation and technology) relatively reflect aspects of the level of economic development, 'the relationship between (economic) growth and development remains controversial. Is growth a cause or consequence of development, and to what extent and in what way is it a core component of wider economic and social processes that characterise the elusive notion of development itself?' (Fine, 2003: 201).

Hardly anyone would disagree that technology has never been as vital to development as it is today, and evidence suggests that varying levels of economic and social well-being are the direct result of differences in the level of scientific and technological development. There has been increasing recognition of the potential of STI to greatly contribute to development and their role to create the development factors (UN, 2000). Lederman and Maloney (2003: 2) have reviewed the relevant literature and indicate that 'the literature suggests that roughly half of cross-country differences in per capita income and growth are driven by differences in total factor productivity (TFP), generally associated with technological progress'. They confirm that the countries generating new technologies at the frontier appear to have a faster growth of TFP in their economic activities. Indeed, 'technology has become a key factor in national survival' (Gunasekaran, 1997: 637).

Romer (1990) stresses that the relationship between high capabilities and intensity of R&D activity and economic growth is that technological progress is the major source of productivity growth in the long run. R&D resulting in new knowledge, new process, and new products and services, is a major source of technological progress according to the R&D-based endogenous growth theory. Edquist (2000) confirms that technological change and innovation driven by R&D activities have been the most important sources of productivity growth and increased welfare. There is a high correlation between those countries that have shown significant economic improvements in the past and those that have made substantial investment in R&D (Amsden, 2001; UNCTAD, 2005b). Thus, it is highly justifiable to consider the technological progress for classifying any country.

4.3 Determinants of technologically underdeveloped countries

For a long time, there has been and still remains a widespread use of terms (developed and developing countries) to distinguish between countries in terms of economic development. Others use advanced and third world to describe the same situation, where it brings in a

political dimension that may have been derived from a colonial perspective. Based on industrialisation, other terms used are: industrialised, late/ or newly industrialised countries and less developing countries. In addition, the term of the least developed countries (LDCs) has been used to describe the poor countries in the world, which are already among the category of developing countries.

Seemingly, all these terms do not relatively reflect the aspects of technological development level in a country. However, given that there is a positive relationship between the technological development level and economic growth and development level, it has been noticed that some countries have a good level of gross domestic product (GDP)-which reflects the level of economic growth-, but they have a low level of technological development (Sasson, 2007), with which one can call their economies, fragile economies. Thus, one may conclude that all countries that have a high level of technological development, also have a high level of economic development and considerable economic growth. However, the opposite is not correct in some cases. Arab oil producing countries are the best example. Overall, given that business innovation is a driver of economic growth and that R&D in business is a driver of innovation. Based on that, one can realise the relationship between R&D and economic growth, where the expenditure' ratio on R&D has become an indicator on the advancement of nations.

At the current state of knowledge, one of the arguments surrounding the concept of developing countries is that the simplest definition of a developing country is one with an income below a certain level, although a relatively low share of industry in total economic activity is often assumed to be a key character of developing countries (Weiss, 2002: 1). Even when it comes to industrialisation aspects, the conventional grouping 'developing countries' is very diverse. At one extreme, there are some developing countries that have relatively sophisticated industry structures; these are, for example, South East Asia and some Latin American countries which are referred to as newly industrialised or emerging economies. In contrast, there are many countries, mainly in Sub-Saharan Africa and South Asia where there is poor industry structure, which are referred to as LDCs. Between these extremes are a range of other countries about which it is difficult to generalise.

Thus, it is not safe to categorise all these countries in the same group according to or from the economic or technological perspective. Weiss (2002: 1) focuses on this issue and after his review of more recent literature, acknowledged that 'the generic term 'developing

countries' now carries little analytic content'. Similarly, Westholm, *et al*. (2004: 3) confirm that the very notions of 'developed' and 'developing' are increasingly blurring the true picture, even though the positive developments are to a large extent concentrated in a few regions or even a few countries. They provide a simple example of grouping some of the very low-income countries in the Commonwealth of Independent States (CIS) as 'developed' when Singapore, South Korea and the like are still 'developing'. This shows that statistically meaningful conclusions are better drawn at a more disaggregated level.

The paper of Wilson and Purushothaman (2003) on the shift in the global economy's situation provides good illustrations of the increasing importance of BRIC[1] economies (Brazil, Russia, India and China) in the world economy. Even though they admit that their projections are optimistic, in the sense that they assume reasonably successful development, it has concluded that the list of the world's ten largest economies may look quite different in 2050, where the BRIC are likely to be highly placed (Wilson and Purushothaman, 2003: 2- 3). To some extent, some developing countries have developed considerable technological capacity and become strong in terms of technological sophistication. Thus, it is not surprising that G8 countries admit to these developments by stating 'we recognise the increasing significance of many emerging economies in science and research and invite them to actively participate in the process of innovation for sustainable growth' (G8 summit, 2007: 9). On the other hand, others are still very weak in terms of S&T and lag far behind with a very narrow-ranging technological capability (UNCTAD, 2005a). Overall, one can address that developing countries can no longer be categorised as a homogenous group of countries, which is more accurate at technological aspects. There is a need to review and rethink about terms used regarding the classification of countries. This is for reflecting current technological competences and the potential role that can be played by countries in the production of future technologies.

4.3.1 The historical roots of the technologically underdeveloped countries' term

Generally, the term of technologically underdeveloped countries is not a new term as one might think. Although it is not common in use between scholars and in academic circles, it has historical roots in academic research and writings. For example, in 1953, this term appeared in a thesis by Van der Veen (cited in Mazrui, 1964: 505). It was also used by Wiggins and Schoeck (1958) for describing some developing economies conditions, such

[1] It is now called BRICS, as South Africa has recently joined them.

as Indonesia and China at that time. In 1979, the UN used this term to describe some developing countries that are highly likely to be continuously dependent for quite some time upon technology produced, owned or controlled by TNCs (UN, 1979). Latterly, Arseculeratne (2005) used this term, and clearly addresses that he refuses to call developing in contrast to developed, and would rather use words technologically developed, or developing countries. Generally, some dislike using the term developing countries as it implies that industrialisation is the only way forward, while they believe that it is not necessarily the most beneficial (Chaliand, 2008).

Contrary to some recent literature on so-called 'globalisation and/ or internationalisation of R&D', this research adopts the term of technologically underdeveloped countries instead of developing countries or any others. It is for describing countries that are non-traditional R&D locations and have not exported any technology or produced any high-technological products yet. This is in order to make a distinction among developing countries in terms of their technological capability. The importance of this term derives from that it can express the current situation of technological development levels in these target countries. Although one can state that all developing countries suffer from knowledge and technology gaps, it can be noted that there are greater differences among these countries in the capacity to create knowledge and produce technological products. These inequalities in the capacity to create knowledge exceed even in income. In other words, differences in some important measures of knowledge creation and technology generation are far greater among developing countries than the difference in income (The World Bank, 1998, 2008a; Arocena and Senker, 2003). If one might ask why there is all this focus on the issue of variety in the technological development among countries, the answer will be that technology has been central to both economic growth and many elements of social welfare, and it is expected to play a central role in meeting several challenges of the remainder of this century (The World Bank, 2008a: 2).

4.3.2 An approach to measure countries on a technological scale

Seemingly, there is no one specific systematic approach or scientific measurement that can be followed to determine a country is a technologically underdeveloped country. Thus, it is important to look at several indicators that have been used relevant to technological development. Among of them, UNCTAD's classification categorising countries in terms of producing, acquiring, adapting and developing technology that reflect the innovation capability of any country. Table 4.1 shows the criteria of this classification:

Table 4.1 Components of the UNCTAD Innovation Capability Index

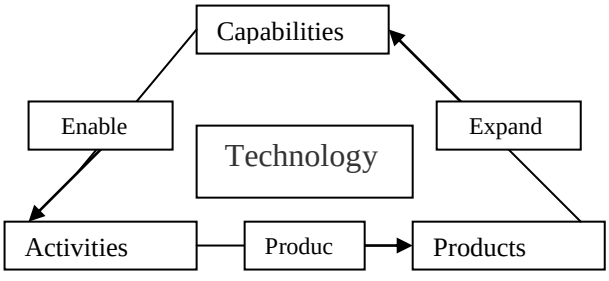
Indices	Components	Weights attached
Technological Activity Index	R&D personnel per million population United States patents granted per million population Scientific publications per million population	All 3 components have equal weights
Human Capital Index	Literacy rate as % of population Secondary school enrolment as % age group Tertiary enrolment as % age group	Weight of 1 Weight of 2 Weight of 3
UNCTAD Innovation Capability Index	Technological Activity index Human capital Index	Both indices have equal weights

Source: (UNCTAD, 2005a: 113).

There is another contribution provided by UNDP (2001) in its report on human development, where it suggests a Technology Achievement Index, which is a composite of different measures of a country's technological innovation capability and performance. The index measures how well a country is creating and diffusing technology and building its human skill base. It includes R&D expenditures as a percent of GDP, the number of scientists and engineers per million population, the number of patent applications, and the percent of exports with high technology content to total manufacturing exports.

Based on these indexes, it is very useful to focus upon the aspects of technology at country level. In this regard, technology has three major aspects: products (goods and services); human activities that create these products; and capabilities that enable technical activities. Figure 4.1 shows the relation and the interaction mechanism between these aspects:

Figure 4.1 The aspects of technology



Source: http://www.creatingtechnology.org/tech.htm, accessed on 11/10/2007.

From Figure 4.1, it can be seen that the three aspects of technology are interrelated and mutually reinforcing. According to this point of view, 'activities in R&D and production create not only consumer goods and services but also knowledge and skills, which supply the growth of technological ability. On other side, people's demand for goods and services stimulate technological activities, some of its results are ploughed back as social investments in education, R&D, and infrastructure, which expand technological capability' (http://www.creatingtechnology.org/tech.htm, accessed on 11/10/2007). Thus, from my

point of view, any country that does not have a sufficient technological capability within which it can produce technological products and in some part conduct significant R&D activities that lead to produce new products or new technologies and processes, can be called a technologically underdeveloped country. This is irrespective of the nature and type of technological activities performed, and its ability to finance these activities.

Furthermore, as technological capability is the main engine for technological progress, it is very useful to present some main indicators that can be used to classify any country in terms of technological capability and performance. Table 4.2 shows these indicators:

Table 4.2 Selected indicators for a measurement of the technological capability

No.	The name of indicator	Type of indicator
1	Royalty and License Fees Payments/ Mil. Pop.	Quantitative
2	Royalty and License Fees Receipts/ Mil. Pop.	Quantitative
3	Science & Engineering Enrolment Ratio (%of tertiary students)	Quantitative
4	Researchers in R&D/Mil. Pop.	Quantitative
5	Total Expenditure for R&D as %of GDP	Quantitative
6	University-Company Research Collaboration	Qualitative
7	Scientific and Technical Journal Articles/Mil. Pop.	Quantitative
8	Availability of Venture Capital	Qualitative
9	High-Tech Exports as % of Manufacturing Exports	Quantitative
10	Private Sector Spending on R&D	Quantitative
11	Embodying technological advances in the country's productive system	Qualitative
12	Patent applications Granted by the USPTO/Mil. Pop.	Quantitative

Source: Based on (UNCTAD, 2007a: 3; UNCTAD, 2005a; UNDP, 2001).

It can be seen from Table 4.2 that the majority of indicators are quantitative, which could mean that they are likely to be easier to calculate. However, most of these indicators can only reflect the quantity of technology used rather than the quality that reflects the real level of technological achievements. Generally, 'the global indicators of technological level do not take differences in quality sufficiently into account' (The World Bank, 2008a: 60). There are limitations to the relevance of such as those indicators in many developing countries and in particular the LDCs (UNCTAD, 2007a). The implication which can be drawn is that as much as a country has a high level in each of these indicators, it can be classified as a technologically developed country, and if it does not reach a good level in most of these indicators, it would be classified as a technologically underdeveloped one.

Thus, the countries in the category of low innovation capability (see UNCTAD, 2005a: 114) which also do not have wide-ranging technological capability, can be located in the category of technologically underdeveloped countries. However, it is worth pointing out that among them, there are fifty countries that have been designated by the UN (UNCTAD, 2007a) as LDCs (to know these countries, see the more recent appendixes in UNCTAD, 2007a: iii; 2008: iii; 2009: iii). These countries are classified as poor countries and had low

socioeconomic progress accordingly. Consequently, UNCTAD (2007a: 1) argues that unless LDCs adopt policies to stimulate technological catch-up with the rest of the world, they will continue to fall behind other countries technologically and face deepening marginalisation in the global economy. Most of them are struggling to overcome poverty and the problem of ignorance. Indeed, many of LDCs have not been able to allocate an adequate amount of funds towards S&T activities (Albuquerque, 2004).

When it comes for example to technology transfer's issue, the evidence suggests that these countries do not often have the technological capability to make transferred technologies well observed, utilised, and diffused in their countries. Indeed, these countries may not be on the frontiers of innovation and some are not even able to utilise modern technologies, which need the minimum basic infrastructure to exist. What could it imply? It is partly unexpected in the near future that these countries would have a chance to join the global R&D networks, and also it might be impossible to construct a picture of long-term changes in the technological development for them (UNCTAD, 2007a). As a result, this research is more concerned with other technologically underdeveloped countries, especially rich countries (for example oil producing countries in MENA's region), which might have more a chance to join global R&D networks if they were to deploy all efforts into building and enhancing their technological and innovative capabilities. On this basis, one of them (Libya) has been chosen to be a case study for investigating the research topic.

4.3.3 Attempts to measure countries on a technological scale

One of the early studies that addresses this issue is the study of Glismann and Horn (1988), who analysed the invention performance of six countries (France, Italy, Japan, United Kingdom, USSR, West Germany) relative to the United States for 41 SIC industries over the past 20 years. Although they have based their comparison as measured just by patenting activities, -which is clear in its limitation-, their study demonstrates the possibility and significance of categorising countries according to their inventive activity.

From an international marketing prospective, Leal and Powers (1997) address the need for taxonomy of countries based on inventive activity. Their attempt aims at classifying countries by characteristics that are related to their innovative capability, which will enable then to target other countries with effective marketing programmes. Their study was confined to examine the relative position of USA, Japan, and European countries on the technological activity and performance. They focus on finding the major differences across

competing economies in the way that they fund, develop, and retain technology, which has influences on their future ability to penetrate other markets with new products and to protect themselves from losing their technology to other countries (Leal and Powers, 1997: 446). Despite their attempt could be worth considering as an early work on this issue, the criteria they have used were just limited to five factors; R&D expenditures relative to GDP, inventiveness coefficient, diffusion ratio, dependency ratio, and relative technology balance of payment. It is clear that these factors can just cover a few dimensions of technological competences, which may have caused the differences between countries.

From a technological development perspective, Castellacci and Archibugi (2008: 1659) point out that 'it is well accepted that the distribution of knowledge across nations is unbalanced. Countries in the world economy are characterised by different levels of technological development and have unequal access to knowledge stocks, and this is a major factor in explaining their different competitive patterns and diverging economic dynamics in the long run'. They have carried out an empirical study of the cross-country distribution of knowledge in a large sample of developed and developing economies in the 1990s. The results indicate the existence of three technology clubs characterised by markedly different levels of technological development, where countries have been grouped on the base of their ability to create and imitate advanced knowledge and dynamics of their capabilities over the decade. Table 4.3 shows these technology clubs with the detailed list of countries and their respective category:

Table 4.3 The composition of the three technology clubs*

Clusters	Countries
Advanced Countries	Japan, US, Germany, Netherlands, Switzerland, UK, Denmark, Finland, Iceland, Norway, Sweden, Australia, Canada, New Zealand, Israel.
Follower Countries	Honk Kong (↑), South Korea (↑), Singapore (↑), Malaysia, Philippines, Thailand, Fiji, Austria (↑), Belgium (↑), France (↑), Luxembourg, Cyprus, Greece, Ireland, Italy, Malta, Portugal, Spain, Turkey, Bahrain, Jordan, Kuwait, Lebanon, Saudi Arabia, Syria, United Arab Emirates, Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Jamaica, Mexico, Panama, Paraguay, Peru, Puerto Rico, Uruguay, Venezuela, South Africa, Trinidad and Tobago, Armenia, Azerbaijan, Belarus, Bulgaria, Croatia, Czech Republic, Georgia, Estonia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
Marginalised Countries	China (↑), Indonesia (↑), Vietnam (↑), Bangladesh, India, Mongolia, Nepal, Papua New Guinea, Pakistan, Sri Lanka, Iran (↑), Oman (↑), Yemen, Albania (↑), El Salvador (↑), Guyana (↑), Honduras (↑), Guatemala, Haiti, Nicaragua, Algeria (↑), Botswana (↑), Mauritius (↑), Tunisia (↑), Zimbabwe (↑), Benin, Cameroon, Central African Republic, Congo Rep., Cote d'Ivoire, Egypt, Gabon, Ghana, Kenya, Lesotho, Madagascar, Malawi, Morocco, Mozambique, Namibia, Nigeria, Senegal, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia.

Source: (Castellacci and Archibugi, 2008: 1671).
* The arrows indicate those countries shifting towards the cluster above between 1990 and 2000.

Before one can comment on Table 4.3, it is significant to highlight variables that have been used to measure the above categories. They include variables such as patents per capita, scientific articles, internet penetration, telephone penetration, electricity consumption,

tertiary S&E enrolment, mean years of schooling and literacy rate. It can be noticed that although they can be good in measuring the aspects of national knowledge capabilities and the countries' position in the process of knowledge creation and dissemination, they have some limitation in measuring the ability of countries to access, generate, exploit, and use technological knowledge, which is one of the fundamentals in building and developing national technological capability and R&D capacity. This ability is more linked to international integration of nation into and the degree of its connection with the world economy (Castellacci and Archibugi, 2008: 1662).

In the 2000s, some studies advise the technological dimension to be considered for categorising the countries and represent valuable attempts in this context (see for example: Albuquerque, 2004; Schmoch, 2008; UNCTAD, 2005a: 114). However, the first attempt to classify the world countries upon their S&T capacity was seemingly in 2001 by RAND Corporation (Mentioned in Wagner, *et al*., 2001; Silberglitt, *et al*., 2006), when it drew up a composite index to measure a country's capacity to conduct scientific research and foster technological progress, as well as offering pointers to policy measures that might strengthen specific NISs. Its index was based on country level data, and covers both inputs and outputs of S&T capacity, where all key indicators that had been used for measuring S&TI capacity were taken into account.

The RAND's analysis includes 150 countries, and they have been divided into four categories, which include scientifically advanced countries, scientifically proficient countries, scientifically developing countries, and scientifically lagging countries. According to RAND's index, the first group includes 22 countries, among of them Japan, South Korea, Taiwan, Russia, Australia, Israel and developed counties from Western Europe and North America. These countries were recognised as they possess capacities in all areas of S&T, and perform better than the international mean.

The second group consists of 24 countries, mainly from transition and emerging economies in Asia, Latin America and Europe and South Africa. Examples of them are Brazil, China, India, Hungary, Poland and Spain. These countries were recognised as they perform at, or slightly above the international average on some S&T activities, but do not show uniform capabilities across all S&T indicators. The significant note about these countries is that they lack some important elements of a NIS.

The third group also includes 24 countries whose scientific capacity is below the international average. Among them are Argentina, Chile, Turkey, Colombia, Indonesia, Pakistan, and Latvia. However, it has been noted that these countries invest substantially in S&T, have a reasonable ability to attract international research partners, and can participate at some level in international STI activities. In addition, the index shows that some of them, such as Argentina, Chile and Latvia, are close to the second group, but lack an appropriate technological infrastructure.

The last group is the largest, as it consists of 80 countries, which fell in most cases well below the international average in all components of the S&T capacity index. Examples of them include countries such as Nepal, Albania, Mali, Ecuador, and Libya. Generally, it has been noticed that these countries usually lack both appreciable indigenous S&T capacities, and enabling conditions within their political, economic and scientific systems and infrastructure. As a result, they are currently unable to generate new knowledge, and have only a limited capacity to absorb technologies that are available in the international market. Thus, based on RAND's classification and the study of Castellacci and Archibugi (2008), it is clear that on the technological scale, Libya lags behind even in comparison with some countries of the MENA's region.

In this context, it should be mentioned that RAND's classification has been criticised as the approaches used in it have limitations that could affect the real classification of a country (see Wagner, *et al*., 2001: 17- 18). In addition, some trends related to the development of S&T capacities in some nations can have an impact on the categories of RAND's classification (Silberglitt, *et al.*, 2006: 11- 12). Beyond the limitation of this classification, it is clear that developing countries are not alike in S&T capacity, and there is a wide range of differences among them. For example 'Brazil, China, and India may have more in common in S&T-relevant sectors with OECD countries than with the low income countries' (Watson, *et al*., 2003: 3). The implication of these changes in the map of S&T capacities has impacted also on the world of R&D's landscape, as several of so called developing countries have recently gained a high rank among the top 10 R&D generators, users, and mainly importers. Table 4.4 demonstrates the position of developing countries that possess a strong base of S&T capacity on the global R&D network:

Table 4.4 The world of R&D's landscape in 2007

TOP R&D GENERATORS [by home country of HQ]		**TOP R&D USERS** [includes domestic spending]		**TOP SOLE R&D "IMPORTERS"** [for countries generating less than US$1 billion in R&D]	
U.S.	$146.1bil.	U.S.	$108.5bil.	China	$24.7bil.
Japan	71.6	Japan	40.4	India	13.0
Germany	30.7	Germany	27.8	Israel	6.5
France	19.7	China	24.8	Australia	4.3
U.K.	18.1	U.K.	23.3	Spain	4.0
Switzerland	16.8	France	19.8	Ireland	4.0
South Korea	11.1	India	13.1	Russia	3.7
Netherlands	9.2	Canada	9.0	Singapore	3.2
Finland	7.7	Italy	7.8	Taiwan	2.4
Sweden	6.8	Sweden	7.2	Brazil	2.3

Source: (Jaruzelski and Dehoff, 2008: 6).

Based on the above observation, the implications derived from studies of Wagner, *et al*. (2001), Watson, *et al*. (2003), Silberglitt, *et al.* (2006) and Jaruzelski and Dehoff (2008), one can conclude that there are some so called developing countries that have been playing a notable role in global R&D activities and in building strong STI capacities. Indeed, some of them have achieved high rankings on technological scales and in some cases even higher than some of so called developed countries. These are countries such as China, India, Russia, Brazil, South Africa, Taiwan, Singapore, South Korea and Israel. Thus, there is less meaning in using developed and developing countries terms, rather to use technologically developed and underdeveloped countries. Accordingly, it can be suggested that countries that have been classified as scientifically advanced and scientifically proficient countries could be applied to the category of technologically developed countries, while scientifically developing and scientifically lagging countries could be applied to technologically underdeveloped countries. This is because the first two categories have many common technology aspects, while the second two categories have in common a lack of an appropriate technological infrastructure.

The parallel concept (technologically developed countries) has been recently used to describe the countries that have already built a strong global R&D capacity, and based on a high level of technological capabilities. The significance is it has been implicitly mentioned that some developing countries must belong to this category. Duga and Studt (2006: 1) point out that 'The examination of the changing dedication to R&D on a global scale is an essential component in understanding the R&D structure and practices now occurring within the U.S. and other technologically developed countries. Indeed, it has become well established that the expansion of R&D activities- especially in China, India, and other countries of Eastern and Southern Asia- cannot be viewed as isolated events'.

Grueber and Studt (2009) confirm that in recent years, continued expansion of R&D in Asia is fuelling much of the growth in worldwide R&D spending, and consequently, it has grown to be a major player in global R&D efforts. The emergence of some so called developing countries in Asia, mainly China and India, as major powers in R&D capacity can be seen from a high commitment of R&D activities. It is higher than many of so called developed countries in Europe for example. Table 4.5 shows the distribution of global R&D spending, where China and India have been increasingly playing important roles. This notable spending can reflect the wide range of STI development in these countries.

Table 4.5 Share of total global R&D spending

Countries/ years	2006	2007	2008	2009	2010
Americas	35.7%	39.1%	39.9%	39.4%	39.2%
U.S.	32.7%	34.3%	35.4%	35.0%	34.8%
Asia	36.9%	31.6%	32.0%	33.5%	34.6%
Japan	13.0%	13.5%	13.2%	12.5%	12.3%
China	13.5%	9.5%	9.1%	11.1%	12.2%
India	3.7%	2.0%	2.4%	2.5%	2.9%
Europe	25.2%	25.9%	24.5%	24.0%	23.2%
Rest of world	2.2%	3.3%	3.2%	3.1%	3.0%

Source: (Grueber and Studt, 2009: 3; Duga, *et al*., 2008: 3; Duga and Studt, 2007: 3).

Generally, the emergence of China and India among the main players in global R&D growth has impacted upon global technology drivers too. Table 4.6 demonstrates the leadership position of these countries in the promising technologies:

Table 4.6 Non-U.S. technology leaders and challengers

Technology Area	Rank (1= the best)				
	1	2	3	4	5
Energy and Environment	Germany	China	Japan	France	UK
Health and Bioscience	UK	Germany	Japan	China	France
Defence and Security	China	Israel	UK	Russia	Germany
Information and Communications	Japan	China	India	UK	Germany
Composite, Nanotech and Advanced Materials	Japan	China	Germany	UK	India

Source: (Grueber and Studt, 2009: 31).

As can be seen from Table 4.6 China and India have gained a high position in leading advanced technologies, which in some cases are higher than those of so called developed countries that have a long history in producing advanced technologies. Several countries that are now so called developing countries have now gained a higher position in producing advanced technologies. Grueber and Studt (2009: 32) demonstrate that 'emerging economies that include China, India, Korea, Brazil, and Eastern Europe are now able to compete with the former technology triumvirate for development of the most sophisticated and technologically complex new products'.

Another study from the IFIA may be also useful in this context. It was done by (Vedres, 2006) who studies the innovation potential by countries, where he finds that remarkable

changes in the geographical dimensions of innovation, as the innovation map has changed. His predictions have been summarised as follows (Vedres, 2006: 9):

- *Japan has the highest innovation potential. No country which can reach the Japan level until 2020.*
- *The speed of US innovation is not sufficient to reach Japan. Asia became the most innovation continent.*
- *The decline of Europe will increase; because of the EU innovation remains a fiction while the innovation in Europe based on national systems.*
- *The innovation in South America will develop slowly; the backwardness of African continent will not decrease.*
- *The importance of Austral continent innovation will be higher in the future.*
- *The innovation potential of Russia will more quickly increase if the role of its army will grow or Russia will approach Asia and will move away from Europe.*

Based on these observations, as this research focuses on one of the African countries, their conclusion confirms that Libya lags behind in innovation potential.

The implications derived from all contributions in this section can support my point of view about the unreality to classify countries on the basis of developed and developing countries. There are several developments; the most significant one is in terms of technological progress, which the major difference between countries can attribute to. Hence, dividing countries into technologically developed and underdeveloped is more reliable, objective, justifiable and practical. It is a time to rethink classifying the world's countries on a technological scale. These terms are more accurate in reflecting the reality of aspects and level of development for any country, and the use of this does not imply any bias against historical, geographical, cultural, and political phases, rather it is based upon technological and innovation capacity, which is the most important driver for economic growth and development. Eventually, accurate criteria of classifying countries on this scale need to be developed. This is in order to suggest applicable indicators with which any country can be classified into these two categories. However, based on all attempts mentioned, it is safe to conclude that most of African and the Middle East countries fall into the category of technologically underdeveloped countries.

4.4 Case study of Libya

This part provides an example to technologically underdeveloped countries, highlighting key aspects that present relevant implications through discussing several trends and issues.

4.4.1 General relevant Information

Highlighting general information about Libya serves as an approach to identify a case study of this research. Geographically, it is located in North Africa to the East of Tunisia and the West of Egypt, and it encompasses 1,759,540 sq km (with a coastline stretching 2,000 kilometres (km) along the southern Mediterranean). It is surrounded by Egypt to the East (1,150 km); Sudan (383 km), Chad (1055 km) and Niger (354 km) to the South and Algeria (982 km) and Tunisia (459 km) to the West. The population was estimated to be 6,310, 434 in mid 2009, and it includes 166,510 non-nationals (CIA, 2009). Libya could be defined as a socialist-oriented economy taking into account some consideration to its unique political regime. With Arab spring revolutions, its regime has been changed and Libya now looks forward to reform its economy to become an open economy.

The Libyan economy primarily depends upon oil sector revenues, which account for the vast majority of export earnings and government revenues. Its contribution was about 95% of export earnings, about one-quarter of GDP, and 60% of public sector wages (CIA, 2009). This relatively reflects the position of Libya, based on the limitation of the exports of other sectors such as high-tech exports. However, the combination of high oil revenues from the energy sector coupled with a small population afford Libya to be one of the highest per capita incomes in Africa (CIA, 2009). In 2005, Libya was considered among 12 African nations that had the average gross national income (GNI) per capita that was greater than China (Mahajan, 2007: 22). Its macroeconomic indicators are robust and among the highest rank on macro-economy (Porter, *et al*., 2007: 172). This huge wealth can represent a potential market for companies worldwide. Libya could be a country with unique values and distinctive heritage. 'The country possesses key strengths including an enterprising workforce, rich endowment of natural resources, accumulated capital reserves, and an attractive geographical location linking Europe to Africa' (Porter and Yergin, 2006: v). Import restrictions and inefficient resource allocations have led to periodic shortages of basic goods and foodstuffs. However, the non-oil manufacturing and construction sectors, which account for a low percentage of GDP, have expanded from processing mostly agricultural products to include petrochemicals, iron, steel, and aluminium (Russo, 2005).

One of the main reasons that has hindered the journey of development in Libya is a period of international isolation in the 1990s and later. Immediately after the suspension of international sanctions in 2004, Libya attempted to position itself as a key economic intermediary between Europe and Africa (Otman and Karlberg, 2007). Important

characteristics that helped Libya to achieve an improving position in the global economy have been highlighted by Russo (2005: 4) as follows:

- *Libya is rich in natural and mineral resources that can be considered the basis for many potential industrial, agricultural and tourism projects.*
- *Libya is a major oil producer and can be considered the hot spot for new explorations.*
- *Profiles and ready access to European markets make Libya one of the industry's highest profile targets.*
- *Recently, after major strategic changes and the resolution of the Lockerbie case, Libya has re-entered the world economic scene.*
- *Libya has a pool of skilled workers eager to emerge in the work force.*

It is clear that these conditions may indeed be likely to provide ample opportunities for Libya to attract FDI, in both natural resources and manufacturing. However, for turning these potentials into realities, appropriate policies at national and international level are crucial and essential. Since all sanctions were removed by June 2006, it has helped Libya to attract a greater FDI, especially in the energy sector. Indeed, 'NOC set a goal of nearly doubling oil production to three million bbl/day by 2012' (CIA, 2009). Libya has addressed the necessity to consolidate and accelerate growth and reforms of the past few years by stepping up privatisation, diversification and international cooperation, and it is seeking FDI across all sectors of the economy (OBG, 2008). But the process of reform is still slow and there has been little tangible change on the ground. Indeed, there has been no real attempt to tackle the chronic problems that continue to blight the country. The real nature of political regime (State of the Masses) was the key obstacle to reform, as there was no real political has affected internal change (Pargeter, 2006: 219- 220).

However, some significant initial steps have already taken place. These include applying for WTO membership, reducing some subsidies and announcing plans for privatisation. Considerable efforts have taken place to support this transition, by changes in regulations, establishing the Libyan Stock Market and the development of the new Libyan Economic Development Board (OBG, 2008). These changes and developments are laying the groundwork for a transition to a more market-based economy. But, the road is still long and many improvements need to be done, and done rapidly, if Libya is to live up to its promise and potential. Table 4.7 demonstrates that Libya has been weak in the overall environment for business and productive enterprises.

Table 4.7 Libyan business sophistication

The indicator	Year 2007	Year 2008	Year 2009
	Ranking among 128 countries	**Ranking among 134 countries**	**Ranking among 133 countries**
Local supplier quantity	58	81	79
Local supplier quality	100	91	102
Production process sophistication	101	82	88
Extant of marketing	124	126	119
Control of international distribution	19	95	100
Willingness to delegate authority	116	110	130
Nature of competitive advantage	94	129	132
Value chain presence	113	----	132
State of cluster development	----	93	89

Source: Based on (Porter, *et al*., 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201).

Although there is some slight progress in some elements, most of these elements have a remarkable retreat to the bottom of the list on the global scale, which mean that several areas of business environment require immediate attention. Thus, in order to review the most important points in Libyan modern development, more detailed consideration of these developments is significant in this context.

4.4.2 General technological aspects

Based on the indicators and classifications mentioned in Section 4.3.2 & 4.3.3, it can be said that Libya is a technologically underdeveloped country, and there is a large technical, scientific, technological, and innovation gap that is basically what distinguishes it as other technologically underdeveloped countries from developed countries. Libya is among the category of countries with low innovation capability and scientifically lagging countries. Libya is not already amongst LDCs; however, it even lags behind many of so called developing countries in terms of technological capability and also in its R&D intensity (Djeflat, 2002). This is the situation of most Arab countries, as indicated that the Arab States have a low ranking in R&D and technological innovation (Sasson, 2007). Table 4.8 demonstrates the rank of Libya on the several aspects of technological readiness:

Table 4.8 The technological readiness of Libya

The indicator	Year 2007	Year 2008	Year 2009
	Ranking among 128 countries	**Ranking among 134 countries**	**Ranking among 133 countries**
Technological readiness	89	---	---
Availability of latest technologies	---	85	70
Firm-level technology absorption	71	97	66
Laws relating to ICT	127	126	130
FDI and technology transfer	108	105	91
Mobile telephone subscribers*	120	68	85
Internet users*	101	111	111
Personal computers*	92	101	100
Broad band internet subscribers*	---	95	100

Source: Based on (Porter, *et al*., 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201).
* Hard data

It can be seen from Table 4.8 that the overall technological readiness in Libya is still low, and it is lagging behind in many elements, with consideration to progress in terms of the

absorptive capacity of firms and knowledge spillover from the technology transfer by FDI. This could reflect changes in the Libyan business environment to attract a specific type of FDI and the result of small scale reform adopted. However, with this level of technological readiness, it is quite hard for Libya to attract much FDI in technological fields.

The large disparities between technologically developed and underdeveloped countries in many terms (e.g., socio-economic environments, S&T and innovation capabilities) are definitely resulting in creating decisive obstacles and difficulty to join the latter group with the global R&D network (Koehler and Wurzel, 2003). The starting point to study the dimensions of this gap for corporate R&D activities practice is through shedding light on related aspects in terms of technological capability and other relevant elements. Unfortunately, studies based on a deep analysis of a technologically underdeveloped context in terms of corporate R&D activities are still rare. An attempt is made to discuss some relevant policy elements. These such as S&T policy, industrial policy, economic development and challenges related to building and upgrading technological capabilities.

4.4.3 General overview on science and technology policy

Over the last few years, there have been signs of a shift towards exploring the potential of S&T for development, globally, regionally, and nationally. The final report of the World Summit on Sustainable Development held in 2003 in Johannesburg highlights the importance of S&T in obtaining the development goals of nations. The summit called for placing more emphasis on promoting S&T base by implementing a wise S&T policy.

The recent studies on S&T policy devote special attention to recent efforts at extending S&T indicators to cover innovation activities. These indicators are naturally more closely related to the implementation of S&T inputs in almost all production and services sectors in today's global economy. Thus, based on these indicators, the state of national capabilities of the STI of any country can be characterised and compared with any regional and international level (UN, 2003; OECD, 2006b; OECD, 2007b). All activities related to STI knowledge creation, dissemination, transfer and utilisation have been considered at developing STI indicators. These indicators are now one of the most important components in determining the level of competitiveness and socio-economic development of any country. The traditional set of S&T indicators were concerned with variety of input and output indicators. The inputs provide tools for evaluating resources employed for S&T activities, typically including expenditure and manpower devoted to higher education,

R&D and related areas of scientific and technological activities. While the outputs are associated with traditional S&T systems, and measure the patents and S&T publications (Chinaprayoon, 2007).

As STI policy is targeted to build and upgrade national technological capabilities, it can be developed by considering the indicators that assess and monitor these technological capabilities. The following represents the most widely indicators used to date by the International Community to measure the status of any country's position:

- The expenditure on R&D as percentage of GDP
- Number of scientists and engineers working in R&D fields per million people
- Research organisations
- Scientific journal publications and citations
- Quality of education system
- Higher education enrolment
- Intellectual property statistics and Patents registered
- Technology balance of payments
- High technology trade values
- International inflow of R&D activities

It is clear that there are several indicators related to either input or output measurement, but a criticism is made on using singularly these indicators, rather it should consider all elements of NIS and how these elements interact with each other to provide innovation outputs and other technological achievements (UN, 2003; OECD, 2006b; OECD, 2007b). The growing importance of developing these indicators comes from the fact that the competitiveness of nations has become more technologically-oriented. Moreover, STI policies aim at building and updating the components of the country's technological capability, where indeed, the technological capability is an intriguing asset, which typically must be built, as it cannot be bought. The next section can serve as a basis for understanding an example of S&T policy in technologically underdeveloped countries.

4.4.4 Libya's science and technology policy

4.4.4.1 Main indicators analysis and the status of S&T activities

In view of the lack of literature about the Libyan S&T policy , the key to the analysis of the Libyan S&T policy could be found within the framework of comparative S&T policy of

the region in general and Arab countries in particular. It is thus assumed that the S&T policy of Arab countries has certain common characteristics, as they share several institutional characteristics, historical backgrounds and others. From a regional perspective, Libya is linked to MENA, which is not considered to be the leading region either in scientific production or in technological production. However, countries of this region may have different levels of technological sophistication, ranging from countries with moderate technological sophistication to countries with or without very weak S&T institutions (Koehler and Wurzel, 2003). In this context, given that literature on Libya's level of technology innovation and technological activities is scarce (Twati and Gammack, 2006).

In this context, it seems that only under the recent changes regarding the reforming of Libyan economy and recent S&T policy adopted by the Libyan government, the focus upon R&D activities has been relatively intensified compared to past periods. However, the efforts in this regard have been generally far from satisfactory. Some political reasons have played a role. For example, there have been considerable foreign efforts intending to offer the Libyan experts new research topics in civilian areas and help eliminate the threat of future weapons proliferation (Bissani, *et al*., 2004; IAEA, 2004). This has impacted upon the priorities of R&D areas that the economic development may need at this stage of the country's technological development.

It is useful to analyse the recent S&T policy which was issued in 2001, and it basically aims to build an ambitious technical and scientific base, which is able to transform Libya to a developed country by the end of 2020 (NBSR, 2001: 8). In brief, this policy centralises on the following elements: (a) promoting the sustainable human development in R&D field, (b) settling, developing and producing advanced industrial technologies that are suitable to the local conditions, (c) ensuring continuous funds for R&D projects, (d) supporting R&D policies by strong legal laws, adopting advanced techniques in the management of R&D, (e) setting up science parks, (f) adopting advanced programmes for building a developed research base in IT, (g) pushing awareness and enhancing attitudes of people into the applied sciences and technical education, and (h) ensuring a coordination and equivalence of the R&D goals with the development requirements. It also aims to increase the number of researchers and technical workers to reach (44500) by 2010 and (70000) by 2020, with insuring a gradual increase in the expenditure on R&D activities to reach 1.6% from GDP by 2010 and 2.6% by 2020 (NBSR, 2001: 9-12).

Thus, it can be relatively said that it is an ambitious S&T policy, but some relevant indicators show modest achievements. By using available relevant data, it can present a brief assessment of S&T indicators for Libya in comparison to the Arab region. Table 4.9 shows the nature of expenditure on R&D in some Arab countries:

Table 4.9 The nature of expenditure on R&D in the Arab region.

Country	Government spending as a percentage of 2006 GDP[1]	Private sector spending (scale of 1- 7)[1]	Corporate spending on R&D (out of 134 countries)[2]
Oman	--	3.9	44
Tunisia	1.3	3.8	38
Qatar	--	3.6	35
Saudi Arabia	--	3.5	43
UAE	--	3.3	50
Morocco	0.75	3.2	69
Egypt	0.2*	3.1	57
Kuwait	0.18	3.1	93
Jordan	0.34	3.1	79
Algeria	--	2.8	116
Syria	--	2.7	115
Bahrain	--	2.6	82
Libya	0.7*	--	124
Lebanon[3]	0.2	--	--
Sudan	0.3	--	--

Source: (MBRF, 2009: 193), based on:
[1]World Bank Database, Knowledge Assessment Methodology (KAM), accessed on 10/06/2009;
[2]The World Economic Forum, 2008;
[3]The National Council for Scientific Research, Lebanon;
*COMSTECH, 2007.

As can be seen from Table 4.9 the position of Libya is high compared to the rest of Arab countries in terms of the ratio of expenditure on R&D as a percentage of GDP, but this however is very low compared to the global average, where it was about 2.0% in 2007 (Duga, *et al*., 2008: 4). Furthermore, although there is not available data on the expenditure of the private sector on R&D in Libya, it is not expected that this sector has had significant expenditure on R&D activity as it is a new sector and centralises on almost non-high-tech fields. Overall, the corporate expenditure on industrial R&D is not significant, as data shows that Libya is ranked at a low level and lagged behind most of Arab countries. One of the possible explanations for little expenditure on R&D by the production and service sectors is that they often relied upon imported, ready-made technology, on the basis of turn-key agreements (Omar, 2000). In addition, while the cost of R&D activity is highly expensive, the recent business and industrial polices in Libya do not consider spending on R&D by local firms to be tax exempt (MIEM, 2006), which can mean that there are no incentives for companies to spend heavily on this vital activity.

Another important indicator is the number of researchers (scientists and engineers) who work in the R&D field. Table 4.10 shows some available data in this regard:

Table 4.10 The number of R&D staff in some Arab countries

Country	Researcher per million inhabitants		Availability of researchers (out of 134 countries) World Economic Forum 2008-2009
	ESTIME 2007	COMSTECH 1998-2007	
Tunisia	492	1013	10
Algeria	170	---	41
Egypt	---	---	47
Morocco	166	782	68
Jordan	280	1927	39
Kuwait	---	69	62
Libya	---	361	44
Syria	---	29	40
Saudi Arabia	---	---	43
Qatar	---	1236	53
United Arab Emirates	---	---	75
Oman	---	---	95
Bahrain	---	---	94
Iraq	---	---	---
Lebanon	200	---	---
Sudan	---	263	---

Source: (MBRF, 2009: 190) based on World Economic Forum 2008;
World Bank Database, Knowledge Assessment Methodology (KAM) accessed on 10/06/09;
ESTIME, in English 2007;
COMSTECH, 2007.

Similarly, this indicator also confirms that Libya lagged behind several Arab countries in terms of R&D intensity with regard to the number of researchers per million people. The paradox here is, while Libya is in an advanced rank in terms of researchers' availability from some Arab countries, it lags behind them in terms of the number of researchers working in R&D fields. This could reflect that professional scientists and engineers tend to work outside of the R&D field. There are some reasons that lead to this situation. For example, as most of the economic units in Libya are still of public ownerships, where all employers have their salaries according to the same salaries Law No. 51, 1981, with no special allowances or benefits for working in the R&D field. Thus, working in other jobs may give more benefits and other utilities, such as teaching at universities and some other high-position technical and management jobs. In addition, the change in the political agenda might influence this context. A big difference as compared to the number reported in the above table and what was in recent years is, however, open to question. For example, in 2003, when Libya announced that it would disband its R&D on non-conventional weapons and eliminate existing stockpiles, it also admitted that 800 nuclear specialists, including 140 with advanced degrees, were involved in the program (Stone, 2005: 186).

There is an acceptance to measure R&D intensity. The most frequent ratio quoted is R&D/GDP and the number of R&D staff per million people in a country. However, while such figures can provide a broad overview of the commitment by the various components of a NIS, it omits consideration of the manner in which different types of institutions have different roles and responsibilities when it comes to supporting R&D. This leads us to look

at other indicators concerned with other elements of the S&T policy that have an influence upon NIS in general and R&D activity in particular. This needs detailed data on these elements, which might not be easy to find in many technologically underdeveloped countries.

The lack of accurate data on R&D activities is not only a trait of the Libyan business environment; rather it is common in most countries in MENA. The Arab knowledge report 2009 indicates that 'the Arab world lacks a pan-national monitor that could prepare quantitative and qualitative indices for the Arab region and guarantee the credibility of data on research and the dissemination of science and innovation within it' (MBRF, 2009: 181). Regardless of precision and prevalence, the report reveals that in all Arab countries, the innovative performance is weak in comparison to that of the other pillars of knowledge. In this context, the available data indicates that Libya is at a low level of business sophistication, innovation, and technological readiness, even compared to the countries in the same stage of development (see Porter, *et al*., 2007; Porter and Schwab, 2008; Schwab, 2009; MBRF, 2009).

Thus, to have an overview on S&T policy indicators related to the most important inputs and outputs of Libyan NIS, it is significant to highlight some figures related to the recent Libyan innovation performance. Table 4.11 shows the trends on the indicators:

Table 4.11 The recent Libyan innovation performance

The indicator	Year 2007	Year 2008	Year 2009
	Ranking among 128 countries	**Ranking among 134 countries**	**Ranking among 133 countries**
Quality of scientific research institutions	92	82	91
Company spending on R&D	118	124	129
University-industry research collaboration	97	114	115
Gov't. procurement of advanced tech products	97	96	99
Availability of scientists and engineers	72	44	66
Utility patents*	80	88	90
Intellectual property protection	95	88	82
Capacity for innovation	117	131	133

Source: Based on (Porter, *et al*. 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201).
* Hard data

It can be seen from Table 4.11 that Libya remains near the bottom in this scale in several indicators, especially, the expenditure of the companies on R&D, university-industry research collaboration, the engagement of the government to supply the high-advanced tech-products and the overall capacity for innovation. Moreover, although Libya can relatively be considered at quite a good level in terms of availability of scientists and engineers, it has shown low levels at the quality of scientific research institutions, which is reflected on utility patents and the capacity for innovation. In spite of the current S&T

policy which focuses on some related issues as presented previously in this section, these indicators can confirm that it failed to resolve or improve these issues. Another outcome of this situation is the weak impact of this performance on the economic development process and the limited applicability of its outcomes. A related reason to S&T policy is that most of research agencies are attached to the higher education system rather than somehow to the production and service sectors. This has contributed to creating a gap between education and research on one hand and economic and social needs on the other. Thus, this can clarify the missing cycle in the coordination between S&T policy and industrial policy, where R&D efforts must be directly tied to industry, trade, services, and etc.

Given the stability and growth of GDP in Libya as mentioned in Section 4.4.1, it can be noticed that while most of the studies on innovation performance assume the existence of a positive correlation between GDP and the innovative performance, Libya, however, does not show a positive correlation between them. In addition, despite Libya being classified with high GDP, its ranking on the innovation and scientific research index remains low in comparison even to some Arab countries with low incomes level (MBRF, 2009). The possible implication of this is the deficiencies in its NIS in general, and with more reference to the allocation of resources. Overall, Libya has been classified by the Arab knowledge report 2009 as among:

'Countries have research institutions that are characterised by a highly centralised administration and a bureaucratic relationship with the public sector. The funding for these research institutions is limited to state contributions, and they show no diversity in their financial or human resources. The missions of these research institutions and their programmes are burdened with scientific services required by public utilities. Thus, their contribution to the production of original research and patents are limited and they do not include all scientific specialisations' (MBRF, 2009: 188).

The reality of Libyan research institutions could reflect that constraints of R&D in Libya are not limited to the weakness of institutional structures or the small number of their staff. They may also include the weakness of relevant administrative arrangements and legal frameworks, and their impact upon the efficiency and effectiveness of these institutions. 99% of research centres and scientific institutions are public, while most of them are linked to the Ministry of Higher Education and Scientific Research by its affiliates, mainly the National Board for Scientific Research. Other research institutions link to Energy, Industry, Economy and Agriculture Ministries. In an absence of the good level of coordination between these parties and clear strategies and policies on research's priorities,

they are heavily informed by a notion of technology transfer rather than knowledge production or innovation. For example, this can be partially seen from the limitation of scientific publications. Table 4.12 shows the productivity of the Libyan research institutions in terms of the published research articles in some main S&T fields, in comparison to some Arab countries:

Table 4.12 Number of scientific articles published in the Arab world (1997- 2007)

Country	Environment and Agriculture	Public Health and Biology	Basic Science	Energy Science	Engineering and Industrial Science	Total	Number of articles per one million inhabitants (2005)
Egypt	827	205	720	2276	245	4273	50.9
Jordan	474	113	202	523	113	1425	177.3
Morocco	366	78	317	614	69	1444	39.1
Saudi Arabia	352	111	183	846	182	1674	72.3
Tunisia	264	95	179	622	56	1216	146.2
Kuwait	240	56	70	216	81	663	267.2
Algeria	206	20	190	737	67	1220	27.1
Syria	183	30	25	92	9	339	12.8
Lebanon	160	158	83	201	53	655	347.3
Oman	145	20	52	152	39	408	117.2
Sudan	62	29	3	32	4	130	4.4
Libya	31	8	10	39	9	97	14.7
United Arab Emirates	29	6	5	39	8	87	66.3
Bahrain	26	7	7	54	16	110	189.7
Iraq	26	3	8	57	13	107	3.8
Qatar	24	7	16	50	6	103	226.2
Yemen	18	6	2	24	7	57	2.7
Mauritania	18	6	2	6	---	32	7.5
Occupied Palestinian Territories	12	2	4	13	4	35	17.3
Comoros	4	---	---	---	---	4	8.2
Djibouti	2	---	---	---	---	2	6.3
Somalia	1	---	---	---	---	1	0.3

Source: (MBRF, 2009: 198) based on COMSTECH, 2007.

Given that scientific and technical journal articles are one of the most important S&T indicators. It can be seen from Table 4.12 that the total scientific and technical publications of Libya in the main S&T fields between 1997 and 2007 stand at 97 and the number of articles per million people in Libya is recorded as 14.7 in this ten years. This reflects that Libya is at a very low level of the research publications and lags far behind most of the Arab countries. In fact, if it was linked to the availability of scientists and engineers, which Libya is considered to be quite good in the global scale, it would reflect the reality of the quality of higher education system in general and research institutions in particular. Unfortunately, this issue has not been addressed by the recent S&T policy in Libya as one of its concerns. Thus, it represents one of the deficiencies in this policy.

Furthermore, although the number of articles is an important indicator of S&T policy, one should also look at the quality of those articles. Albuquerque (2004) points out that the criterion that is widely used in measuring the quality of research articles is h-index, which

is based on how many times an article have been cited by other scholars. Generally, in spite of this data not being available with regard to the research articles that have been published by Libyan researchers in Libya, the low level of utility patents mentioned in Table 4.11 could reflect that most of these articles are unlikely to have produced new knowledge or new technological applications.

As the quality of research institutions and the higher education system influences the research publications and patents, here it may be significant to show the state of the higher education system, which is based on some elements. Table 4.13 represents these elements:

Table 4.13 The statue of education and training in Libya

The indicator	Year 2007	Year 2008	Year 2009
	Ranking among 128 countries	**Ranking among 134 countries**	**Ranking among 133 countries**
Secondary enrolment	17	49	48
Tertiary enrolment*	29	32	34
Quality of the educational system	123	121	128
Quality of math and science education	87	90	80
Quality of management schools	118	130	133
Local availability of research and training services	98	106	114
Extent of staff training	109	114	99
Internet access in schools	---	126	121

Source: Based on (Porter, *et al*., 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201).
*Hard data

It can be seen from Table 4.13 that although Libya is at a very good level of school enrolment, which means that Libya does not face the illiteracy matter. However, it is at the bottom of the list in other important elements such as the quality of the education system and the local availability of research and training services. The concern is that there has not been any progress in these elements in the last few years. It is now safe to conclude that the very low research publications can be attributed to the weaknesses in these important elements and among others, as it shows other elements are not better. In this context, the Wold Bank (2006: 6) confirms some of these issues, when the issue of the low quality of higher education system was addressed in its study on Libya, and after studying this issue deduced that some factors have contributed to reduce this quality. These factors include:

(a) The country's isolation for more than a decade,

(b) The high unemployment rate combined with the displacement of local workers by foreigners, and

(c) The ban of foreign languages from the curricula.

World Bank (2006) also stresses the concerns about the quality of the content of curricula and the actual access to up-to-date knowledge and expertise. Porter and Yerign (2006: 4) add that 'this system suffers from the poor quality of teachers, the infrastructure and from

structural problems such as the lack of objective standards and inefficient allocation of public resources'.

The review of the current Libyan S&T policy reveals that it highlights several important issues, but no implementation plan was designed. This might be attributed to the instability of the institutional structure within which this policy can be implemented and reviewed. Therefore, even if the Libyan government decided to increase its spending on R&D or its intensity in general, without adequate planning it would still be difficult for it to conduct and support R&D activities in an efficient way. The increase of the budget of R&D alone is not sufficient to promote its technological sophistication. As Lederman and Maloney (2003: 2) suggest that countries need to develop an 'absorptive' or 'national learning' capacity, which in turn are hypothesised to be functions of spending on R&D. Indeed, evidence indicates that R&D activity has become an essential part of the technological learning process, especially for high technologies.

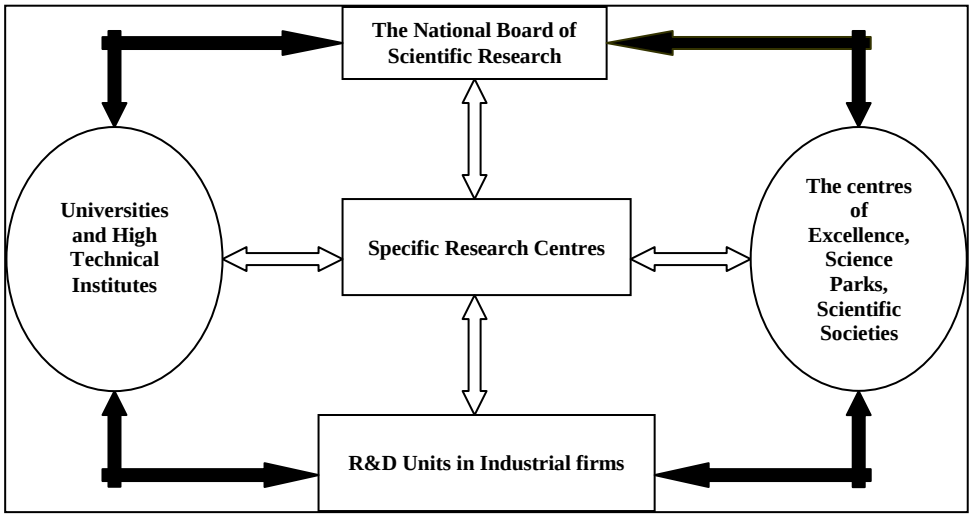
Another limitation regarding S&T policy is that it does not consider any element of linking S&T activities with the international or regional level. Nothing has been mentioned about the channels of co-operation with the international institutions, or even at the individual researchers or scientists level. There is nothing about the corporate R&D activities in terms of designing and implementing multilateral joint R&D and technology transfer programs. Neither does it highlight any focus on or target to the embedding and upgrading of TNC subsidiaries already present in Libya. No consideration to facilitate their evolution towards higher value adding activities and their tendency to engage in R&D. At the national level, nothing has been indicated about the mechanisms and channels of collaboration among research centres and with industrial firms. It means that the vital links are missing, which weakens the performance of NIS and have resulted in poor R&D within the industrial sector (MIEM, 2006). Overall, this S&T policy does not adopt a multidimensional integrated approach to create technological dynamism within the country.

Libya also adopts a technology leverage strategy from TNCs due to its limited local production and manufacturing capabilities. Since 1997, FDI by TNCs has been encouraged through highly favourable conditions. Despite this strategy not focusing mainly on FDI in the manufacturing sector, it might allow Libya to gain access to new technologies and to create new technical jobs for local skilled workers. However, several challenges are still to benefit from these developments, as the current S&T policy has deficiencies in resolving

issues related to the building of its own technological capability and the absorptive capacity of firms. Djeflat (2002) mentions about Libya that the dimensions of its S&T policy and current potential and infrastructure are unlikely to provide a good basis for NIS.

Generally, R&D activities are already to some extent conducted in several manufacturing fields; this is either by the industrial firms themselves or by the research centres and universities (Omar, 2000). Thus, Libyan S&T policy attempts to promote such R&D activities by creating ways for active linkage tools and coordinating research works and arrangements between all these actors (universities, high technical institutes, research centres, science parks, and etc). Figure 4.2 represents the aspects of this interaction:

Figure 4.2 The relationship between bodies involved in Libyan S&T activities



Source: (NBSR, 2001: 27).

In 2000s, two institutions, the National Planning Council (NPC) and the National Office for Research and Development (NORD), were responsible for designing Libya's S&T policy. This covers all fields, except the defence and security field, as it is designed by a separate office under the Ministry of Defence and Military. Recently, the major government institution in charge of the S&T policy is the National Office for Research and Development (NORD), which was established in 2004 instead of the National Board for Scientific Research (NBSR). It has taken its tasks further to supervise the work of the following research centres: The Libyan Centre for Remote Sensing and Space Science, the Centre for Research and Technical Studies, Biotechnological Research centre, and the Centre for Research of Renewable Powers. Overall, The NORD is responsible for the enhancement of R&D capabilities in areas relevant to these centres. In addition, there are several research centres in different sectors. For example, the Industrial Research Centre,

which has as one of its tasks to commercialise the intellectual property that is created by other research centres and to enhance the industrial R&D capabilities in the industrial firms. In addition, the Oil Research Centre is for enhancing the technological capability in the oil industries sector. In the agricultural field, the Agricultural Research Centre is responsible for developing technologies and improving the productivity in this sector. The Nuclear Power Corporation has been established to facilitate the research efforts in using the nuclear power in the civil purposes. In the health field, the Centre for the Medical and Pharmaceutical Research undertakes research in this field. Moreover, some universities conduct significant technical research at their laboratories, where they carry out basic research and some applied research in several advanced technological areas.

It is clear that the research efforts are distributed in most of the S&T fields. In this regard, the current S&T policy does not consider the competitive advantage that Libya may have in some S&T fields to give a priority in terms of the intensity of R&D and the building and upgrading of their technological capabilities. It can be noted that different research centres are linked to different ministries. This can imply that, with the instable administrative system in Libya and an absence of a specific body to coordinate between these research centres, it is highly expected that conflict will happen in their tasks and repetition in their efforts. This is because the current S&T policy does not consider the coordination mechanisms that facilitate these issues. As mentioned in Table 4.12, Libya lags behind in terms of the quality of scientific research institution and university-industry research collaboration. However, it should be mentioned that although there is limited technological capability in these research centres, some of them can be considered. For example, the Oil Research Centre, -which was established in 1977 as a technical arm of NOC- presides over a wide range of activities that include research, consultation and technical support, and training. By 2007, this centre had over 40 fully equipped labs, which were of both upstream and downstream disciplines, and more than 350 persons working in R&D.

In order to enhance the local technological capability, research infrastructures have been created, for instance, the initiative to establish the first Libyan engineering technology incubator was started in April 2007. This project (Libyan Incubator for Technology Innovation) is designed to create a stable framework for the support of Libyan Entrepreneurs and SMEs on their way to successful business models. It is also to fulfil a variety of objectives determined from the regional demand and the respective funding institutions. Such objectives include training and personnel certification of the Incubator

Management, commercialisation of research results, advancing the economic development and rural revitalisation of Libya. This project was accomplished in partnership with the Berlin Innovation and Business Incubation Centre in Germany (Seidel, 2007). Later, the National Council for Economic Development established several business incubators in the main cities, where there are more potential entrepreneurs to develop their innovative ideas, as these incubators incubate these ideas and provide support to commercialise them (NCED, 2009). However, the latest outputs of these incubations are still very modest and not in some high-tech fields. Indeed, indicators regarding the innovation performance in general and the capacity for innovation were at very low levels.

As a result of some observations in 2001 about shortages of Libyan researchers in local research centres and universities- which reached just 2021 researcher- (NBRD, 2001: 4), continuous efforts have been made to stimulate programmes and improve the higher education system in Libya to increase the number of local researchers. In response to this situation, the education system has undergone changes in order to create local expertise in different scientific fields. For example, there has been a new graduate scholarship scheme by the Ministry of Higher Education was set up, in which excellent graduates will be given scholarships to pursue their MScs and PhDs at high ranking universities in technologically developed countries. In this context, it has been noticed that the total of students who have been sent to study abroad is 10000 during 2000- 2007 in all academic fields, mainly in the field of applied sciences (MHESR, 2008). Overall, this may explain why Libya has been recently considered with a good level of availability of scientists and engineers. Although the current S&T policy addresses the need to raise the number of high skilled professionals, it does not consider the distribution of the target number by the S&T fields, where there might be a deficiency in some fields according to socio-economic development needs. This may result in ineffective investment of human resources. A study by Handoussa (2003: 6) indicates that 'S&T policies and their reflection in economic development have been quite weak in Libya and Mauritania'.

4.4.4.2 General aspects of international R&D activities

The internationalisation of R&D has mainly been confined to the developed nations, and more recently -with the globalisation of R&D- to some so-called emerging economies, and newly industrialised countries, such as China, India, Korea, Brazil and some others. Historically, Libya is a non-traditional R&D location (Omar, 2000), and in addition, it was not a favoured destination for FDI involving R&D. Foreign R&D investment in Libya is a

very limited and new phenomenon. Since 2004, some TNCs in the petroleum industry have been conducting some significant R&D activities in Libya (UNCTAD, 2005a: 148). Available information about Libya suggests that there is a growing interest in benefiting from research cooperation that may be offered by some developed countries. However, it can be noticed that most of the bilateral international support was offered on the basis of political relations between Libya and developed countries. In some cases, this support and collaboration has a political dimension. A recent notable example was when France signed a collaborative agreement to support Libya in the field of nuclear energy. This is within a framework of the redirection of the Libyan nuclear capability to civil purposes. It seems to be that there is extreme competition between Western developed countries. Stone (2005) and Johnston (2005) point out that the USA and the UK have also been involved in R&D collaboration in this field. One initiative gaining traction is a sister lab agreement between Livermore and the Libyan Nuclear Research Centre in 2005 (Stone, 2005: 186). The nature of cooperative agreements has been described by Johnston (2005: 8) as follows:

'The collaboration is covered several areas, ranging from radiation protection and health physics to environmental. A key area of focus for the redirection initiatives is the establishment of the Centre for Mechanical Industries, which will serve as a state-of the-art facility for the design and development of commercial products in Libya and thus provide for the redirection of scientists, technicians and their facilities formerly involved in the weapons program. The Centre will also be used in training programs as well as in support of university research and thus will serve as a technical resource for various technical industries and universities in Libya'.

Thus, although these projects may reflect high-tech R&D activities, it is not safe to state that these R&D collaborative projects have come as a result of an attractiveness of the Libyan business environment in terms of technological capability or S&T policy. If anything, they have been probably driven by a political dimension firstly, as these collaborations came after Libya had changed its political agenda with the West. Indeed, the S&T policy does not address the importance of corporate R&D activity to be placed among main targets to promote and strengthen the international cooperation in S&T.

Zanatta, *et al*. (2008: 1) provide important factors that are relevant to the attraction of foreign R&D investments. These are, 'an appropriate physical infrastructure for setting up technological facilities, an abundance of qualified professionals-mainly scientists and engineers- and a proximity to high level universities and research institutes, appropriate intellectual property regimes and fiscal incentives'. In the case of Libya, it is far from

being an attractive environment for such investments, as indicators on some of these elements show that Libya is at a low rank. The implementation of current S&T policy, in particular, failed to improve these factors. Overall, the Libyan government has recently signed several bilateral and multilateral international cooperation agreements and memorandums of understanding for exchanging scientific knowledge and technical cooperation with several countries, mostly with technologically developed countries. However, the review of the current S&T policy reveals that there is no target to promote and strengthen the collaboration in terms of sharing knowledge and technological experiences for industrial development and improving the technological capacity of the industrial sector. This can mean that Libya does not pay sufficient attention to the international dimension of corporate R&D activities. Under such conditions, it can be expected that there would be a limited attractiveness of FDI involving R&D.

4.4.4.3 Status of intellectual property rights

In the light of global economic development, Libya has applied for membership of the WTO in December 2001, but its request was rejected by the USA for political reasons. Later, around mid 2004, as most of the economic sanctions against Libya were lifted, it applied again on 10 June 2004 and WTO members agreed to start talks with Libya on its membership bid (WTO, 2004). Consequently, this means that once a country accepts the terms and conditions attached to its joining the WTO, it has little choice and most aspects of its economy and governance must meet those conditions. In addition, while Libya is in the process of applying for entry to WTO, it is not currently a member, and thus this means that it is not a party to TRIPS. Similarly, it is not a Member State of WIPO. Nor does it have a comprehensive law on IPRs, similar, for instance, to Egypt's Law No. 82 of 2002 pertaining to the Protection of IPRs (Otman and Karlberg, 2007: 86).

Thus, it is becoming clear that these conditions have attracted foreign companies in some technological fields to transfer advanced technology and generate maximum spillover effects. Although domestic laws exist to protect for example; copyright, trademarks, and patents, it is very noticeable that trademark violations involving pirate copies of known brands are a common feature in Libya's retail shops and markets (Otman and Karlberg, 2007). Overall, a relevant figure presented in Table 4.12 indicates that Libya lags behind in terms of IPRs. In this context, it important to mention that there are two governmental departments dealing with the IPRs subject. The first is the Department of Industrial Property, which is linked to the Industrial Research Centre. It is responsible for registering

the patents, the trademarks and brands and the industrial models and designs that have been done by individuals or firms. In addition, it is responsible for making arrangements and exchanging of knowledge with the relevant international organisations, and in particular with WIPO. The second one is the Department of Intellectual Property Rights, which is linked to NBSR. It is responsible for protecting the rights of authorship, publishing, translating, and copyrights. It is also making arrangements and exchanging of knowledge with the relevant international organisations, and in particular with WIPO.

Regarding corporate R&D activities, one can argue that the impact of IPRs is not easy to determine or measure and overall it might not be a big barrier. Recent evidence reveals that many TNCs are conducting some types of R&D activities in countries such as China and India, where IPRs protection is still far from satisfactory (Zhao, 2004: 1). It can imply that this trend is in apparent contradiction of conventional wisdom, which advises firms to keep their knowledge intensive activities away from weak IPR countries. It seems like a puzzle. What has enabled some TNCs to act differently? An attempt has been made by Zhao (2004: 2- 3) to interpret this puzzle. He has found that 'patents developed in weak IPR countries are cited more internally than those developed in other foreign countries. In addition, firms doing R&D in weak IPR countries feature significantly stronger internal linkages among their technologies than those who do not. In other words, internal linkage could allow firms to appropriate value from their knowledge even in weak institutional environments'. His examination comes from an assumption that TNCs may find it desirable to conduct R&D across borders when technologies are complementary internally. He finds that by keeping the complementary resources well protected, TNCs are able to leverage the strong institutions in the home country for their operation overseas. However, he admits that the validity of this strategy depends on a set of firm-specific and knowledge-specific characteristics (Zhao, 2004: 2). At any rate, this cannot mean that it does not matter whether the S&T policy has taken into account the protection of IPR issues or not. The literature on S&T policy suggests that IPRs are very important for innovation and creativity. Overall, they can stimulate R&D and productivity growth by affecting the technical efficiency of production and R&D accumulation.

4.4.5 Libyan industrial policy and economic and technological developments

4.4.5.1 Evolutionary and development of industrialisation

Libya obtained its national independence in 1951, but due to its economic conditions in the 1950s and the early 1960s as one of the poorest countries in the world, there was no ability

to establish any significant industrial projects. Later in 1961, Libya exported its first shipment of oil, and thus, its trade balance tilted towards the positive and its economy gradually started to improve. Then, some small industrial factories were established. The industrialisation plan was modelled largely on the experience of neighbouring Algeria (The World Bank, 2006: 3).

During the 1970s, Libya's industrial policy focused on manufacturing at the start of its significant industrialisation processes, and this sector was given special priority by the government with emphasis upon petroleum and petrochemical industries. The main goal of development was to lay a foundation for industrialisation through the development of import-substitution industries, then the expansion of light industries and support for producer-good industries. As a result, many imported products categories began to decline (The World Bank, 2006: 3). Generally, this pattern of strategies was common practice to nurture 'infant industries' throughout the developing countries (Nabli, *et al*., 2006: 1). With the late 1970s, all important industrial firms were controlled by the Libyan government and a public ownership. All technologies used in those manufacturing firms were imported technologies, with the exception of some limited professional industries (Omar, 2000).

Most technologies applied in the industrial sector were imported from developed countries. Thus, these technologies needed to be adapted to the local conditions. In the early stages, it would be highly expected to have concerns about building STI capacity to use these existing technologies. 'For the most part, this requires developing, engineering, technical, and vocational skills, rather than conducting frontier-level R&D' (Watkins and Ehst, 2008: 5). Indeed, during that period, the government expanded the technical and professional education and training, where several technical institutes established to supply technical graduates to operate those factories and substitute gradually the foreign technical employees. In addition, many students were sent to study abroad in high-technical fields and for vocational and technical training (Stromberg, 1980). This was usually the country of origin from which the technology of the factory was imported. This S&T policy has relatively contributed to gradually reducing the technological reliance upon the foreign partners or the technology suppliers.

In order to promote the industrial sector in the 1970s, the Libyan government issued the Laws No. 24, 25 of 1970 thereby establishing two bodies; The Public Board of

Manufacturing and The Industrial Research Centre. The first one was in charge of the task of the supervision of industrial firms, while providing required services of R&D was among the Industrial Research Centre's responsibilities. In addition, the NOC was established in the early 1960s to supervise the projects of oil and gas production and petrochemical industries sector, while the Oil Research Centre was established to provide R&D services to these projects and train workers on some fields related to the oil and gas industry. As the result of a sharp increase in the oil prices in the mid- 1970s, the Libyan government decided to expand the industry sector, to supply more diversity and high-techno products. From the early 1980s the government's priority shifted towards encouraging the development of heavy industry. Industries such as cement, steel and mining consume huge quantities of oil, but indeed the development of import-dependent heavy industry seemed feasible, as Libya enjoyed cheap energy costs and possessed the foreign exchange to pay for raw material imports (The World Bank, 2006: 3).

An important point which should be mentioned here is that the petroleum and petrochemical industries sector was and still remains under the supervision of NOC, which means that the industrial policy for these industries is usually formulated by NOC. Thus, it might not be in line with the industrial policy targeted in the rest of industrial sectors in the country. This represents missing institutional links, which may result in developing some part of the industry on account of the others. There were weak links between the industrial policy and the S&T policy. Stromberg (1980: 2) demonstrates that for the light industry sector, technical and other specialised education does not at all respond to the needs of the country which is extensively dependent on expatriate staff. Generally, in the late 1980s, beyond the oil and gas industry, the main types of industry were petroleum and petrochemicals, steel and mining, food processing, textiles, handicrafts, and cement. Recently, the non-oil manufacturing and construction sectors have accounted more than 20% of GDP (CIA, 2009). With this extension in industrial areas, to reduce the dependency on foreign staff, the Ministry of Industry has determined to improve the quality of technical education and vocational and technical training-programmes in the country.

Considering the development of industrialisation at the industry level, there has been a shift from less sophisticated technology to more sophisticated technology of product, process, technical knowledge and management. However, they are still fairly limited. It seems that the S&T policy was not linked to the industrial policy. Some observations

during the late 1980s can confirm this. It is well known, for example, that the teaching of the foreign languages such as English, French and Dutch were forbidden in the academic institutions at all levels of the educational system. This means that whole generation of students have graduated from S&T schools and technical institutes with limited or no knowledge of these foreign languages. However, they have been appointed in different industrial sectors, where most, if not all of the operational technologies in these sectors have been imported from countries speaking these languages. Thus, one could imagine how they dealt with these technologies. The effects of this issue have continued for some years. In general, the education system does not provide the professional skills that are required to drive the industrial sector and other economic sectors (Porter and Yerign, 2006: 4). This reflects the negative effects of government policy.

Given that the industrial policy adopted by the Libyan government can be simply explained to diversify its income and exploit oil revenues effectively. During the 1970s and 1980s the Libyan industrial policy focused upon diversification into different industries with a vertical expansion in petroleum and petrochemical industries (Al-Magpoob, 1995: 11). However, because of the USA (1986- 2004) and UN (1991- 2003) sanctions, Libya was economically isolated for several decades, and the industry sector was influenced by these sanctions, for example; no new technological equipment could be obtained, and the collaboration with foreign enterprises in technological activities was seriously limited. In the 1990s, the Libyan economy was seriously affected by a critical shortage of spare parts and lack of access to raw materials and new technologies, which imposed serious limitations upon Libya's industrial infrastructure (The World Bank, 2006: 5). These conditions have contributed to making the Libyan industrial base insufficient even to cover local market requirements in some phases.

It has been noted that the Libyan S&T policy and its integration into economic policies (including the industrial policy) was low on its agenda (Djeflat, 2002: 5). This was even though the Libyan government adopted a strategy of R&D established on a comprehensive perspective of the vehicle of industrial R&D activities, which linked it to all scientific and technological systems in the country (Ben Al-Ashhar, 1994). Thus, the best interpretation for this situation is that the linking tools and communication channels between these bodies were not very strong (Omar, 2000). Indeed, Libya was and still claims to be highly dependent on foreign sources of technology for industrial development. The reality demonstrates, for example, that due to Libya's technology leverage strategy from TNCs,

Libyan's oil industry in its early stages relied almost exclusively on foreign companies and even after the nationalisation of foreign oil companies in the late 1970s, this industry has been relying on a big part of specific technological support from foreign partners.

After the sanctions were lifted, Libya began to open up to the global economy, privatisation began to take place and FDI was encouraged with investment in all industrial sectors. The industrial policy has been directed to transforming the industrial structure into one based on comparative advantage, to developing technology-intensive industry, such as machinery and electronics, which in the past were mostly assembly industries (MIEM, 2006). Another important point that should be mentioned here is that several industrial firms have begun to establish their own labs to meet the growing need for technology development. Although it seems reasonable, according to the current S&T policy and its implementation mechanisms, Libya may face some challenges with regard to the industrial policy and industrialisation strategy. These challenges are weaknesses of the national industrial entrepreneurial community, limited local technological capacity in industrial sectors and the lack of management expertise. This is especially because the current S&T and industrial policies do not pay sufficient attention to these issues (see NBRD, 2001; MIEM, 2006). Evidence strongly suggests that the ability of any industry to compete alike in the global or local markets, is often significantly dependent upon a continued strong investment in scientific knowledge and technology and with well managed R&D. In this context, reviewing the annual financial reports of Libyan industrial firms reveals that the investment in R&D activity within most Libyan industrial firms was very low or hardly existed (MIEM, 2006).

An overview of the recent industrial policy reveals that to some extent it has been considered the approach of horizontal industrial policy, such as fostering R&D activities within the industrial firms and enhancing relations between the universities and industrial sectors. However, despite the limitation of these figures, the implementation of the recent industrial policy has failed to achieve satisfactory levels on these aspects. This can be supported by indicators provided in Tables 4.8 and 4.11. Thus, one can conclude that in order to develop and diversify the manufacturing sector, the Libyan government should adopt the whole elements of horizontal industrial policy and link the industrial policy to the S&T policy, so they can go together along the same lines to respond to the economic development needs and changing market conditions. Overall, horizontal industrial policy can contribute to build a strong NIS.

4.4.5.2 The role of industry in the recent economic growth and development

Considering the Libyan level of industrialisation, the degree of export orientation of the manufacturing sector, and the contribution of manufacturing to total exports, it has resulted in that the contribution of the industry sector (except petroleum sector) in GDP is very low. Even though the annual real GDP growth rate seems to be good, this has been attributed to non-mining and manufacturing sectors and basically to the oil and gas industry sector. For example, in 2007, the dependency of the Libyan economy on exports of oil was 96.9% (UNCTAD, 2007b: 87). The Libyan economy is heavily dependent on revenue from extracting and selling natural resources, rather than creating products and services through investment and innovation (Porter and Yergin, 2006: 10). Table 4.14 provides a more detailed overview of major macroeconomic indicators during the recent years (the latest year for which figures are available):

Table 4.14 Libya: Sectorial distribution of GDP at current prices (2001- 2007)

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Real GDP growth rate (in percent)	-4.3	-1.3	13.0	4.4	9.9	5.9	6.0
In millions of Libyan dinars (LD)							
GDP at factor cost	18.745	26.887	33.077	43.067	60.040	80.730	96.701
Oil sector	7.450	14.916	20.673	29.259	44.507	58.358	69.275
Non-oil sectors	11.295	11.920	12.403	13.808	15.523	22,372	27,426
Agriculture, fishing, and forestry	1.392	1.349	1.376	1.440	1.527	1,643	1,905
Mining	307	387	360	418	459	---	---
Manufacturing	878	813	765	761	794	898	1,162
Electricity, gas, and water	285	294	303	334	379	973	1,019
Construction	1.063	1.342	1.249	1.450	1.648	3,129	4,198
Trade, hotels, and restaurants	1.882	2.090	2.205	2.418	2.859	2,770	3,296
Transportation, communication, and storage	1.299	1.429	1.518	1.641	1.950	2,635	3,202
Financing, insurance, and business services	337	415	440	477	584	790	952
Housing	499	515	534	592	665	4,491	5,065
Public services	2.901	2.859	3.205	3.800	4.149	4,984	6,560
Public services (except education and health	1.301	1.282	1.437	1.704	1.861	4,773	6,315
Educational services	1.035	1.020	1.143	1.355	1.480	---	---
Health services	566	558	625	741	809	---	---
Others	411	428	451	477	539	620	690
In percentage of total for some sectors							
Oil sector	39.7	55.6	62.5	67.9	74.1	72.3	71.6
Mining	1.6	1.4	1.1	1.0	0.8	---	---
Manufacturing	4.7	3.0	2.3	1.8	1.3	1.1	1.2

***Source**:* Based on (IMF, 2007: 4; IMF, 2008: 4; IMFa, 2009: 21; IMFa, 2009: 195).

The macroeconomic trends presented in Table 4.14 show that Libya has experienced sustainable economic growth in recent years. GNP, for instance, increased from LYD[1]

[1] The exchange rate average in recent years is 1 LYD = 0.50 GBP

18.745 million in 2001 to LYD 69.701 million in 2007. Since 2000, this real GDP growth has been boosted by high oil revenues, reaching 4.4% in 2004 and 6.0% in 2007. Thus, the main challenge for Libya is to promote growth of the non-oil sectors and improve the diversification of its economy (The World Bank, 2006; Porter and Yerign, 2006). However, despite efforts to diversify the economy and encourage private sector participation, data presented in Table 4.14 shows that hydrocarbon industries accounted for a high ratio of the Libyan economy. Thus, one can expect that diversification of the economy into the manufacturing industries would remain a long-term issue.

Indeed, the relevant data in Table 4.14 can demonstrate moderate industrial growth, made the stagnation in the GDP share of manufacturing component, largely associated with the increased share of the oil sector. Even after the reform policies, and following the adoption of free market policies, the manufacturing share in GDP was virtually unchanged (in real terms) during 2004 and the later years. In fact, data shows the decisive importance of the construction sector, which has been the real - and perhaps the only - engine of industrial expansion. The growth of construction is better than the growth in mining and manufacturing sectors after 2004. However, it can be noted that the overall contribution of the industrial sector (without the oil sector) to GDP is still very small, where the oil sector dominates the big share of contribution to GDP even after the reform of the economy. 'It seems that the Libyan regime is not even committed to introducing the reforms necessary to create a vibrant diversified economy and the changes that have been made appear to be largely cosmetic' (Pargeter, 2006: 220). Thus, in spite of the overall picture showing that the industrialisation process in Libya is not on the right trajectories, it would be a mistake to think that industrialisation will fail in Libya. There are potentials of remarkable achievements in the petrochemical industries sector, setting stage for renewed developmental industrial policy, which must take into account building a strong technological capability in this sector and upgrading the existing one, as it already has reasonable experience in this field (Porter and Yerign, 2006).

On the basis of Libyan situation, one can conclude that this continual growth could attribute to the continual increase of oil prices rather than anything else. Therefore, to achieve sustainable growth, R&D and innovative activities should gain in importance as a way of sustaining the country's economic growth. According to the economic point of view, the main source of growth has been determined by Carneiro (2007: 51) as follows:

1- *Technological improvement- this type of improvement means that new and better methods of producing goods are possible. Moreover, it is well known that process and technology improvement can contribute for meeting quality and process-performance objectives.*
2- *An increase in the quality of capital- very often, technology is deeply liked to investment because it is embodied in new machinery and better equipment.*
3- *An increase in the number of workers, their skills and educational levels.*

Accordingly, improving the manufacturing sector plays a vital role for growth. This leads us to address that the industrial policy must target these dimensions, and be linked to the S&T policy with an aim to pushing manufacturing activities progress further. In such case, there should be an increase in the technology absorption level, including an increase of investments in S&T, infrastructure development, skills enhancement, and improving management processes. Indeed, evidence suggests that stimulating the absorptive capacity of firms will result in improving their technological capability and productivity, which will impact on the growth of GDP.

The Libyan government has recognised that Libya's economy can no longer rely only on producing oil for its present and future economic development. Libya's most recent economic policy thus aims at the growth of economic activities beyond the oil production to include contribution from production and services sectors. This new policy stresses that an emphasis should be placed on fostering R&D activities within the industrial firms (MIEM, 2006). Generally speaking, it can be assumed that if this policy had strong support and good implementation, it would hope to contribute to better economic growth. In this regard, evidence suggests that to position strongly for future growth in the global marketplace, industrial firms have to make some effort to increase their investment in R&D and to focus upon the implementation of advanced production innovations and practices (Carneiro, 2007). However, in Libya, with weak technological capabilities, there are several challenges. The main problem would be that some firms are unlikely to set up R&D activities in the lack of local capabilities and technical skills to absorb, adapt and develop technology and know-how.

It has a widespread acceptance that the effective industrial policy can be fundamental to economic growth by creating a productive capacity. Based on this approach, other observations can demonstrate some matters surrounding the industrial development in

Libya. Indeed, although the recent economic strategy aims at the growth of economic activities beyond the oil and gas production sectors, it has been noted that industrial policy in Libya has not highly succeeded in building a more diversified economic structure (OBG, 2008). This includes, for example, building new backward and forward linkages across the economy, even in the petroleum and petrochemical industries sectors, where Libya has a comparative advantage. Thus, the impact of industrial policy on diversification was very weak. Moreover, although some industrial zones have been established, this was without considering the idea of industrial clusters. This has led to absence or minimising of possible benefits from exchange of information, transformation of tacit knowledge about business formation and product development and others.

Furthermore, the industrial policy has not addressed the channels that firms can support innovations. Overall, one can conclude that at the current rate of growth in non-oil manufacturing sector and the relevant industrialisation level, there would be a limited role that can play by this sector. This is in terms of both, transferring technological knowledge and supporting to build and upgrade the local technological capability. Several reasons have contributed to the failure of the industrial policy in Libya. For example, impact of sanctions on technological equipments, negative government policies such as forbidden foreign languages, weaknesses in the education system, Soviet-style of control planning, and poor coordination between S&T and industrial polices. This situation made negative consequences for attracting FDI involving R&D. It is especially that all recent changes can not reflect genuine attempts to reform the Libyan economy; rather they are simply window dressing aimed at regime survival (Pargeter, 2010).

4.4.5.3 Overview on the recent development of FDI

As the result of some negative observations of the Libyan economy performance during the1990s, the Libyan government began enacting various laws in the late 1990s, and this process has steadily continued since that time. The most important law dealing with foreign investments is the Law No. 5 of 1997. This law together with its amendments and implementing regulations created a liberal legal framework for attracting FDI. A part of this law states that:

'Imported machinery, tools, equipments, spare parts and raw materials are exempt from all duties and taxes for a period of five years; projects are exempt from income tax also for a period of five years, which can be extended for a further three years; exported goods are exempt from all taxes; no stamp duty is imposed on commercial documents in connection with the project; net profits and

dividends are freely transferable; expatriate personnel can be freely employed in the absence of Libyan substitutes; long term leases for land for production facilities are available; bank accounts in convertible currencies can be freely opened; ownership of project may be transferred in whole or in part to another investor; and the investor can freely re-export his/her invested capital' (DCCI, 2005: 5).

In addition, this law provides the opportunity for 100 percent foreign equity ownership of companies licensed under the law (Otman and Karlberg, 2007: 69). Further, this law has been enhanced by the resolution No. 21 of 2002 regarding encouragement of FDI, which includes detailed regulations covering the application of Law No. 5. Therefore, the FDI inflows into Libya have been stimulated and there has been recently remarkable competition among foreign investors, mainly in the oil and gas industry. Indeed, during the period 1995- 2005, the share of TNCs in the oil and gas industry in Libya rose particularly fast from 14.5% to 34.7% (UNCTAD, 2007b: 106).

As its objective is to be among the world's leading investment destinations, Libya is at an advanced stage of restructuring its administration establishments, and has been reviewing its investment laws and regulations. In this regard, Libya has reorganised several establishments which include, among others, an investment promotion authority, new R&D centres, an environment protection authority, a health services development authority, an industrial promotion and development board, and a labour force secretariat. All these steps have come to reflect the development in the institutional structure within which FDI and industrial policies can be promoted. In this context, evidence suggests that FDI attraction policies are part of industrial and development policies, and should not be assessed or used in isolation (Zanatta, *et al*., 2008). Generally, Table 4.15 shows FDI inflows in Libya during the recent years as compared to some Arab countries:

Table 4.15 FDI inflows for some Arab countries (million USD)

County/ Years	2001	2002	2003	2004	2005	2006	2007	2008
Algeria	1196	1065	634	882	1081	1795	1665	7651
Egypt	510	647	237	2157	5376	10043	11578	10900
Jordan	180	122	443	816	1774	3219	1835	2400
Lebanon	1451	1336	2977	1993	2791	2793	2845	2200
Morocco	2808	481	2314	895	1653	2450	2577	2400
Syria	110	115	180	275	500	600	885	1563
Tunisia	7242	2278	1283	1540	7281	3312	1618	1740
Libya	-113	145	143	357	1038	2013	2541	4501

Source: (Abdelkrim and Henry, 2009: 18).

Table 4.15 shows that the overall state of inflows FDI in Libya is growing, especially after 2003, as sanctions were lifted and the policy of economic reform was implemented.

Significant improvements in conditions for FDI and scale of FDI can be realised since 2004, and it is clear that since 2007 the increase rate was very remarkable and has exceeded most of the countries mentioned. It is just Egypt, the country that was higher than Libya across all comparative years. Thus, although FDI inflows are still small on a scale, however, it seems that Libya significantly establishes itself on the world level with regard to FDI attraction.

Given that Libya has already planned to increase the size and variety of FDI inflows into it, and if it implemented the planned developments wisely, it would have a large potential to become a major FDI attractor (DCCI, 2005: 5). Thus, analysing the distribution of these FDI inflows is significant in this context. It can give an indication that demonstrates the nature of technological knowledge spillover that may be associated with it, as it depends upon the technological level of an industry sector. In this regard, it has been mentioned that during the last years, most of FDI inflows into Libya is largely concentrated in the energy sector, and mainly in the oil and gas industry. Porter and Yerign (2006) indicate that the distribution of FDI is heavily skewed towards energy. Their estimation indicates that in 2004, 80% of FDI went to the energy sector and the remaining 20% to other sectors of the economy (Porter and Yerign, 2006: 35). In 2008, the share of this sector was 12 FDI projects out of 27 (Abdelkrim and Henry, 2009: 64). Generally, notable trends show that international investors are rushing into the Libyan market, which is developing at a very high speed, after a whole decade of trade embargo. Indeed, Libya is North Africa's largest oil producer and has more proven reserves than any other country in Africa, with 3.3% of the world's total. A report form OBG (2008) confirms the investment' trends, as it indicates that since 2003, four exploration bidding rounds have been held, production has been boosted by 25%, large investments have flown in and international oil companies have been battling to return to the country at any price. Porter and Yergin (2006) point out that until 2005, there was a limited presence of the famous TNCs outside the resource extraction industries.

Overall, the oil and gas industry has accounted for the largest share of FDI in Libya, where for example in 2007, the main forms of TNCs contracts in this industry were, 80.5% production sharing and 19.5% concessions or joint venture (UNCTAD, 2007b: 108). A study by Abdelkrim and Henry (2009: 64) reveals that the origin of investments inflow into Libya are from different countries (developed and developing countries), but for example, in 2008, the three largest foreign investment in Libya were from Western businesses.

Unfortunately, 'Libya still has a long way to go to really upgrade its economy and to make the country attractive to foreign investors outside the energy sector' (Pargeter, 2010: 10).

Given that foreign investors' focus is on the energy sector. Thus, this may have limited the upgrading of the rest of the Libyan economy. The possible technical knowledge spillover would not benefit all industrial sectors. The chances of R&D collaboration are more likely to be among the oil and gas industry sector and other relevant areas. This can lead to some policy implication for enhancing and upgrading the technological capability as well as domestic R&D capacity. This is in order to attract foreign companies to collaborate in and fund R&D projects. Overall, the Libyan government should adopt a horizontal industrial policy and linking it with the S&T policy for enhancing and upgrading the technological capability and domestic R&D capacity of other industrial sectors, so that they may be able to compete and attract FDI involving R&D in those sectors.

4.4.6 Challenges for Libya as a non-traditional R&D location

Despite the efforts of the recent S&T policy in Libya, challenges remain on the way to more R&D activities. Since Libya has a short industrial history and limited industrial base, and with current industrial policy, it faces the challenges of a smaller industrial R&D scale compared even to some countries in MENA (NBSR, 2001). It also has a weaker technical capability since the Libyan economy was mostly based on producing oil, mostly by foreign firms, rather than producing other high-add value products in partnership for example. Even in the oil and gas industry sector, with NOC's experience for more than 40 years, the overdependence on foreign technology is clearly noticeable in most operational processes. In this context, as has been illustrated in previous sections, there seems to be several challenges Libya's transition might face towards more intensive R&D activities. These challenges may include lack of entrepreneurship and creativity, the limitations in building strong NIS, and insufficient local human resources specialising in R&D fields.

4.4.6.1 Lack of entrepreneurship and creativity

The role of entrepreneurship and creativity in enhancing the economic development has been widely recognised by scholars and policy-makers. Porter and Yergin (2006: 3) advise Libya to find ways to balance between inherited wealth, which is dependent on natural resources, and created wealth, which is dependent on the ingenuity and innovation of the country's entrepreneurs. Recently, in response to the economic needs and changing market conditions and the process of reforming, the new Libyan Economic Development Board

(LEDB) was established in 2007 to spur and promote domestic entrepreneurship. Among its tasks, 'setting up a series of business advisory centres for prospective entrepreneurs, developing an effective loans vehicle for SMEs, and undertaking information and awards campaign to recognise successful entrepreneurs' (Porter, *et al.*, 2007: 172).

However, the lack of entrepreneurship and creativity in Libya can be seen in several phases. This is often at all levels; individuals, groups and firms. The recent indicators reported in the global competitiveness reports can demonstrate this gap (see Porter, *et al*., 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201). Furthermore, even with the assumption that some entrepreneurial activities exist, they are often not being directed toward productive ends conductive to economic progress. There are many factors that might contribute to these situations and conditions. For example, reviewing of the recent S&T and industrial policy reveals that the Libyan government does not provide a variety of support and incentives, including tax and financial aid to private enterprises, in order to accelerate industrial technology innovations. In other words, there is no policy measures aim to stimulate the R & D activities of private industries (see NBSR, 2001; MIEM, 2006). This can be linked to the consequences of Soviet-style control planning adopted and the state ownership to all institutions in the past. In addition, although the recent S&T policy has made efforts to enhance the awareness on S&T among youth and the general public and foster a healthy culture of S&T as well as innovation (NBSR, 2001), but, to date, there are no significant achievements in this regard. For example, there is no a corporation of civil community represents this level of awareness such as Libyan R&D community. If anything, there are some S&T associations, which represent a membership of professionals in some scientific or engineering fields.

Given that the technology management has grown over the last 20 years as a field within business schools in response to the growing importance of technology to the strategy and operations of firms. In this context, another dimension can reflect the level of awareness of innovation and creativity culture. This is at the academics and academic institutions level. For example, though the fact that, 'in the majority of institutions of management education, the topic of R&D management usually tends to occupy a very narrow and rarefied niche which occasionally gets sharper and more insightful in case studies published by consulting firms' (Ganguly, 1999: 9), in Libya, the situation is extremely limited.

From my experience in the academic field in Libya, one can confirm that in all Libyan business and management schools, there are no academic courses on the subjects such as (Technology Management, Innovation Management, R&D Management, Economics of S&T and S&T Policy) being taught and if any it is just with little related knowledge. There are limited curricula in the Libyan universities, which focus upon courses refering to Enterprise and Entrepreneurship. This can be noticed even in the postgraduate level, where many Libyan students obtained an opportunity to study at international universities for masters and doctoral degrees. For example, the search on the website of the UK theses – which includes all theses that have been approved by the UK universities-, indicates that although there are many theses in business, economic, and management fields written by Libyan students, there were none relevant to these academic disciplines until the end of 2009. Thus, one of the main challenges in conjunction with promoting the innovation and creativity is how to metamorphose Libyan business schools to be able to keep up with these intellectual fields and the rapid technological changes that drive business.

4.4.6.2 Limitation to building strong national innovation system

The processes of building a strong NIS take a long time and allocate huge resources, human and fiscal, with adequate plans and coherent policies as well as institutional improvements at all levels of the country. In this context, Aggarwal (2001: 225) stresses that four conditions need to be satisfied for building an effective NIS:

- Strong competitive pressures on domestic firms.
- The presence of high-quality human capital.
- Well-developed industry-institutes-academia linkages.
- Access to foreign technologies.

According to the available indicators that have been presented in the last sections, which are relevant to building NIS, one can conclude that Libya at this stage of its development has failed to evolve an appropriate mix of these critical ingredients. This has been caused by many reasons, economic, political, social and cultural, as well as structural and institutional. Considering given information in Section 2.3.4 regarding the requirements and conditions to produce a more systematic and effective NIS, recent available indicators reveal that Libya is at a low level with regard to these requirements and conditions (see Porter, *et al*., 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201; MBRF, 2009: 190, 193, 198).

Given the fact that conducting a comprehensive evaluation of the effectiveness of NIS needs reliable data from different sources, for Libya, it is not easy due to the lack of detailed and reliable data. However, these available indicators and other implications that have been deduced from observation and examples provided across the discussion in the case of Libya can make sense. Thus, one can conclude that Libya has to strongly improve institutions at different levels for the road it can travel toward building an effective NIS. This is a big challenge and it may already, in a broad sense, include other challenges mentioned. Indeed, relevant trends have shown that NIS in Libya suffers from many deficiencies. These deficiencies are mainly a lack of high quality of human capital, which was as a result of a weakness in the education system and professional training programmes, poor coordination between S&T, industrial and FDI policies, an absence of adequate goals and plans for research projects and programmes and weak mechanisms to implement these plans, weak linkage between the industry and research institutions, weak institutional frameworks and legislation laws to organise and manage the research and innovation processes at the macro and micro level. Additionally, the banking system in Libya needs a lot of improvements to be able to respond to the requirements of funding such R&D activities (Pargeter, 2006). Overall, these limitations and weaknesses reflect that the problem includes in its both weaknesses in institutions and weaknesses in links between institutions. Generally, these aspects and others have made Libya lag behind in terms of the innovation performance in general and the capacity for innovation in particular (see Table 4.12).

4.4.6.3 Insufficient local human resources specialising in R&D field

Given that the Libyan economy is already in the process of overcoming some of the barriers which have been mentioned, it is thus very likely that Libya will increase its efforts in strengthening R&D and other innovation activities in the next decades (Kocker, 2007). However, since Libya will only have limited R&D capabilities (if it cannot attract foreign talents mainly scientists and engineers) due to the small Libyan population even in the near future, one can expect that those efforts might not succeed if they do not consider this limitation. Further, brain drain influence can make the situation more critical. Libya, as most of Arab countries, has suffered relatively from the brain drain that includes even professionals and highly-qualified individuals (MBRF, 2009). Table 4.16 shows the rank of Libya at the international level regarding the brain drain:

Table 4.16 The rank of Libya regarding brain drain phenomenon

Years	2007 **(out of 128 countries)**	2008 **(out of 134 countries)**	2009 **(out of 133 countries)**
Ranking	91	73	95

Source: Based on (Porter, *et al*., 2007: 171; Porter and Schwab, 2008: 219; Schwab, 2009: 201).

Table 4.16 shows that Libya can be considered among the countries with a significant level of brain drain, which means that it has a serious problem in retaining its skilled manpower. Thus, this can be a general indicator that its labour market efficiency will be affected by brain drain. This should raise the importance to be placed on its policy agenda of S&T policy, especially that the recent S&T policy does not give sufficient concern to this issue. Recently, there has been new phenomenon which represents the leaking of local high-skilled employees into TNCs' subsidiaries in Libya. This is in the oil and gas industry sector especially. Although one could argue that this will contribute somehow to transferring knowledge from these companies to local business environment in the long-term and develop skills of local talents. However, in the short-terms it may relatively affect the capacity of human resources. Several reasons may create this phenomenon. In this regard, Cappelli (2008: 78) argues that the main reason good employees in general leave an organisation is that they find better opportunities elsewhere. Thus, this makes talent developments a perishable commodity.

Furthermore, Libya ranks at a good level of the availability of scientists and engineers, but it is just a small number of scientists and engineers working in the field of R&D compared to some other Arab countries. It may reflect the indicator of brain drain or the low quality of these figures. This can be one of the causes and consequences of the current condition of Libyan NIS. Generally, one of the recommendations has been provided by Kocker (2007) that transnational R&D co-operation with other Arabic neighbour countries might be an appropriate solution to develop the Libyan NIS beyond this bottleneck.

4.5 Conclusion

This chapter has focused upon the determinants of technologically underdeveloped countries, where the central term, other relevant debates and attempts to categorise countries on a technological scale have been discussed. Based on applying classifications provided by these attempts, the position of Libya on the technological scale is among the countries that have a low score in many relevant aspects. Thus it is safe to conclude that Libya is located in the category of technologically underdeveloped countries.

The findings demonstrate that the intensity of R&D activity in Libya is at a low level, even in comparison to some countries in The MENA region. The technological capability and domestic R&D capacity in Libya are at low levels, where NIS suffers from several significant deficiencies. These conditions have resulted in limited capacity for innovation and limited technology transfer by FDI. From a policy perspective, Libyan economic and industrial policies have failed to diversify the economy with GDP still dominated by the oil industry. Policies have failed to build a strong technological capability at both micro and macro levels, while FDI policy has failed to attract significant FDI involving R&D. The implications derived from relevant aspects about Libya suggest that several possible obstacles may hinder the R&D globalisation process in Libya. These mainly represent a weak NIS, and they include, for example, a lack of human resources, a limited capacity for innovation, a weak IPR system, weak institutional frameworks and mechanisms and the low level of technological readiness. Overall, based on these observations, one can conclude that the pretended reform process in Libya in terms of the technological capabilities seems to be extremely a chimera rather than reality.

Chapter Five

The Context of the Practice of R&D Activity in Libya

5.1 Introduction

This chapter presents and discusses the findings of the empirical study that was undertaken to investigate the aspects of the practices of R&D activity in Libya. They are based on a questionnaire survey of 10 Libyan public owned organisations, illuminating the conditions in which R&D activity is organised and how it is managed in reality. It also demonstrates the aspects of collaborative R&D activities within these organisations and discusses the significant obstacles that have been hindering the practice of R&D activities and the collaborative R&D processes. These issues are discussed with references to 5 research centres and 5 industrial firms, where 3 relevant managers at different levels provided data (30 respondents in total), (for more details, see Section 3.7). This is in order to achieve the aim of investigating the principal obstacles that face the R&D internationalisation process in Libya as well as identifying the nature and patterns of corporate R&D activities that are conducted there and evaluating the capability of R&D activities.

5.2 The characteristics of the researched organisations

In this section, an attempt is made to classify the 10 organisations studied according to the level of R&D sophistication. Several important variables are employed. Table 5.1 shows the organisational description of these organisations.

Table 5.1 The organisational description of the organisations studied

The characteristics of organisations								
No	**Age**	**Area of work**	**Size**		**Targeted market of prod./serv.**		**Obtaining ISO certificates**	
			No. of workers	Capital (LYD m)	Local market	Global market	Type	Years
Technological and research services sector								
1	37	Agricultural and animal research	557	19	√			
1	38	Industrial R&D and benchmark	450	152	√		17025, 9001	2008
1	32	Petroleum research	550	156	√	√	17025	2006
1	35	Renewable energy and water desalination	1800	240	√			
1	31	Biotechnology research	320	156	√			
5	**Total**		3677					
Manufacturing sector								
1	32,	Electronic and telecoms industry	1800	198	√		2000	2000
1	25	Chemical industries	423	270	√		9001, 2000	2006
1	31	Assembling of heavy equipment	154	7.5	√		9001, 2000	2008
1	25	Electrical engineering industry	640	175	√	√		
1	27	Motor vehicles and trucks industry	1000	196	√		9001, 2000, 14001	2004
5	**Total**		4017					

It can be seen from Table 5.1 that variables employed include: area of work, age and size of organisation, marketing level, and obtaining of ISO certificates. Based on relevant data,

the selected organisations are well established and cover several important sectors, which should be involved in significant R&D operations. Their characteristics and reflections are presented in the following subsections.

5.2.1 The age of organisations studied

It can be seen from Table 5.1 that 7 organisations, which represent 70% of the sample, have been established for more than three decades, and the other 30% for more than two decades. This reflects that these organisations have a significant history of operations in their fields that could give them the knowledge accumulation and technological experience required to build a strong technological capability and high absorptive capacity. In comparison between two categories in terms of their main activities and ages, the research centres might be at a higher technological development stage than industrial firms.

5.2.2 The size of the organisations studied

The size of organisation was measured by two elements; capital and number of employees. The current capital of the organisation reflects its size and the ability to pursue costly activities such as R&D activity. Thus, it can be noted from the Table 5.1 that the current capital of the organisations is above LYD 100 million, where 6 organisations, which represent 60%, their current capital is between LYD 151- 200 million, and two of them have over LYD 200 million. This reflects that these organisations are large and their activities have a significant role in the development of the national economy.

Another element which reflects the size of the organisation is the number of employees. Table 5.1 shows that 8 organisations, which represent 80% of the sample, the number of employees in each are more than 500. This is a significant number, especially for the research centres, where 60% of them have more than 500 employees. Overall, it can be said that this indicator is in line with the current capital, as they are both reflecting the large size of the organisations studied.

5.2.3 Marketing the outputs of organisations

The targeted markets indicate the nature of the competition that the organisations might face. With consideration to the nature of Libyan economy and its current development stage, the Libyan organisations expect to have some levels of competition in the local market. In this context, Table 5.1 shows that 8 organisations, which represent (80%), only marketed their products in the local market. Moreover, there is a similarity in this situation

for both research centres and industrial firms. Thus, it can be concluded that the majority only produce for the local Libyan market. Given Libya's relative isolation during sanctions period, it is expected they will be limited technologically. Meanwhile, according to this indicator, one can expect that these organisations may in general lack the ability to produce advanced products and services through the entire developmental process and market them worldwide. This might lead them to seek out licensing and collaborative deals with TNCs in different developmental terms. Another relevant issue which can be seen from Table 5.1 is that six organisations do not get ISO certificates. This may partially explain why the organisations are still marketing their outputs in the local market. Overall, these conditions may have also had an effect on attracting outsourcing or cooperative R&D activities.

5.3 The level of attention to R&D within Libyan organisations

This section demonstrates the level of attention to R&D activity at the micro-level. In order to highlight this level, two main dimensions have been chosen to reflect this attention; the organisational and financial aspects to the R&D activity.

5.3.1 The level of organisational attention to R&D

Table 5.2 shows that 70% of these organisations have a separate organisational unit for fostering the practice of R&D activity.

Table 5.2 The existence and age of separate R&D unit within the organisations

Existence of separate R&D unit (n= 10)							**Age of R&D units (n= 7)**					
	Yes		No		Total		1- 5		6- 10		11- 15	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Research centres	3	60	2	40	5	100	2	67	1	33	0	0
Industrial firms	4	80	1	20	5	100	0	0	2	50	2	50
Total	7	70	3	30	10	100	2	28.5	3	43	2	28.5

This indicates the significance of R&D activities within these organisations or their intention to expand conducting this activity. However, the ages of R&D units within 71% of these organisations are not more than 10 years. This reflects the late recognition of the role of R&D activity in their operations and, in general, the situation of Libyan economic environment in the past, where there was limited or no competition faced by these organisations. However, there is a tendency to grow the development of R&D activity within the Libyan organisations. Two thirds of respondents whose organisations do not have a separate R&D unit, expect to establish one in the near future.

Beyond this tendency, another indicator can demonstrate the organisational attention to R&D and its capacity within these organisations. Accordingly, Table 5.3 shows the size and distribution of R&D staff within the organisations studied:

Table 5.3 The distribution of R&D staff within the organisations

Components of R&D staff	Scientists & Engineers		Technicians		Officers and others		Total number of R&D staff	
	No.	%	No.	%	No.	%	No.	%
Research centres	298	27.5	721	67	62	0.05.5	1081	70
Industrial firms	105	22	308	65	59	13	472	30
Total	403	26	1029	66	121	0.08	1553	100

It is logical that different kinds of organisations need different kinds of technological capabilities. In addition, basic research, applied research and development need different kinds of R&D staff. While basic research tends to need more scientists, applied research needs engineers and development activity needs more engineers and technicians. In this context, it can be noted from Table 5.3 that in all the organisations studied, the technicians represent about two thirds (66%) of the R&D staff, while the number of scientists and engineers represent just 26%. This suggests that these organisations suffer from a lack of scientists and engineers. Based on linking the total number of R&D staff with the size of workforce in these organisations in Table 5.1, this number represents just 29% in research centres and 18% in industrial firms. These low levels indicate weaknesses in the supply of labour, which may reflect the absence of a strong scientific and technology community. Overall, this reflects the failure of NIS in providing specialised human resources. This finding goes in line with trends mentioned in Chapter Four. At any rate, this situation would result in making the outputs of R&D activities from these organisations to be more limited to activities related to the development phase. Through all indications mentioned in this subsection, one can conclude that it shows the lack of technological capability and it is in line with what we can expect based on trends from the previous chapter.

5.3.2 The level of financial attention to R&D

The level of financial concern to R&D activity can be seen from several aspects, but the most important ones are the amount of money spent on R&D and the manner by which these amounts were allocated. Table 5.4 shows relevant aspects within the organisations:

Table 5.4 The existence of independent budget expend on R&D and its efficiency

(n= 10)	Existence of independent budget for R&D activity						Budget sufficient for requirements of R&D activity					
	Yes		No		Total		Yes		No		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Research centres	5	100	0	0	5	100	1	20	4	80	5	100
Industrial firms	3	60	2	40	5	100	0	0	5	100	5	100
Total	8	80	2	20	10	100	1	10	9	90	10	100

It can be seen from Table 5.4 that while all research centres allocate independent budgets to expend on R&D activity, 40% of industrial firms do not allocate such budgets for this activity. This is a primary indicator of how these firms look at the importance of business

R&D activity. Generally, despite the manner by which the organisations expend on R&D activity, the majority of organisations suffer from a lack of expenditure on R&D. Indeed, 90% of organisations do not allocate sufficient amounts to finance R&D activity. This can reflect the low level of attention to R&D. This confirms the trend presented in Table 4.11 regarding company spending on R&D.

5.4 The nature of R&D practice within the Libyan organisations

This section highlights the significance of R&D activities within the organisations studied, focusing upon the nature of these activities, the consequences for the level of development in these activities, and their capacity for innovation.

5.4.1 Types of R&D activities

Different organisations may undertake different R&D activities. In this context, Table 5.5 shows the type of R&D activities carried out by the organisations studied:

Table 5.5 The types of R&D activities conducting within the organisations

Type of R&D activity (n= 10)	Basic research		Applied research		Development	
	No.	%	No.	%	No.	%
Research centres	4	80	5	100	1	20
Industrial firms	0	0	2	40	5	100
Total	4	40	7	70	6	60

As can be seen from Table 5.5 that 80% of research centres carry out basic research, in contrast, industrial firms do not undertake this type of R&D activity, which is what one would expect. In addition, while all industrial firms conduct development processes, only 20% of research centres carry out such processes. Further, all research centres carry out applied research, where as 40% of industrial firms undertake this type of research. Thus, the findings are in line with the literature review. Industrial firms tend to focus upon the development side, while research centres often focus their activities upon the research side. More precisely, looking at the nature and phases of R&D activities in the organisations studied is significant in this context. Table 5.6 demonstrates these aspects:

Table 5.6 The nature of R&D activities practiced by the organisations

Types of research activity (n= 30)	Research centres		Industrial firms		Total	
	No.	%	No.	%	No.	%
R&D for improving products	6	40	12	80	18	60
R&D for improving methods of production and industrial processes	5	33	12	80	17	56.5
R&D for an attempt to use alternatives to current raw materials	7	46.5	5	33	12	40
R&D related to attempts to innovate new products or new processes	4	26.5	3	20	7	23
R&D for overcoming technical problems	12	80	11	73	23	76.5
R&D for doing modifications to tools or machines that have been used in the productivity operation	5	33	3	20	8	26.5
R&D related to the benefits from recycling materials	15	100	3	20	18	60
R&D related to technology transfer	14	93	12	80	26	86.5

The data in Table 5.6 shows that significant R&D has been undertaken by research centres related to overcoming technical problems, recycling materials, and technology transfer. Most of these R&D activities can be linked to applied research or development side. Thus, despite the fact that 80% of respondents from research centres indicated that their organisations conduct basic research, it seems that this research is still at a modest level. For example, there is no significant R&D related to using new materials or other areas based mainly on basic research. This can reflect that their capacities to generate new technological knowledge are still very limited.

The situation in the industrial firms seems to be similar; they just conduct significant R&D on improving products, improving methods of production and industrial processes, overcoming technical problems and technology transfer. These activities can be linked to developments related to the operational processes and final products. Also, it may be linked to applied research in case of R&D related to technology transfer. Furthermore, it can be noted that the common trends between research centres and industrial firms that concentrate highly on R&D are related to technology transfer and to overcoming technical problems. The implication which can be drawn from this situation is that these organisations conduct significant R&D activities oriented to applying new technology and related issues.

5.4.2 The consequence of development of R&D activities

There is a wide range of outputs that result from R&D efforts at the organisations. Based on the previous experience of R&D practices within the organisations studied, Table 5.7 demonstrates the outcomes of these practices:

Table 5.7 The previous experience of R&D activities practiced by the organisation

The outcomes of previous R&D practices (n= 30)	Research centres		Industrial firms		Total	
	No.	%	No.	%	No.	%
Providing new products or services	0	0	0	0	0	0
Increasing in diversification of the organisation's products or services	3	20	14	93	17	56.6
Improving the quality of current products or services	12	80	8	53	20	66.6
Finding solutions for some technical problems	8	53	9	60	17	56.6
Reducing the operation costs	5	33.3	10	66.6	15	50
Adapting some transferable technologies	7	46.6	9	60	16	53
Improving work tools or equipments	4	26.6	0	0	4	13
Facilitating the use of some local raw materials	13	86.6	3	20	17	56.6
Modifying some designs related to products	3	20	0	0	3	10

It can be seen from Table 5.7 that the most significant R&D outcomes of research centres are confined to improving the quality of current products or services and facilitating the

use of some local raw materials. For the industrial firms, such outcomes were upon increasing the diversification of the organisation's products or services, finding solutions for some technical problems, reducing operational costs, adapting transferable technologies and improving the quality of current products or services. Thus, it is clear that most of these outcomes are based on development phase and to some extent on the applied research phase. However, beyond the limitation of these aspects, they might not have a significant impact on the organisations' operations, as indicated in Table 5.8, no organisation has benefited greatly from the practice of R&D activities.

Table 5.8 The degree of benefits from R&D activities practiced in the organisations

The degree of benefits (n= 30)	Yes						No		Total	
	High degree		Medium degree		Low degree					
	No.	%	No.	%	No.	%	No.	%	No.	%
Research centres	0	0	8	53	7	47	0	0	15	100
Industrial firms	0	0	6	40	9	60	0	0	15	100
Total	0	0	14	47	16	53	0	0	30	100

As can be seen from Table 5.8 that 53% of the participants indicated that the benefits from previous R&D activities were at a low degree, and 47% of these participants just thought that it was relatively satisfactory. This can mean that the role of R&D activity in developing the business of Libyan organisations is still marginalised. Overall, the situation seems to indicate that R&D activity practiced within these organisations is of limited value. This adds to the implications of the Libyan NIS mentioned in the previous chapter.

5.4.3 The reality of innovation within the organisations studied

Many organisations pursue innovation from their R&D activities. However, not all of them would succeed in this process, and even when they succeeded, some of these innovations failed to become commercial products or services. In this context, the Table 5.9 shows the situation of innovation at the organisations studied:

Table 5.9 The situation of innovation within the organisations

Status of innovations (n= 30)	Achieving new innovations				Commercialising new innovations			
	Yes		No		Yes		No	
	No.	%	No.	%	No.	%	No.	%
Research centres	6	40	9	60	3	33	3	33
Industrial firms	3	20	12	80	0	0	3	33
Total	9	30	21	70	3	33	6	66

It can be seen from Table 5.9 that 70% of the organisations have failed to achieve new innovations. Moreover, even 30% of those who have succeeded, 66% of them have failed to commercialise these innovations. Thus, it can be said that the processes of innovation at most of these organisations are not effective and have deficiencies in several aspects. This is not surprising as Libya has lagged behind in terms of capacity for innovation and the

culture of innovation as well as creativity is, in general, limited. These results are in line with data presented in previous tables about the types of R&D activities practiced and their outcomes. Given the lack of technical capability and financial resources employed to improve R&D processes, this situation is perhaps to be expected.

5.5 The identification and classification of obstacles to practice of R&D

This section explores the possible obstacles that hinder Libyan organisations in practicing their R&D activities successfully.

5.5.1 The identification of obstacles to R&D

As all organisations studied are public, and working in the same business environment, it can be assumed that they have been similarly influenced by governmental policies with regard to S&T, industrial policies and others. Table 5.10 presents, the more common obstacles to R&D within these organisations:

Table 5.10 Obstacles hindering R&D practice within the organisations

The main obstacles hindering R&D's practice (n= 30)	Research centres		Industrial firms		Total	
	No.	%	No.	%	No.	%
Lack of specialised and qualified human resources	9	60	15	100	24	80
Absence of effective programmes to promote employees' creativity and innovation	12	80	15	100	27	90
Instability of highly specialised personnel in the R&D field	15	100	15	100	30	100
Shortage of technological information	12	80	6	40	18	60
Unavailability of R&D information systems	10	67	12	80	22	73.3
High cost of R&D activities	10	67	15	100	25	83.3
Lack of strong financial support	7	47	9	60	16	53.3
Lack of experience	6	40	6	40	12	40
Absence of clear plans to practice R&D	9	60	15	100	24	80
Poor trust and appreciation of R&D results by the top management, consequently making it less interested in supporting R&D activities	5	33.3	9	60	14	47
Absence of appropriate organisational environment to practice R&D successfully, and poor communication and cooperation between the R&D unit and other units in the organisation	11	73.3	9	60	20	66.6
Absence of scientific management in running R&D activities	6	40	3	20	9	30
There is no management stability	7	47	0	0	7	23.3
The R&D activity is not on the proprieties of attention of the management's agenda	7	47	3	20	10	33.3

Table 5.10 demonstrates the wide range of obstacles, where they may vary in their significance and influence within two sectors studied. It can be noted that the most significant common obstacles that have been indicated by participants are; instability of highly specialised personnel in the R&D field, absence of effective programmes and systems to promote employees' creativity and innovation. Accordingly, it can be concluded that these factors are related to human resource obstacles, where this reflects weaknesses in the NIS. It is very critical especially that these organisations suffered from a lack of specialised and qualified human resources in the R&D field. Although there is a difference of score between research centres and industrial firms in this issue, it can in

general be as a result of the low quality of the education system and a lack of coordination between S&T and an industrial policy.

Furthermore, it can be also noted that there are some differences between the two categories in terms of influencing different obstacles. For example, all industrial firms studied suffer from the issue of the high cost of R&D activities and the absence of clear goal plans to practice R&D, while these issues are less significant at research centres. In addition, while research centres suffer more from the issue of the shortage of technological information, industrial firms have suffered from the unavailability of R&D information systems.

Generally, the issues such as the high cost of R&D activity and the absence of clear goal plans to practice R&D reflect the deficiency of an industrial policy regarding government support for R&D activity and its low coordination with S&T policy. They are also related to managerial illiteracy in practicing of R&D and innovation management, which indicates the lack of management capability, especially in industrial firms. As the research centres have more experience in the practicing R&D activities, these issues had less significance. This can be explained by the limited R&D conducted by industrial firms comparing with research centres. Overall, the emergence of these obstacles can be closely linked to the influences of the organisational and financial attention level to R&D activity within Libyan organisations. Moreover, the issues such as shortage of technological information and unavailability of R&D information system reflect in general the limited linkage of Libyan organisations with knowledge created bodies, and the institutional gaps in the NIS.

5.5.2 The classification of obstacles to the proper practice of R&D activity

The significance of these obstacles and the degree of their influence can be classified into two main groups as follows:

1- Obstacles related to human resource issues

These include several of the high score ones, which represented the instability of highly specialised personnel in the R&D field, absence of effective programmes to promote employees' creativity and innovation and lack of specialised and qualified human resources in R&D field . These can be linked to weaknesses of NIS in general and failure of the S&T policy to improve the education system and professional training programmes, dealing with brain drain problems and attracting specialised people to work in R&D fields. Indeed, based on the current conditions of Libyan NIS, it was to be expected that the

Libyan organisations face such obstacles. This has implications for the possibility of Libyan organisations to attract corporate R&D, especially as it is based on a knowledge seeking strategy, as it targets tapping into the wide pool of scientists and engineers.

2- Obstacles related to management and financial issues

These include some significant and most of the low score ones, which represented, for example, the unavailability of R&D information systems, absence of clear plans to practice R&D, high cost of R&D activity, absence of appropriate organisational environment to practice R&D successfully, and poor communication and cooperation between the R&D unit and other units in the organisation. These can be linked to managerial illiteracy and poor management in general. In addition, trends on the level of organisational and financial attention to R&D in previous sections can reflect these obstacles.

5.6 Collaborative R&D activities in the Libyan organisations

The implications derived from the last sections can clearly reveal the limitation and lack of technological and management capability to practice R&D activities within the organisations studied. Under such conditions, collaborative R&D may maintain their needs for R&D services. Thus, this section highlights the significance and aspects of these processes.

5.6.1 The significance of corporate R&D activity

The collaborative R&D activities have been increasingly becoming important elements to be integrated into the overall R&D strategies of companies and research institutions. In this context, Table 5.11 shows that all organisations studied conduct some sort of corporate R&D activity and dealing with both local and foreign partners, where industrial firms tend to deal more with foreign partners.

Table 5.11 The identity of partners and age of collaborative R&D activities

Partners and age of collaborative R&D projects	Foreign organisations						Local organisations					
	1-10 years		11- 21 years		22 and above		1- 10 years		11- 21 years		22 and above	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Research centres	2	40	2	40	1	20	0	0	2	40	2	40
Industrial firms	1	20	0	0	4	80	2	40	0	0	1	20
Total	3	30	2	20	5	50	2	20	2	20	3	30

The experience of Libyan organisations with R&D collaborative projects could be linked to the history of this collaboration. Thus, it is clear from Table 5.11 that 80% of the industrial firms had more than two decades of being involved in collaborative R&D projects with foreign partners. Compared to the age of these firms mentioned in Table 5.1,

it can indicate that some of them had collaborative projects since the early stages of their establishment. On the other hand, their collaboration with the local agencies is less significant. This can be explained by the reflection of limited technological competences of local agencies and to some extent the reliance on foreign partners -as a technology supplier- in the technology development process and fixing attendant technical problems.

Regarding research centres, just 40% of them have been dealing with foreign partners for 20 years. If this is compared with their age, one can conclude that one organisation just had collaborative R&D projects during the early years of its business. This delay can be linked to the age of R&D units as it was shown in Section 5.3.1 that most of them were only established in recent years. However, the significance of collaborative R&D projects can be seen from the number of recent collaborative projects. Table 5.12 represents these phases:

Table 5.12 The number of collaborative R&D projects in the last three years*

Number of collaborative R&D projects in last three years (n= 10)	1-5 projects		6- 11 projects		12 and above		Total	
	No.	%	No.	%	No.	%	No.	%
Research centres	3	60	1	20	1	20	5	100
Industrial firms	4	80	1	20	0	0	5	100
Total	7	70	2	20	1	10	10	100

**** (2004- 2007)***

Table 5.12 shows a wide range of R&D collaboration within the organisations studied. It can be seen that 70% of the organisations had up to five collaborative R&D projects during the last three years. 80% of the industrial firms and 60% of the research centres fell into this category. This significance could be attributed to the reliance of industrial firms on external sources in many aspects of R&D, and as a result of sanctions left in the case of research centres, where the Libyan government has signed some technological agreements in their fields. Generally, with obstacles related to human resource and management and financial issues mentioned in Section 5.5, to manage the portfolio of such R&D cooperation relationship and sharing the risk involved could be a significant issue, which might have influences on the aspects of R&D collaborative projects.

5.6.2 Dimensions of collaborative R&D activities

The collaboration in R&D activities may take different aspects according to different conditions and the stage of R&D process. In addition, it can be influenced by the degree of ability to conduct independently significant R&D activities. In this context, the evidence suggests that the organisations can rarely generate all technological knowledge they need independently, which can lead to collaboration representing one of the good options for

R&D outsourcing. Thus, the reliance on the external sources may take place in different aspects and levels. The following table demonstrates the main aspects and how much the organisations do rely on foreign partners in R&D processes:

Table 5.13 The extent to which the organisations rely on foreign R&D partners

Aspects of reliance on foreign partners (n= 30)	Research centres			Industrial firms			Total		
	No.	%	Rank	No.	%	Rank	No.	%	Rank
Technical support	11	73	4	12	80	1	23	77	2
In basic research phase	9	60	3	2	13	6	11	37	5
In developing products and services	8	53	5	15	100	2	23	77	4
Training programmers	10	67	1	8	53	3	18	60	1
Supplying laboratory equipment	12	80	2	5	33	4	17	57	3
Scholarships and scientific visiting	3	20	6	0	0	0	3	10	6
Consultations	1	0.07	7	3	20	5	4	13	7

It can be seen from Table 5.13 that the organisations rely upon foreign partners in different relevant technological aspects of R&D activities. The most significant ones highlighted by the participants are: technical support (77%), development processes (77%), and training R&D staff (60%). But, there are some differences between the two sectors studied. In the research centres, the most significant collaborative efforts were in: supplying laboratory equipment (80%), technical support (73%), and training R&D staff (67). While in industrial firms, such efforts were represented in product development (100%) and technical support (80%). In addition, while the research centres ranked training R&D staff as the highest, the industrial firms ranked technical support as the highest. This reflects the limitation of technological capability within these organisations and the need to build and develop such capabilities.

At any rate, the extent of collaboration can represent the basic level of R&D collaboration, with which one cannot expect high technological support and innovative operations are involved in these types of collaboration. Table 5.14 shows the nature of collaborative R&D projects:

Table 5.14 The nature of the R&D collaboration within the organisations

Nature and forms of collaborative R&D projects (n= 30)	Research centres		Industrial firms		Total	
	No.	%	No.	%	No.	%
Buying the results of some research	0	0	8	53.3	8	27
Conducting research financed by the organisation	5	33.3	3	20	8	27
Buying some invention patents	3	20	0	0	3	10
Training R&D staff	11	73.3	9	60	20	66.6
Fixing some technical problems	12	80	15	100	27	90
Providing laboratory tools	10	67	6	40	16	53.3
International R&D subcontracting	3	20	0	0	3	10

It can be noted from Table 5.14 that the most significant operations that have taken place within R&D cooperation are: fixing technical problems (90%), training R&D staff (66.6%). Although there are slight differences between two sectors, one can conclude that

the current R&D collaboration processes are pretty modest and at a low level. Indeed, these operations are still limited to raise the technical readiness level and support to conduct R&D activities. As a result, the range and significance of outputs would not be at advanced levels. Table 5.15 shows the range of benefits obtained and the main issues surrounding it:

Table 5.15 The benefits from collaborative R&D and main factors hindering it

Gaining substantial benefits from collaborative R&D projects (n= 30)	**Yes**		**No**		**Total**	
	No.	%	No.	%	No.	%
Research centres	9	60	6	40	15	100
Industrial firms	9	60	6	40	15	100
Total	18	60	12	40	30	100
Main reasons behind not gaining benefits from collaboration (n= 12)	**Research centres**		**Industrial firms**		**Total**	
	No.	%	No.	%	No.	%
The organisation could not effectively exploit the obtained services	3	50	6	100	9	75
R&D services were not provided in suitable time	3	50	3	50	6	50
The centre does not respond to such benefits	2	33.3	0	0	2	17
The technical collaborative agreement tend to focus more on operational processes than on R&D process	0	0	6	100	6	50

Table 5.15 indicates that 60% of the organisations in both sectors have obtained some benefits from R&D collaboration. For others who think that the collaboration programmes did not contribute much to the whole of R&D activities operations have provided some reasons they think made no tangible benefits. The most significant reason provided is that their organisations could not typically exploit the obtained services (75%). This can reflect the lack of technological and management experience in general and the low level of absorptive capacity of these organisations in particular. Moreover, other reasons have been indicated such as: R&D services were not provided at a suitable time (50%), and the technical collaborative agreements tend to focus more on operational processes rather than on R&D process (50%). These issues are as a result of obstacles, which can be linked to limitations of management and technological capability mentioned in previous sections. Overall, these issues and others may make influences upon the type of benefits they might obtain. Table 5.16 shows the main benefits have obtained by the organisations:

Table 5.16 The main benefits from collaborative R&D within the organisations

Type of benefits obtained from collaborative R&D projects (n= 18)	**Research centres**		**Industrial firms**		**Total**	
	No.	%	No.	%	No.	%
Building the skills and improving the technical services by acquiring of the experience and stimulating technological knowledge.	3	33.3	6	66.6	9	50
Developing and upgrading the level of laboratories and skills of R&D staff.	3	33.3	3	33.3	6	33.3
Acquiring the experience in advanced technological fields and technology transfer	6	66.6	0	0	6	33.3

It can be noticed that 66.6% of those who think that the industrial firms have benefited from the collaborative R&D projects indicated that this collaboration has contributed in building the skills, improving technical services by acquiring experience and stimulating technological knowledge. 66.6% of their parallels in the research centres indicated that

this collaboration contributed to acquiring experience in advanced technological fields and technology transfer. Overall, the outcomes of collaboration can be described as a product of growing experience that may take place during the collaboration process. This can improve the technological capability of these organisations in the long-term.

5.7 Obstacles to the globalisation of R&D: Libyan organisations' perspective

Given that one of the feature aspects of the globalisation of corporate R&D activities is the increase of collaboration in R&D activity within organisations. In this section, an attempt is made to explore the obstacles and problems that hinder these processes within Libyan organisations, especially with foreign partners.

5.7.1 The nature of obstacles and their significance within the organisations

From Libyan organisation's perspective, there are many different obstacles may hinder the R&D globalisation process in Libyan. Table 5.17 demonstrates these obstacles:

Table 5.17 Obstacles hindering corporate R&D activities within the organisations

The main obstacles hindering corporate R&D activities (n= 30)	Research centres		Industrial firms		Total	
	No.	%	No.	%	No.	%
Lack of corporate R&D management expertise	12	80	15	100	27	90
Lack of innovation culture and targeted incentive to attract foreign partners	12	80	15	100	27	90
Difficulty to persuading foreign partners to be involved in R&D projects	11	73.3	12	80	23	77
Deficiencies in strategies related to encouraging foreign partners to become involved in R&D cooperation R&D activities	10	67	6	40	16	53.3
Dealing with employees from different cultures to work as a team	3	20	6	40	9	30
Poor English language skills among R&D staff	7	47	12	80	19	63.3
Limitation of R&D capacity	12	80	15	100	27	90
Weak domestic R&D capabilities	7	47	15	100	22	73.3
Absence of effective institutional mechanisms that provide explicit incentives to investors to target knowledge based activities in Libya	9	60	15	100	24	80
Insufficient stronger intellectual property protection	5	33.3	5	33.3	10	33.3
Deficiency of communication infrastructure and linking with global knowledge networks	9	60	12	80	21	70
Top management does not recognise the importance of corporate R&D activity, consequently, making no independent budget for corporate R&D projects	12	80	12	80	24	80
Issues related to sharing risk agreements	9	60	9	60	18	60
Deficiencies of government policies related to FDI policy	4	27	6	40	10	33.3
Deficiencies of government policies related to S&T policy	13	87	6	40	19	63.3
Deficiencies of government policies related to industry policy	9	60	15	80	24	80
Absence of the ideal implementation to business development policies	5	33.3	9	60	14	47
The local R&D staff are not in the same level of skills with the international employees, for example in the administration, timing, and goals' achievement	6	40	8	53	14	47
Absence of national clear plan with regard to determine proprieties of R&D programmes	9	60	8	53	17	57
Lack of adequate financial support to implement high levels of R&D programmes	12	80	13	86	25	83

Table 5.17 shows that in the industrial firms, the most significant obstacles are: the lack of corporate R&D management expertise, the lack of innovation culture and targeted incentives to attract foreign partners, the limitation of R&D capacity, weak domestic R&D capabilities, and the absence of effective institutional mechanisms that provide explicit

incentives to investors to target knowledge based activities in Libya. The first and second obstacles can be linked to managerial illiteracy and the limitation of management capability for R&D field, while the third and fourth can be linked to the limitation of local capacity for conducting corporate R&D. The fifth one can be also linked to the lack of government support to corporate R&D activity. In addition, there are other significant obstacles indicated by participants from the industrial firms such as difficulty in persuading foreign partners to be involved in R&D projects, poor English language skills among R&D staff, deficiencies of communication infrastructure and linking with global knowledge networks, deficiencies of government policies related to industry and the lack of adequate financial support to implement high levels of R&D programmes. These obstacles reflect the weakness of NIS in terms of education system and institutional factors to support R&D activity. These findings go in line with the relevant indicators mentioned in Chapter Four.

Regarding the research centres, the most significant obstacles indicated by participants are; lack of corporate R&D management expertise, lack of innovation culture and targeted incentive to attract foreign partners and top management does not recognise the importance of corporate R&D activity. These obstacles can be linked to the managerial illiteracy and limitation of management capability for R&D field. In addition to that, those participants have indicated limitation of R&D capacity, deficiencies of government policies related to S&T policy and the lack of adequate financial support to implement high levels of R&D programmes. Thus, the first and second obstacles reflect the weakness of NIS in terms of the failure of government policies in developing and upgrading the domestic R&D capacity, while the last one can be linked to institutional factors, which represent lack of government support for corporate R&D activity. These results go again in line with the implication of many findings in Chapter Four.

In comparison between two sectors investigated, it can be noticed that the industrial firms seem to be suffering more from these obstacles than the research centres in several factors and aspects. Thus, there are some significant differences: while the research centres consider the deficiency in strategies related to encouraging foreign partners to become involved in R&D cooperation and deficiencies of government policies related to S&T policy as significant obstacles, 67% and 87% respectively, they are not significant obstacles for the industrial firms, 40% of both. On the other hand, while the industrial firms consider poor English language skills among R&D staff, weak domestic R&D capabilities, and the absence of the ideal implementation to business development policies

as significant obstacles, 80%, 100%, and 60% respectively, they are not significant obstacles for the research centres, 47%, 47%, and 33.3% respectively.

Thus, one of the explanations for these differences amongst sectors can go to the different nature of their business. For example, the main function of research centres is the R&D function, with which they would have better R&D capabilities than the industrial firms. In contrast, the entire operations of research centres (inputs, processes, outputs) would be more directly affected by the scenarios of S&T policy than industrial firms. In addition, it has been indicated in Chapter Four that most of the international research agreements signed by the Libyan government were linked to research centres. For the issue of poor English language skills among R&D staff in industrial firms, it reflects the lack of focus on training programmes in the industrial policy.

5.7.2 The classification of obstacles to the corporate R&D activity

Table 5.17 identifies several significant obstacles, which differ in their nature, even they are mostly interrelated. In order to make the picture simpler and more accurate, an attempt is made to group them into specific categories as follows:

1- High score category, which includes obstacles related to technological and management capability issues and can be linked to weaknesses in the Libyan NIS. For example, the limitation of R&D capacity, the weak domestic R&D capability and the deficiencies of a communication infrastructure and linking with global knowledge networks reflect such weakness in terms of technological capability. While the issue of the limitation of management capability can be seen from factors such as, the lack of corporate R&D management expertise, the lack of innovation culture and targeted incentive to attract foreign partners, the difficulty in persuading foreign partners to be involved in R&D projects, the deficiencies in strategies related to encouraging foreign partners to become involved in R&D cooperation activities and a top management which does not recognise the importance of corporate R&D activity, consequently, making no independent budget for corporate R&D projects.

2- Medium score category, which includes obstacles related to people and culture factors and can be linked to issue related to interaction between the local and foreign employees in collaborative R&D projects.

3- Low score category, which includes obstacles related to institutional factors and can be linked to government policy such as FDI policy and IPR. These have implications for corporate R&D, as FDI involving R&D tends to prefer locations where there are strong IPRs and a favourite FDI policy.

In this context, it is worthy to mention that most participants stated that no serious measures have been taken by their organisations to address these obstacles, in an attempt to overcome or mitigate some of these obstacles.

5.7.3 Management, legal, financial problems facing cooperative R&D activities

Besides the obstacles to globalisation of corporate R&D activity in Libya, which have appeared to be many, there are some other problems that face the organisations in the daily practice of their collaborative R&D activities. They may include a wide range of problems, but here the focus is upon management and legal and financial problems. Table 5.18 shows the management problems that some organisations studied have faced:

Table 5.18 The main management problems surrounding collaborative R&D activity

Existence of management problems related to practice of corporate R&D activity (n= 30)	**Yes**		**No**		**Total**	
	No.	%	No.	%	No.	%
Research centres	8	53.3	7	46.7	15	100
Industrial firms	12	80	3	20	15	100
Total	20	66.7	10	33.3	30	100
Management problems related to corporate R&D activity (n= 20)	**Research centres**		**Industrial firms**		**Total**	
	No.	%	No.	%	No.	%
High bureaucracy in all management procedures	6	75	9	75	15	75
The centre cannot deals directly with foreign partner. It has to be by the sector's Ministry	5	62.5	0	0	5	25
Lack of awareness of the importance of R&D activity	0	0	9	75	9	45

It can be noted that 66.7% of the participants have indicated that their organisations face management problems related to the practice of corporate R&D activity. The most significant problem mentioned was the high level of bureaucracy in all management procedures related to corporate R&D projects (75%). Also, some research centres face the problem of not being allowed to deal directly with foreign partners (62.5%). They need to have permission from the ministries of the relevant sectors. This problem with bureaucracy makes the situation for arranging collaborative R&D projects difficult. Some industrial firms suffer from a lack of awareness of the importance of the R&D activity (75%). This problem has already impacted on the level of management and financial attention to R&D activity within the organisations in general, and the level of R&D collaboration, both of which are at low levels as demonstrated in previous sections.

In this context, Table 5.19 demonstrates the significance of financial problems related to the practice of cooperative R&D projects:

Table 5.19 The main financial problems surrounding collaborative R&D activity

Existence of financial problems related to practice corporate R&D activity (n= 30)	Yes		No		Total	
	No.	%	No.	%	No.	%
Research centres	14	93.3	1	0.06.7	15	100
Industrial firms	15	100	0	0	15	100
Total	29	96.7	1	0.03.3	30	100
Financial problems related to corporate R&D activity (n= 29)	**Research centres**		**Industrial firms**		**Total**	
	No.	%	No.	%	No.	%
Lack of finance resources for the cooperative R&D projects	6	43	15	100	21	72.4
There is no independent budget or allocating sufficient amounts for cooperative R&D activity	8	57	9	60	17	58.6

Table 5.19 shows that 96.7% of participants have indicated the existence of financial problems facing the practice of R&D activity within their organisations. The main financial issues influencing the practice of corporate R&D projects are: the lack of financial resources for collaborative R&D projects (72.4%) and the absence of an independent budget and the allocation of sufficient amounts for cooperative R&D (58.6%). In this regard, it can be noticed that the research centres have been less influenced by these problems compared to industrial firms. One reason to explain this is that research centres are allocated greater funds than industrial firms as their business is mainly R&D services. In addition, as mentioned in Chapter Four, most of the international agreements between the Libyan government and other countries are implemented through the research centres.

Irrespective of whether these agreements are for the research centres or industrial firms and other collaborative R&D forms; there are some legal problems surrounding the R&D practice based on these forms. Table 5.20 shows the significance of these problems:

Table 5.20 The main legal problems surrounding collaborative R&D activity

Existence of legal problems related to practice corporate R&D activity (n= 30)	Yes		No		Total	
	No.	%	No.	%	No.	%
Research centres	11	73.3	4	26.7	15	100
Industrial firms	9	60	6	40	15	100
Total	20	66.7	10	33.3	30	100
Legal problems related to corporate R&D activity (n= 20)	**Research centres**		**Industrial firms**		**Total**	
	No.	%	No.	%	No.	%
Some procedures in the agreements are relevant to the independence of state and its security	3	27	3	33.3	6	30
Some phases of implementation are not clearly addressed	6	54.5	6	66.7	12	60
The centralisation of decision-making by the government	5	45	0	0	5	25
No law has been issued to separately organise the process of collaboration with foreign partners in the R&D field	0	0	6	66.7	6	30

Table 5.20 demonstrates that 66.7% of the participants have indicated the existence of legal problems related to the practice of corporate R&D activities within their organisations. 60% of them indicated that with regard to R&D collaborative agreements, some phases of implementation are not clearly addressed, where; the industrial firms (66.7%) seem to be more influenced by this problem than the research centres (54.5%).

Furthermore, the industrial firms are significantly affected by the problem of the absence of separate laws that deal with organising and managing R&D collaboration with foreign partners (66.7%).

Thus, it is clear that there are different degrees of influence by the indicated problems. The strongest problems that have faced all organisations are financial problems. As can be seen from the previous analysis, most of these problems (management, financial, and legal) tend to be more as obstacles rather than barriers to the daily practice of corporate R&D activities. If they were linked to the obstacles presented in Table 5.17, it would be safe to state that most of them have already been included in these obstacles. They are not as temporary issues; rather they have been rooted in daily practice for some time.

5.8 Conclusion

This chapter has presented and discussed the findings of a survey used to provide an assessment of R&D practice in Libya and the host country's perspective on obstacles to the globalisation of corporate R&D. The analysis of the organisations' characteristics demonstrates that the organisations studied are well established. However, they are mainly selling their products and services in local markets. This reflects their limited technological capabilities and inability to produce advanced products and services through the entire development process and market them worldwide. In this context, the analysis of R&D activity practice within Libyan organisations demonstrates that in just a few years, R&D activity has taken place as a separate activity and in separate organisational units. Moreover, although many of the organisations studied have a separate R&D unit, they do not have sufficient budgets for the requirements of R&D activities, and this activity is conducted mainly by technicians with a few scientists and engineers involved. Overall, the trends on how R&D activity is fostered indicate that low levels of financial and organisational attention were paid to it. With the low level of technological capability, the significant outcomes of R&D activity were limited to resolving and fixing technical problems and improving some products and services. Most of the R&D processes can be linked to the development side with little applied research even at the research centres. The current practice of R&D gives relatively few benefits and is therefore of limited value. Indeed, the innovation of new products and services was a remote possibility for most of the Libyan organisations.

At the corporate level, all the Libyan organisations studied have recently practised collaborative R&D activities with a tendency to collaborate with foreign partners in the case of the industrial firms. There are quite a lot of collaborative R&D projects, but most R&D collaboration is still at a low level. It takes mostly the form of fixing technical problems and training R&D staff. No significant amount of patenting or licensing was identified. The significance of these activities is still confined to technical support, training programmes and to some extent to helping product development in the case of industrial firms. Several different problems face the daily practice of corporate R&D activity. These include management, legal, and financial problems. Based on these conditions and with the low level of absorptive capacity, the degree of benefit from the R&D collaboration with the foreign partners was at a low level. Indeed, Libyan organisations failed to fully benefit from R&D collaborative projects.

Furthermore, the analysis has shown different significant obstacles hindering corporate R&D activity in Libya, where the industrial firms seem to be suffering from these obstacles more than the research centres in several aspects. This is especially in terms of R&D capacity and management capability for R&D. Many of these obstacles are inter-connected with significant obstacles that hamper daily practice of R&D activity within these organisations. The most significant obstacles can be categorised into three groups: institutional factors, technological capability factors and management and financial capability factors. The institutional factors mainly represented in deficiencies in S&T and industrial policy, deficiencies of communication infrastructure, poor linkages with global knowledge networks and the absence of institutional mechanisms that provide explicit incentives for FDI involving R&D. The technological capability factors mainly include limited R&D capacity and weak domestic R&D capability. The management and financial factors mainly represented lack of experience to manage corporate R&D activity, lack of funding and support to corporate R&D and lack of an innovation culture. Many reasons can be behind poor management within Libyan organisations. It is well understood that state owned organisations tend to suffer from a lack of managerial development opportunities for managers, as these organisations often do not provide a good opportunity to training managers. Moreover, Libya lags behind in terms of the quality of management schools. Other important reasons may be the lack of competition and the intervention of political regime in appointing the leaders in these organisations, which is mainly based on loyalty rather than effectiveness. Overall, most of the obstacles mentioned reflect the major weaknesses and limitation of Libyan NIS to improve such factors.

Chapter Six

Analysis of Case Studies on TNCs' Perspective

6.1 Introduction

The purpose of this chapter is to provide TNCs' perspective on the obstacles to R&D globalisation process in Libya and relevant issues. This is through presenting and discussing the findings of the empirical study that was undertaken to investigate the aspects and development of the practices of foreign R&D activities in Libya and the obstacles surrounding these processes. They are mainly the result of an interview based-survey of two case studies of TNCs working in Libya. The next sections (6.2, 6.3, 6.4) in this chapter illuminate these issues and others for each case and then by a cross case studies analysis.

6.2 ServCo's case study

6.2.1 Introduction

ServCo has a branch working in Libya since the early 2000s. It is located in Tripoli, Libya's capital city. This case study highlights organisational aspects of ServCo and its divisions. General background about its significant operations and business developments is discussed as well as presenting the company profile. Particular emphasis is placed on the function of corporate R&D, its technological activities and its point of view toward the possible obstacles, which may hinder its corporate R&D activity in Libya.

6.2.2 General background on ServCo

ServCo is an American company in origin. It is a company incorporated and with the global headquarters offices in Houston city in the State of Texas, where one of the oldest oil industries was set up and its fundamental technologies were established. It is a famous worldwide company and operates in over 90 countries serving independent, international and national oil companies. Accordingly, it ranks among the top 100 TNCs in the technological services in the petroleum sector. ServCo works in different forms across its offices, which are located throughout the world. It is the combination of several leading companies with a strong range of innovations, and their combined history dates back to the early 1900s. ServCo has a long corporation history. In 1954, it established its first manufacturing plant outside the United States, in Belfast, Northern Ireland.

ServCo has, during its history, undergone several transformations, through many M&As, which led to the creation of the present company. For example, in 1962, when the business growth potential of Milwhite1 attracted attention outside the oil industry, it led to its acquisition of another company, a chemicals and metals company based in Missouri. It was formed to supply drilling fluids and oilfield chemicals, and this new company launched THERMEX, an oil-based drilling mud system in 1965. Generally, in the late 1960s and 1970s, new markets, new products, new applications, and corporate mergers drove oil industry growth and diversification. Thus, ServCo went public and grew through acquisitions. In 1968, the company brought together LW and PGAC to form a new division. PGAC's expertise in open-hole logging and its international operations made it an ideal merger partner to form an integrated wire-line services company. In 1972, a corporation was formed to acquire the oil tool assets of a public company, and this new company achieved high growth through the decade as revenues grew from $150 million in 1973 to $450 million in 1977. By 1982, it had 75 units working outside the United States.

In the 1980s, when the price of oil reached a low point of $8 per barrel, oil companies' revenues declined and made losses in the millions of dollars. Many companies were therefore taken over through mergers. Thus, in 1987, ServCo and another oilfield service industry leader merged to form the present company. It has been pointed out that 'The merger had transformed the company from a provider of discrete oil-well products and services into an integrated life of the field company focused on the reservoir' (ServCo fact book, 2006). During the 1990s, ServCo made more than 30 acquisitions and divestitures to reinforce its core technical competencies in drilling formation evaluation, completion and production. Overall, during its history, it has acquired and assimilated numerous oilfield pioneers including Brown Oil Tools and Elder Oil Tools for. This makes it one of the largest companies of the oil and gas service industry around the world. It is worth mentioning that most of its mergers and acquisitions were American companies and just a few acquisitions were with companies in the developed countries mainly in Canada, the UK and Germany.

ServCo has played an important role in developing and introducing advanced technologies to serve the petroleum service industry. For example, in 1994, one of its divisions introduced the concept of reservoir drill-in fluids with the PERF*FLOW* system. Since then the company has developed proprietary software to determine the optimum Particle Size Distribution, necessary to bridge pore openings that may otherwise be damaged during

reservoir drill-in. In 1997, a number of key innovations in sand control technology were introduced. Other important technologies introduced by the company include 3D Explorer resistivity logging service for evaluating thinly laminated zones and EARTH Imager service for obtaining well-bore images in oil-based mud.

Furthermore, in terms of technological development, ServCo, in the early part of the last century, contributed to developing expertise that revolutionised cable tool drilling and tools that dramatically improved the rotary drilling process. For instance, it received a patent on a casing shoe that advanced well cementing in 1907. In 1909, it patented a roller cone bit that made it possible to drill through deeper and harder rock. Generally, it is still carrying on the tradition of technical innovation to enhance its business lines as a global oilfield service leader. ServCo particularly focuses on down-hole tool technologies and reservoir information with leadership positions in these fields as shown in Table 6.1:

Table 6.1 Rank of ServCo in its industry fields

The field	The rank
Wire-line logging	2
Directional drilling systems	1
Measurement-while-drilling	1
Drill bits	1
Drilling fluids	3
Sand control	1
Completions	1
Electric submersible pumps	1
Oilfield chemicals	1

Source: company's website, (accessed on 30/08/08).

As can be seen from Table 6.1, ServCo has been recently classified as number one in several technological fields. According to the nature of these technologies and the nature of ServCo's division tasks, it can be said that most of its divisions have become leaders in one or more of the technological fields. In other technological fields, it is still highly ranked. Thus, it is clear that ServCo is leading several specific advanced technologies, which implies that it has a strong technological capability and it is really a technology-based company. Another aspect of ServCo's capability can be seen from the following data or statistics in 2007; it had revenues of approximately $10.4 billion with net income of $1.5 billion, and total assets of $9.8 billion in 2007. For this period, the number of employees rose to 35,800. During recent years, approximately 64% of its revenues have come from sales outside of the United States. This evidence suggests that it has a wide corporate range in its activities and a high global capability level. It is clearly a TNC.

From marketing and management perspectives, ServCo provides the worldwide oil and natural gas industry with products and services through eight divisions that are organised

in two segments: Exploration and Production. Each of these segments includes four divisions with specific tasks (see Table 6.2). In this regard, it is worth mentioning that each division has offices or branches established in several countries around the world, but headquarters of divisions are still located in the home country.

Table 6.2 The ServCo divisions' tasks

Segment	Division	Some services
Exploration	A	• Offering a complete range of down-hole well logging services for every environment. • Offers perforating and completion technologies, pipe recovery. • Processing and analysis of open and cased whole data.
	B	• Providing fluids systems and services. • Leading technologies include environmentally compliant water-based and synthetic-based mud systems.
	C	• Providing real-time services to help oil companies drill more efficiently. • Providing data communications, data management and expert centres to improve drilling operations.
	D	• Working with customers to provide the best drill bit for its applications.
Production	E	• Providing completion and intervention solutions.
	F	• Providing chemical technology solutions. • Delivering pipeline integrity services. • Providing chemicals and technical support to serve refinery and petrochemical customers.
	G	• Providing artificial lift systems. • Providing ESP systems to harsh down-hole environments.
	H	• Providing technologies and services that help maximise recovery from both new and mature fields. • Providing production optimization services. • Managing projects and combining technologies and services from the company's divisions and subcontractors to meet customer objectives.

Source: The Company's website, accessed on 03/08/08.

Thus, ServCo identifies itself as the provider of the best-in-class products and services used within oil and gas wells, pipelines and refineries. In addition, it provides reservoir engineering and other consulting services. In 2005, one of its divisions won "The Best Drilling Technology Award" at the 2005 World Oil Awards. It has been recognised with Lifetime Technology Achievement Awards for innovation and for mentoring generations of young technology professionals. Three innovators from different divisions have done unique innovative achievements. The first received more than 60 U.S. patents for completions and liner hanger technology. The second was awarded 55 U.S. patents for advancing drill bit products. While the third, has been instrumental in developing drilling systems, which has led to the accumulation of 37 U.S. patents.

Therefore, one can conclude that all these achievements clearly reflect that the company is a technology-based company with a tendency to refocus strategy upon corporate R&D activities. Indeed, data from the 2009 EU industrial R&D investment Scoreboard shows that ServCo is ranked 181 in the ranking of the top 1000 non-EU companies by level of R&D investment. In 2008 its R&D investment was € 306.48 million and R&D/Net sales ratio was 3.6% and change 08/07 was 14.5 (European Commission, 2009: 93).

6.2.3 The function of corporate R&D: beyond the boundaries

The corporate R&D activity of ServCo has a long history of internationalisation by conducting it in both developed and developing countries. For example, in 1957, the company opened a manufacturing plant in Germany to serve international markets, and just a few years later it became a large technology centre, utilising the talents of German engineers in all disciplines. Today, this centre is a leading R&D facility for ServCo in the Western. In 1962, a complete reservoir fluid analysis lab was established in Nigeria.

In ServCo, engineers and scientists conduct R&D programmes at 10 major facilities in the United States, Germany and the UK and these R&D locations are supported by a central research centre at corporate headquarters in the USA. Each division has a central research centre at corporate level locating most of them in Houston and others in other American regions such as Oklahoma and California. Although these 10 facilities have the same R&D intensity, developing the core technologies are still carried out at the headquarters in the home country. The logical reason that may justify this is that R&D facilities in the home country have more experience as they are older and it is well known that the USA is a traditional location for oil and gas technology development (Neal, *et al*., 2007). Accordingly, the most significant parts of R&D activities are still heavily centralised at the corporate headquarters level. The laboratories at its branches are rather designed to test research practice and develop implementations. This can reflect the evidence that development activities tend to be more decentralised than research activities in general. In addition, this could provide a platform for a more effective understanding of collaboration patterns which exist in practicing R&D activities between headquarters and subsidiaries.

The policy strongly focuses upon R&D staff exchange across the divisions and between ServCo's offices to stimulate their knowledge and increase the range of their technical experience. Thus, as ServCo produces different products and services from different divisions, it may follow a strategy of exchange and diffusion of technical knowledge across all its divisions. It is turning the R&D staff to facilitate the technology and R&D services to the whole company. Based on these conditions, evidence suggests that it is not easy to determine the number of R&D staff at each location in an exact period of time. However, given that the R&D staff team usually consisted of at least 10 persons, and ServCo employs more than 1500 engineers and scientists, specialising in electronic, mechanical, materials research, and in geophysical, petrophysical and software disciplines.

ServCo has world class technology centres at the international level, such as laboratories for developing new products and conducting application-specific tests for optimum performance on the job. For example:

- Division (E) has engineers who use state of the art environmental testing labs in Houston, Aberdeen and Broken Arrow.
- Division (C) has a technology centre in Germany that includes test loops for down-hole motors and rotary steerable systems.
- Division (B) has state of the art analytical laboratories, R&D and field support centred in Houston with regional laboratories in more than 40 countries.

These technological centres have been established to support the central research headquarters of their divisions. According to given information about some of their tasks, it can be expected that most of their R&D activities are not often beyond the process of adapting an already established product or process technology to some particular condition and/ or helping others to use those applications. This fits with Medcof's taxonomy indicated in Section 2.3.2. However, some of ServCo's successes have come from R&D activities conducted at these centres. It has been observed that these successes are often on the development side of technological applications rather than generating new technologies. Later processes are still often concentrated in the home country.

Another important element in upgrading ServCo's technological capability is that it has an Education Centre located in Houston. This centre serves as a central resource to help employees achieve their full potential and to inform customers about its technology. It hosts nearly 50000 attendees each year, including R&D staff. Indeed, these processes play an important role in contributing to unlocking the potential of R&D staff and further in making ServCo a leader in several technological products and services among its industry field. It could be argued that the training of new R&D staff is immensely important in creating the new generations of scientists, engineers, and geologists within the company. This can also reflect ServCo's strategy to transfer knowledge across the company and control of the real technological resources and, the generation of knowledge and training on technology are kept at home.

Despite the fact that divisions of ServCo are independent, it is usually the divisions that work with each other to improve its product efficiency, and it is clear that the general technology policy is shared technology, as one of its managers says:

"*When it adds more value for our customers, the company can integrate technologies and expertise across divisions to improve process such as reservoir characterisation, drilling, completion and mature field optimisation*" (*Source:* BD manager interview).

As a result, it consistently invests in R&D as a long-term strategy for having the potential to add significantly to the resource base, as one of the managers indicates:
"The company has consistently invested significantly in R&D as a long-term strategy to support and grow its technology" (*Source:* BD manager interview).

For example, in 2006, ServCo's revenues topped $9 billion and $339 million was invested in R&D during that year. This is a high rate of expenditure on R&D activities (above 3%), and it is over the average of industry expenditure, which is around (1-3%) in the chemical industry in the USA excluding the pharmaceutical sector (www.icis.com, accessed on 20/12/09). This also tends to demonstrate a higher R&D intensity in the field of process engineering, which ServCo belongs to. Thanks to such investments, this led ServCo to discover many patents, which allowed it to get to market first. ServCo's operations have been supported by world class- research and engineering, and manufacturing capabilities to provide innovative products and services. A key trend is that its technologists were awarded more than 7,500 patents by the end of 2007. This suggests that these patents are evidence of a strong technological capability of ServCo.

In its corporate R&D function, ServCo adopts a strategy that depends on several dimensions. These dimensions were explained by BD manager as follows:
"When there is a need to fix something, put it into experimental applications, developing processes and then marketing them. In fact, we keen on developing relationship between us and our customers for supplying them with more services. This is throughout providing to them catalogues, and we sometimes take companies' directors to our workplaces (laboratories) for closely seeing our technologies. Also, we have a technology day for marketing our products" (*Source:* BD manager interview).

This statement suggests that there is a strong linkage between corporate marketing and R&D functions. This reflects that ServCo uses customers' feedback on its products and utilises this knowledge to improve and develop new products. In addition, it uses this to create a demand on its technological innovations. In order to achieve that, ServCo deploys all its divisions' technological capabilities to provide more innovative and suitable

products and services. For example, in 1995, innovations across ServCo's divisions were combined to offer a cost-effective horizontal re-entry system that enabled operators to boost production from old wells and extend the economic life of existing fields. In understanding the importance of technology as a differentiator, ServCo is always making an ongoing commitment to R&D to assure a steady stream of innovations. There is no doubt that ServCo has strong technological capability. This can be seen from four main aspects; the number of R&D staff, technology support centres, and products patented as well as the level of expenditure on R&D activities. It is not surprising that ServCo is leading in its field, because of its current corporate R&D conditions.

From an analysis of the structure of corporate R&D activities in ServCo, it can conclude that all its R&D locations in any country are coordinated by one global research centre located in the home country. This structure suggests that the knowledge which is created in its various locations around the globe would be used in a complementary manner, enhancing innovativeness and competitiveness of all its divisions. This together with high mobility to move R&D staff between units clearly reflects adopting policies toward circulating and diffusing knowledge as much as within the various units of R&D. Thus, it is clear that ServCo applies integrated R&D network as the typical form for its international R&D organisation.

6.2.4 Emergence of ServCo in Libya

Perhaps in the field of oil and gas technology services, several TNCs have been working in Libya for some time. However, ServCo formally established its limited office in Libya just after the United States lifted restrictions in 2003 that had previously barred American oil companies from doing business in Libya for nearly two decades. However, its published reports indicate that it had been working in Libya since the1960s. The first major export of one of its divisions was to Oasis Oil Company in Tripoli, Libya in 1965, a contact for 43 operational units. Thus it is clear that it had experienced the Libyan market since early time, and knew its potential. ServCo might return later but in a different form as The New York Times (1997) shows that American companies during the sanctions period got around the sanctions by having the work in Libya done by their foreign subsidiaries. In this context, it should be mentioned that Oasis Oil Company returned back to work in Libya in 2005 after it had signed a sharing agreement with NOC to develop and operate its old fields which were stopped for more than two decades. This can thus mean that the two companies might work together again and further ServCo started attracting its clients.

As the Libyan office is linked to one of the ServCo's divisions, which is categorised in the exploration segment, it is committed to providing the most effective services and products in the exploration field. It had been established as a small office, but with the rapid growth of oil drilling business, gradually developed and expanded its activities. This is a Greenfield investment to supply technological services and products to local and international companies working in Libya in the field of oil and gas industry, as BD manager points out:

"As a technological services supplier, we have begun with some simple businesses to supply spare parts and technological advice for resolving technical problems in drilling operations. Then, day by day, we have developed our business" (*Source:* BD manager interview).

Thus, this operational unit (spare parts supply) only needs limited technical inputs and processes. This is especially in terms of tools and equipment facilities and the level of knowledge and technical skills needed. However, as the nature of the commercial activity associated with these types of products especially attendant problems during their use, ServCo found itself, in many cases, needing to provide technical consultations to help customers in using its products. Hence, it does provide opportunities for technical development through experimental learning. The simple interpretation on developing activities of ServCo in Libya is that with the increasing demand for ServCo's products in the market and also the number of technical problems, which need quick solutions, there was a need to increase the size and develop the type of its activities.

Beyond these interpretations, it can be realised that although the Libyan office had a short work history, it had a special importance, as BD manager says:

"The company has good exposure to international markets, especially in the North Sea, West Africa, and a growing presence in Russia. The Middle East and other places such as Libya also have a good potential" (*Source:* BD manager interview).

This statement demonstrates that ServCo looks at Libya as a unique place to run its business. The importance of this is that ServCo relies on the Libyan office to provide technological services not just for the Libyan market, but to neighbouring markets too, thus, one can say that it tends to operate as a regional office. Indeed, in the last few years, new oil stocks have been discovered in several neighbouring countries such as Sudan, Chad and others, and thus, these potential markets could be targeted by ServCo. Possibly,

Libya would be a better place to locate a regional service office, especially that this office has achieved some significant results, which makes it able to perform this task. ServCo realised earlier that in order to meet the growing demand for energy, operating companies must increase production from their existing fields while continuing to explore new reserves under increasingly challenging conditions. In this respect, the BD manager says:

"We understand these changing dynamics in the reservoir and completions market segments and are committed to delivering solutions and services enabled by innovative products" (*Source:* BD manager interview).

Based on these changes, ServCo realises that the Libyan market will not be far from these developments. This has led it to place more emphasis on significant technological activities for obtaining a big share of the Libyan oil market. These endeavours resulted in one of the ServCo's successes in 2006 for the Libyan office. This was when it had continued success with the PERFORMAX (R) high performance water-based mud system in the Sirte Basin of Libya, where use of the system enabled the client to drill the complicated well design previously achieved only when drilling with oil-based mud (ServCo Announce Record, the Second Quarter Results, 2006). This is not considered as a grassroots innovation rather than it expects to make radical changes in the drilling world under seas and oceans water. According to ServCo's message (providing technological services worldwide), it would not be surprising that ServCo may see how this technology can be used and/or created breakthrough innovation in other markets. Furthermore, it can be argued that this success can definitely be conducive to developing ServCo's business in technological terms in Libya.

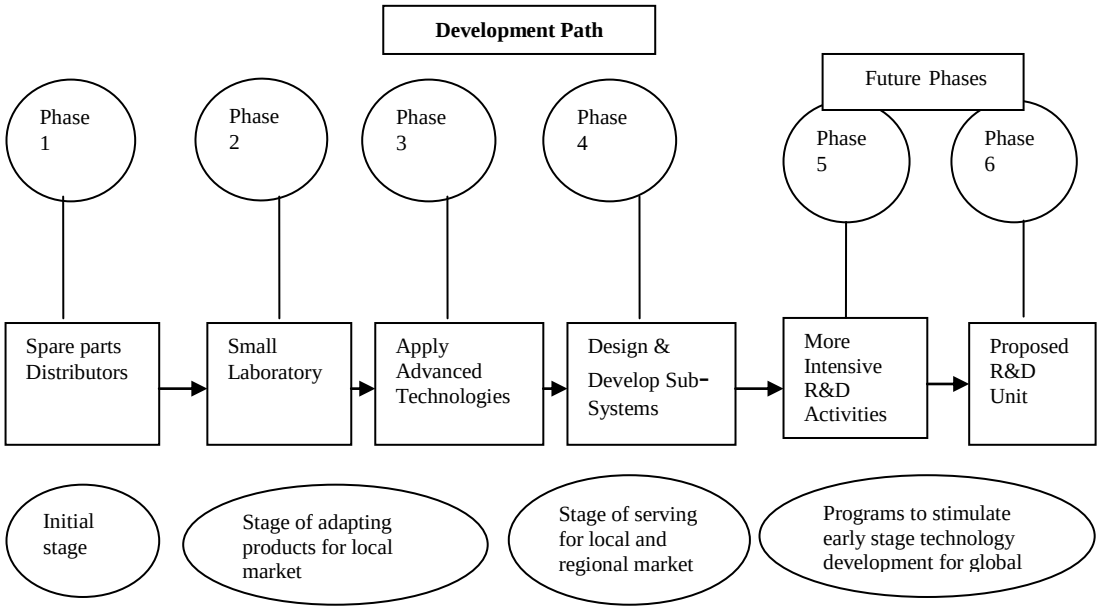
6.2.5 Development path of its business development in Libya

In this section, an attempt is made to identify how ServCo's office in Libya has developed over time. Hence, it is very useful to identify the nature of technological products and services related to drilling fluids, which ServCo prodives in Libya. Simply, drilling fluid can be defined as 'a combination of fluid and solids required in certain drilling processes to facilitate the production and removal of cuttings from a borehole. Commonly, and especially in the field, liquid drilling fluids are referred to as mud' (Roscoe Moss Company, 1990: 155). Thus, this technology is orientated into two main purposes; seals and slurries in the drilling processes, and overall, this type of activity largely involves the application of chemical process engineering to drilling, where several technical engineers

from at least three disciplines (Chemical, Mechanical and Geological Engineering) are needed to deal with such activity.

The reflection of how ServCo deals with and runs this technology in the Libyan market provides a useful insight into the study of the development path of its business growth. The Libyan office has grown in scope, tasks and ambition in a short time period between 2003 and 2008, and it is beginning to take a significant role in efficiently applying and developing technology. Figure 6.1 shows the phases of this development both in terms of what has been achieved so far (2008) and the expected next phases.

Figure 6.1 Development paths of ServCo in Libya



While ServCo started with a sales agency as many TNCs commence, it provides an interesting and informative case, because it supplies products that require technical services and technological advice and consultation. From Figure 6.1, it can be noticed that ServCo has developed its activities through several phases. Phase 1 may represent selling spare parts of specific technological products to be used in the field of drilling fluids with technological advice as product support and services after selling. This kind of activity has certain technical dimensions based on the nature of products and services provided; salesmen must have technical knowledge about these products and services, which can help customers in using them correctly and effectively. Thus, one could argue that these supply processes involve functions that focus on the ease of use and efficiency, fixing related technical problems and sending feedback on these issues. Therefore, even if it is assumed that many attendant technical problems can be supplied as solutions from the

headquarters, there are still some problems and other issues which need close examinations and direct input at the local level.

Although this initial stage does seemingly require only limited assets even from human resources and technical knowledge, some specific technical skills and knowledge have to be employed in order to operate as a seller of these spare parts. Further, some specific technical knowledge would be generated as a function of fixing technical problems, where the technical team can learn new techniques from these processes. Overall, selling technical spare parts with supervision of the whole processes of use can imply that it results in some transfer of corporate R&D activities. A large body of tacit knowledge can be generated during these processes, which will contribute to stimulating the technical knowledge that may be used in the products development and can also contribute to creating new innovations.

With the increase of exploration operations in Libya, ServCo found a chance to increase their sales in the Libyan market. Consequently, with this growth in sales, it is definitely expected to need more technical knowledge involvement in solving technical problems and helping customers in using its products and services. This process of technological development has pushed ServCo to open a small laboratory to investigate technical issues, mainly relevant to the local environment (Phase 2). In this regard, BD manager states:
"We have now a small laboratory in Libya for conducting some studies and research, and complicated technological phases are usually sent to Aberdeen office in UK" (*Source:* BD manager interview).

This statement supports the tendency for the potential growth in the level of the Libyan office's operation in terms of corporate R&D activity. As can be noticed that activities of this office have been developed from an agency for selling spare parts to establishing a small laboratory, conducting experiments and tests associated with practicing technologies of drilling fluids. The establishment of a small lab in a host country indicates the transfer of corporate R&D activities in order to engage in some specific technical analysis and resolve technical problems. However, considering the small lab's characteristics, R&D activities could be run by ten or fewer analysts and perform a limited suite of analyses for some technological activities. This can also reflect the low intensity of R&D activities in terms of staff involved and limited outputs in general.

Based on the kind of spare parts related to drilling fluids, the people who are involved in these activities are likely to be chemical and mechanical engineers and geologists and not high level experts. If anything, they are technicians and technical staff. An indication of this is that all complicated technological phases are usually sent outside Libya. Hence, the efforts of this laboratory can be described as a small scale activity and technologically non-advanced. However, this can be considered as a starting point for further development into further innovative and technological efforts. This small laboratory can be considered as a technology support adaptation lab responsible for providing some technical solutions and contributing to adapting products to the local market.

Accordingly, because of due involvement of ServCo in these processes, some new specific knowledge will be generated. This could give ServCo an opportunity to expand its technological knowledge capability within these operations even though they may be very modest at present. Based on the cumulative experience from operations run in the labs with utilising the technological experience of the whole company, the Libyan office was willing to provide outcomes that are highly reliable and maintainable. As a result, its outcomes exceeded its customers' expectations and earned their trust. For these reasons and with the potential of the Libyan market, ServCo was motivated to develop its technological efforts by attempting to apply some new technologies, which led to the emergence of Phase 3.

One of the success stories was to market a new technology in Libya that the company successfully performed in a high-profile job for a major client. 'Logging suites were comprised of some specific types of services. The job marked the launching of both MREX and CBIL tools with this particular client. Forty-two RCI pressure tests, three samples, MREX logged in PP+naft mode and 34 sidewall cores were completed in reservoir section' (*Source:* Company's website, accessed on 20/01/2009). Further, ServCo indicates that; 'The client expressed satisfaction for the flawless, safe and efficient execution of the job in addition to excellent data quality. Further, well site and office geologists were very impressed by the MREX results and CBIL images and have decided to run them on subsequent wells' (*Source:* ServCo Report 2006).

These achievements in applying new technologies can give ServCo the trust to rely more on the Libyan office to achieve some significant technological products and services. This success would motivate ServCo to increase the intensity of R&D activity in Libya. It has done so, when its technological activities were developed into Phase 4 of design and

developing sub-systems as suggested in the last statement. In addition, the decision to run them on subsequent wells can imply that these technologies have been successfully applied and are targeted to apply in other projects, with a possibility to be in other markets. This means that in this stage, the technological effort is regional orientated. It is clear that all these activities are on the development side. And this is not surprising, especially that it goes in line with the rest of the literature, which has been mentioned by Dunning (1992), when he points out that R&D activities undertaken by foreign subsidiary units are primarily development related, including product, material, or process adaptations or improvements. However, despite these developments in the utilising and applying of advanced technology, there is not so far a separate R&D unit in the Libyan office, which made conducting significant R&D activities to be still somewhat limited.

Given that there is a need to develop continuously the drilling techniques, and Libya is one of the potential markets, ServCo has a strong desire to increase the level of R&D operations in Libya. BD manager explains this situation by saying:
"We are one of the leading companies in the field; we want to increase the size and quality of corporation. In fact we have three generations of the inventions in the field of drilling fluid. Thus, we have some new technologies in the field. We intend to do R&D project at independent level, and we prefer to work separately" (*Source:* BD manager interview).

This statement suggests that ServCo has a desire to increase the size of its technological sophistication, especially that some new technologies are needed to be successfully applied. This inevitably needs a high R&D capability. Based on the nature of developing and designing sub-systems, these processes need high R&D capability to meet the transforming requirements into working designs. Such activities undergo extensive analysis, specific testing and need high technical facilities with a high level of expertise as well as scientists. This could create a scope to establish R&D unit in Libyan in the near future. It is to run specific operations on these new technologies and others, which are intended to be globally used. In addition to that, evidence shows that TNCs have long been driven by the need to be close to the markets they serve to respond to market demands more quickly. Further, evidence suggests a direct linkage between the location where firms focus their sales efforts and where they conduct their R&D activities. Thus, with increasing growth on demands of ServCo's products in regional markets, there would be a high tendency to establish R&D unit in the Libyan office (future phase).

From the previous analysis, it can conclude that there is a tendency to increase and diversify the size and scope of the company's operations in Libya. This is particularly that the Libyan office had considerable developments in a short period of time. ServCo has also been involved in advanced technological applications and later going further to design and develop sub-systems. These developments might be attributed to its experience that already exists on the Libyan market and could be explained by the increasing demand on the company's products as high quality and advanced technology products. It could be also for providing these products and services at the right time.

6.2.6 Rationale and strategy of corporate R&D activities in Libya

The literature review indicates various motivations and reasons that might be behind conducting R&D activities outside the home country. From the ServCo's perspective, it is necessary to locate some degree of R&D in Libya to facilitate its branch service and adaptation of products to the local conditions. When the customers are satisfied with these products, they may use them in other locations in other countries, especially in similar applications. Thus, the rationale is that as the demand on products is growing, increasingly sophisticated, R&D facilities are useful in helping the branch to adapt existing technologies better to local needs and may develop them to be used in other locations.

For ServCo, some of the main reasons that were behind its involvement in current corporate R&D operations have been pointed out by BD manager as follows:

"To have more knowledge about existing businesses for developing these businesses and providing better services and exploring new techniques (there is an increasing demand on how it may increase oil production throughout improving the production techniques) one of these knowledge is related to the drilling techniques" (*Source:* BD Manager Interview).

This statement implies that these reasons go in line with the implications for knowledge spillover and knowledge seeking perspective. Indeed, there is no doubt that knowledge could be the enabler of growth in any firms, because the creation of technology is the result of knowledge accumulation. This is inevitably needed to enhance absorptive capacity and investment in new knowledge sources, where the R&D personnel represent the most important absorptive capacity, and to compete globally, external knowledge is the essential knowledge source. Thus, for ServCo to secure a high ability to access the local knowledge environment, the rationale is to establish R&D unit in the Libyan office.

Moreover, with the intensity of exploration and drilling operations in the Libyan market, it can be concluded that supplying new technologies to customers is one of the main reasons for conducting R&D (Market seeking). This is according to what BD manager says:
"We have realised that Libya is one of boom markets in oil industry, so the initiative was from the company when it provided offers regarding its possibilities to implement R&D projects" (*Source:* BD manager interview).

This statement suggests that the R&D activities conducted in the Libyan office are driven by the company market orientation on R&D abroad. ServCo is a scale-intensive firm (technological services industry), and technology supplier which tends to concentrate on process innovation and incremental product development and exploit its R&D capacity as business. Accordingly, the rationale to locate corporate R&D activities in Libya is the need to help support customers in the implementation of technical solutions or the adaptation of bespoke products. In this respect, it is worth mentioning that the classification of ServCo is based on Pavitt's classification, when he refers to it as this category all firms are process technologies and those tend to have capabilities in engineering, design and manufacturing. Also, many science-based firms belong to it, where chemical companies are usually a case in point (Pavitt, 1994, cited in Trott, 2002: 72).

This view is supported by another reason, as BD manager indicates that:
"*In Libya, the company does undertake R&D operations for resolving existing technical problems in the drilling processes. This is in form of insuring contracts for technological services with local and foreign companies in Libya"* (*Source:* BD Manager Interview).

This statement shows that market seeking is applied to ServCo's rationale to conduct corporate R&D activities, and technology seeking might have a role. This indicates that it may employ local talents more familiar with these technical problems. At any rate, it is more linked to market seeking as the reason to resolve technical problems, which are usually related to services after selling. However, it cannot be ignored that it is still serving as a knowledge seeking which is highly involved in technological knowledge issues. It would be true to expand its technological knowledge capability within these operations, especially if these operations resulted in significant solutions to complex problems.

Furthermore, technology seeking could be seen from initial scientific collaboration. In this respect, it seems to be that ServCo is beginning to exploit some local technical talents

within a simple collaboration, which has recently been utilised in the Libyan office. As has been mentioned in Section 6.2.2 with regard to wining one of the 2005 World Oil Awards, in which, three academic institutions have benefited from this award. Among these institutions was the Academy of Graduate Studies in Libya. This was as a programme gathering hundreds of submissions from points around the global (*Source:* ServCo's website, accessed on 20/01/2009). Thus, this kind of collaboration will allow ServCo to access the local pool of talents and could attract some of them to work with it later.

In this context, there are some attractive factors in the Libyan business environment that could be as motivations to attract ServCo to conduct corporate R&D activities in the Libyan office. Some of these motivations have been addressed by the BD manager, as he says:

"There are some good points which can be addressed. For example, support corporate R&D activities by allowing research equipments to enter free. Also, a special tax regime has been issued for encouraging FDI in oil and gas sector" (*Source:* BD manager interview).

This can help and encourage FDI involving R&D inflows into Libya in general and in the oil and gas sector in particular. According to these advantages, the investment climate might be desirable to attract ServCo to conduct more R&D activities in Libya. In addition, ServCo has realised some enabling factors that Libya has and which could in general motivate TNCs to conduct corporate R&D activities in Libya. These factors were monitoring their potentials on several dimensions, as BD manager stats:

"Libya is a politically stable country. Also it has some ability to finance corporate R&D projects if there was a desire for that. Furthermore, there are research centres that we might be made a partnership with and exchanged knowledge in between" (*Source:* BD manager interview).

It is true, as some empirical evidence suggests that the availability of R&D funds can influence R&D investment decisions. It usually has a positive impact on attracting FDI related to R&D. In addition, there is no doubt that the existence of excellence centres would be an attractive factor to TNCs to conduct corporate R&D activities outside their home country, especially when these activities are driven by a technology seeking. Further, the political situation has, in general, a big influence on attracting any kind of FDI.

From a regional development perspective, the rationale for corporate R&D activities in Libya could derive from some special advantages that Libya has over other neighbouring countries in the region. This is what BD manager says:

"I think that Libya can be differentiated from other neighbouring countries in attracting FDI involving R&D, because there are differences in terms of desire and security and safety" (*Source:* BD manager interview).

Libya has been considered a more secure and safe place than other neighbouring oil producer countries in the region (such as Sudan, Chad, Egypt and Algeria). In addition, with the recent changes in the Libyan foreign policy, Libya exhibits its high desire to sign scientific and technological collaborative agreements with developed countries. However, it should be mentioned that although these three elements are very important to run any business, empirical evidence suggests that they are alone not enough to attract FDI involving R&D.

As Libya seeks to improve policies and management of petroleum industry, and in line with these developments to improve and increase the capability of this sector, ServCo attempts to exploit all available opportunities concerning corporate R&D activities in its industry field. These initiatives have been explained by BD manager as:

"When there is a chance to obtain work, we usually attempt to prepare an integrated work team and we invite the customer to participate in discussing the issues related to that work, and then consider its opinions and we give it an opportunity to exchange the expertises and in some cases, we make a partnership with it" (*Source:* BD manager interview).

This statement could imply that ServCo adopts a strategy which has been established on the marketing relationship perspective. It can support an idea that ServCo has been driven by the market seeking in general, which directly has an impact on corporate R&D activity too.

6.2.7 Possible obstacles to corporate R&D activities in Libya

Given that the characteristics of business environments in which TNCs prefer to undertake corporate R&D activities, it appears to be that there are several possible obstacles in the Libyan business environment, which may hinder the evolution of corporate R&D operations in Libya. Generally, the aspects of the future of corporate R&D activity in Libya depend upon several different policies and institutional frameworks, which are

related to focusing on building and upgrading technological sophistication of the local companies and developing and improving the domestic R&D capability. In addition, actions on improving the general investment climate are also needed. These implications have been derived from the ServCo's point view, when DB manager has to say:

"To benefit from the globalisation of R&D activity, I think that Libya needs policies to develop and improve the education system at all levels. Also, FDI policies should include possibility to facilitate process of partnership between the local and foreign companies" (*Source:* BD manager interview).

In this context, Libya has made some improvements in terms of the general investment climate such as adopting some policies related to the market orientation, taxation regimes, improving infrastructure, and others. However, the evidence shows that the implementation of these policies faces many challenges. First of all, as the statement above suggests the inefficiency of education system is at all levels, which means that the country lacks good skilled professionals and talents. It goes in line with the World Bank's observation, which indicates that Libya still lags behind many countries in the region in terms of the quality of the education system (The World Bank, 2008b). It also confirms that the relevant findings about the Libyan education system indicated in Chapter Four. In addition, another obstacle is the weak linkage between academic institutions, research centres and other economic sectors (NBRD, 2007). Thus, it is clear that there is a big weakness in NIS, which represents one of the challenges that Libya faces in order to attract foreign R&D activity.

While it has been mentioned that Libya strives to improve the climate of investment environment, it seems that there are some obstacles related to institutional issues that affect the FDI. For example, according to the regulations and laws within which the work of foreign companies are regulated in Libya, ServCo sometimes faces some pressures from NOC concerning the sharing of work with the local oil companies or even to do some research work at the Oil Research Centre. Furthermore, it has been addressed that the extreme matter is related to investment policies, as BD manager says:

"In fact, NOC restricts constraints on the company work. For example, we have to employ some Libyan workers, and then we find that they are not qualified for those jobs, so we just give them salary and say to them stay in you houses!. This is on the base of that there are no institutional mechanisms to resolve this issue" (Source: BD manager interview*).*

More precisely, the real situation goes further in its implications. If one looked at the roots of the matter, a complex and mixed picture would be noticed. It is mainly rooted in institutional arrangements. As I have observed, a big paradox could result from analysing the dimensions of whole picture. While ServCo complains about the lack of qualified skills of workforces who have been employed according to the response to FDI contracting conditions with the NOC, it has also noted that the NOC complains about the phenomenon of churning many qualified personnel from its companies to foreign oil companies. This has led it to raise this issue by policy-makers in an attempt to resolve this matter- but unfortunately in the wrong way- by implying to issue a law to hinder the movement of personnel into foreign companies. Overall, this statement could imply that with the notable degree of staff mobility, the problem becomes rather than a lack of qualified personnel. They are the wrong policies to deal with inducing foreign companies to local professionals. Furthermore, it is not safe to deny or ignore the influences of supply side factors involved in the issue such as lack of qualified staff, which once again could reflect on the quality of the Libyan education system' outputs.

Indeed, some of these obstacles can go in line with Chazan (2009), when he points out that with regard to oil companies, Libya is a difficult country to operate in. He provides some examples of that, as the oil companies often have to pay heavy customs duties on imported equipment, despite the exemptions written into their contracts. Onerous labour laws require them to hire Libyan nationals even when they lack the appropriate skills. Signing a simple rental agreement for an office can be hard, because of the chaos of competing ownership claims.

In this context, one can expect that there is no doubt that such policies will have negative impacts on the nature and size of R&D collaboration in Libya by ServCo. The evidence suggests that a lack of professional skills among domestic workers usually results in TNCs avoiding to involve those workers in their business. On the other hand, this could mean that the host country would miss benefits from a good access to the knowledge capability of these companies.

Other several obstacles have been mentioned by BD manager which include different institutional, political and cultural dimensions. In general, he thinks that:

"*There are some disadvantages such as problems related to obtain entry visa. Also, the companies are working under international agreements. Thus, when there is a problem in relation between*

two countries, it may affect the corporate projects. For example, there are some companies only demand allowing them to conduct freely research, and although there would be some benefits for both, company and the host country. In Libya, for political reasons, they do not allow companies to do that. Moreover, where foreign companies would like to help in building the local infrastructure, they sometimes find that corruption is surrounding" (*Source:* BD manager interview).

Therefore, Libya needs to enhance its competitiveness position by rethinking about existing policies in many different areas, from S&T to the infrastructural environment in general. From the analysis of previous statement, these obstacles can be grouped into three categories; the first one represents institutional obstacles, which includes, for example, problems related to the entry visa. Second one represents political and policy obstacles, which includes, for example, the dominance of political decision on the business environment as in some cases the TNCs are not allowed to do some research, just for political reasons. This part of the statement can reflect two obstacles; one represents that there is planning myopia in policies, both FDI policy and S&T policy to benefit from these potential knowledge spillovers, and the second represents inefficiencies in the legal frameworks, which should have not considered the matters of international relations on account of development and growth issues. The third one represents cultural and institutional obstacles, which include, for example, the corruption in most institutions and government agencies. In fact, no one in Libya can deny the existence of managerial corruption at a high rate. This is tending to grow, especially that Libya has been considered to have a low rate of transparency on the international transparency indicator (see Lambsdorff, 2009: 400). Thus, there is no doubt that this will be a strong challenge for Libya to attract not just foreign R&D activities but any kind of FDI.

Some of these issues are interacted with different social and cultural factors, with which one can say that it will not be easy to change for some time. The problem is that these factors will have a strong negative impact on implementing all policies. This could imply that these negative phases will hinder the opportunities related to the R&D globalisation process in Libya. Another significant obstacle has been mentioned by BD manager that the current management system has a big influence on corporate R&D projects. He says:
"For Libya, I consider one of the major future R&D collaboration challenges is management in Libyan institutions" (*Source:* BD manager interview).

There is widespread acceptance that management is an issue on any collaboration project. Corporate resources need to be managed properly by sharing risks and benefits. Generally, while Libya has achieved some improvement in performance of its management system, it is true that there is still a managerial illiteracy in terms of the different aspects even at the leadership level in some institutions. This is a result of some incorrect policies and culture and social factors. In many cases, there are no clear criteria to select managers and political and social advantages come on account of the effectiveness. Further, this issue can also apply to official levels. Thus, this will definitely be one of the challenges that Libya faces to attract and benefit from available opportunities related to corporate R&D activities. In other words, this can reflect the fact that Libya actually needs to combat the managerial illiteracy to promote inward FDI in general.

Irrespective of these disadvantages, it seems that it cannot be rely much on the advantages that were mentioned in the previous section to attract a high level of FDI involving R&D, as there is still a little exploitation of these advantages. This can be seen through the technological trajectories that have been adopted to foster the domestic R&D capability. The evidence in Chapter Four shows that there is still a weak linkage between the industry sector and the research centres and other academic institutions. In addition, the expenditure on R&D activities is still under the reasonable level that should be. Overall, with the current Libyan R&D capability, it is unexpected to see many R&D collaboration projects in oil technology industries in Libya. Especially that, foreign companies in general cannot rely much on this capability, which can lead to conclude that the development of the R&D activities of ServCo in Libya might relatively be linked to the development of Libyan R&D capability. This situation has been described by BD manager when he had to say:
"I think that the domestic capability of R&D activity is very limited. For example, if there are Libyan companies or Libyan research centres which have the ability to analyse our samples, why do we send them to outside of Libya" (*Source:* BD manager interview).

Thus, based on potential causes of this situation, the infrastructural dimension can represent another obstacle that may make TNCs not very interested to undertaking corporate R&D activities in Libya. Given the consideration to the fact that there is a lack of a technological infrastructure base in Libya, any foreign company may face increased obstacles in internal knowledge transfer due to inter-unit geographical and technological distance.

6.2.8 Conclusion

ServCo is really a technology-based company, and it conducts some sort of corporate R&D by some facilities, mainly small labs. The analysis of the development path (Figure 6.1) to its technological activities in Libya demonstrates that it has upgraded these activities in a short time and in a wide range, from developing technologies to applying new advanced technologies. They involve advanced technological applications and later go further to design and develop sub-system. However, corporate R&D activities are still modest and limited to a large extant in fixing technical problems and experiments to help customers use its products and services effectively. The significance associated with conducting these activities is that ServCo relies on them to serve the region. It is now being caught up the Phase 5 (Figure 6.1), and trends indicate that its R&D activities may grow in the coming years.

Evidence on the relative importance of different global R&D strategies in Libya shows some strategies have been applied by ServCo. Libya, as one of the highest oil producing countries, has made the market seeking the main driver for corporate R&D activities. In addition, knowledge, and technology seeking can have a role. This is relatively related to the nature of its products and service provided in Libya. On the other hand, the role of national polices have a limited attraction and promotion of R&D activities in Libya.

From the ServCo's perspective, there are many obstacles hindering corporate R&D activity in Libya. These obstacles differ from political, institutional, policy and cultural obstacles, where culture here can take a wider definition to include the culture of innovation. The main obstacles mentioned are; issues related to entry visa, a lack of skilled professionals and talents, a limited domestic R&D capacity, planning myopia in FDI and S&T policies, a managerial illiteracy at different levels, inefficiencies in legal frameworks, the corruption at different levels with a low rate of transparency and the low quality of education system.

6.3 ProdCo's case study

6.3.1 Introduction

ProdCo works in the Libyan market in the field of oil and gas. Its branch has been working in Libya for more than five decades. The main office is located in Tripoli, Libya's capital city, while it has several operational units distributed in different geographical parts

of Libya. ProdCo is one of the leading companies in its field, and it has maintained its position even during the nationalising period (1970s) when many foreign oil companies left Libya. ProdCo works in Libya in three different engineering fields, which are different in nature from that of the first case' company activities. Generally, the case study highlights aspects of ProdCo's divisions. General background about its significant operations and business developments is discussed and ProdCo profile is represented. In addition, a particular emphasis is placed on the function of corporate R&D, its technological activities in Libya and its point of view toward the possible obstacles which may hinder its corporate R&D activity in Libya.

6.3.2 General background on ProdCo

ProdCo is an Italian company in origin. Indeed, it is a company incorporated and with three global headquarters, one in Rome city and two are in Milan city where the largest industrial region in Italy. It can be described as a TNC, as it is a famous worldwide company operating in more than 70 countries, with a staff strength of about 76,000 by 2007, and approximately 49% of its workforces are outside the home country (Italy). ProdCo identifies its mission as a major integrated energy company, committed to growth in the activities of research, production, transport, transformation and marketing of oil and natural gas. Indeed, it is a vertical integrated company to the whole of oil and gas industry. In most of these businesses, it has a strong edge and leading international market position. Its history dates back to the 1920s. Its incorporation of exploration activities began in Italy and foreign ventures initiated in (Romania, Albania, and Iraq) and after a few years, its distribution network was created to operate different kinds of business, from exploration and production to the refining and petrochemicals business started in 1936.

Its high capability allowed it to work in different forms across its subsidiaries. ProdCo has a long corporation history in both developing and developed countries. For example, in 1936, it provided a direct supply of crude oil for Soviet Union. In 1958, it established fuel distribution facilities in Libya. In 1961, it built its first refinery in Africa in Morocco. In 1964, it took part with some other oil companies in the search for oil in the North Sea, UK, and in 1965 commenced its operations in Norway. In 1998, it commenced its operations in United States in the field of exploration and production. Thus, it is safe to indicate that ProdCo is familiar with working in various business environments around the world, which in some part could reflect the good dynamic capability it has.

ProdCo has undergone several transformations in the past, through many M&As, which led to the creation of the present company and gave it this dynamic capability. With the new millennium, ProdCo has put one of the main strategic objectives for the coming years to be developing proprietary technologies to support its growth process. Based on this orientation, in 2001, ProdCo acquired Lasmo, which has advanced technology in producing oil, and as a result of this acquisition, it strengthened its position in key areas, such as North Sea and North Africa, and has given it the ability to establish a significant presence in the Asian market and Venezuela. In 2006, ProdCo bought one of the famous companies in the field of oil engineering, and as a result of this integration it has become a world leader in the engineering and oilfield service constructions, both onshore and offshore. Therefore, these M&As and others have made it one of the largest companies in the oil and gas and energy industry around the world.

From a marketing perspective, ProdCo provides the worldwide oil and natural gas industry with manufacturing of over 250 products and services, and it is the world's major producer of some of these products. These products and services are provided by ProdCo's five divisions. Table 6.3 shows briefly its divisions and the diverse aspects of their main tasks:

Table 6.3 The nature of tasks of the ProdCo's divisions

Division	Aspects of activities	Main advantage
Exploration and Production	Oil and natural gas exploration, development and production	Strong competitive position in a number of strategic oil and gas basins in the world
Gas and Power	All phases of the gas value chain and power generation activity.	Ability to generate substantial earnings and cash flow.
Refining and Marketing	Refining and marketing of petroleum products.	Vertical integration with upstream operations.
Engineering and Construction	Providing engineering and oilfield services.	Designing and executing world scale projects.
Petrochemicals	Producing several petrochemical products	Excellent developments and improvements, mainly in areas of (styrenes and elastomers)

Source: (The ProdCo company's website, accessed on 02/12/09).

It is clear that its operations are vertically integrated from exploring and searching for oil and gas as raw materials to marketing final products use for generating the energy. This may call for having high technological sophistications in several disciplines. At the current state of knowledge, it is necessary to mention that ProdCo has been involved in a wide range of technologically innovative projects. Some of the recent technological achievements are (*Source:* ProdCo's annual reports, 2006- 2007):

1- Advanced Drilling Systems and Well Testing

ProdCo has developed significant industrial applications of innovative technologies that enable them to drill highly complex wells with greater operating efficiency. This project was developed by ProdCo in a joint venture with Shell.

2- ProdCo has developed technological solutions aimed at minimising the environmental impact of the exploration, refining and utilisation of hydrocarbon. For example, referring to the CO_2 conversion in energy vectors via biofissation, it has evaluated the opportunity to test it on a demonstrative scale.

3- ProdCo has completed a research project on 'ADBlue'. This represents (Water solution with urea at 32.5%), which uses to remove nitrogen oxide (NO_X) from the exhaust gas of diesel commercial motors with catalytic disposal for the selective reduction on NO_X.

Thus, it can be noted that these projects have aimed at developing and improving specific technologies or innovating new ones. Although ProdCo might be formed around few technologies, today it makes use of hundreds of technologies, with some developed in-house R&D and others through collaborative R&D projects. Accordingly, all these indicators can clearly reflect that ProdCo is a technology-based company.

Other aspects that reflect ProdCo's high capabilities include delivering excellent financial and operational results. ProdCo has achieved an average year-on-year growth in profits of approximately 5 to 8 per cent. The net profit increased from €8,788 million in 2005 to €10,011 million in 2007. It is sensible to mention that during recent years; approximately more than 50% of its revenues have come from sales and activities outside of Italy (ProdCo's annual report, 2007). These revenues have been effectively deployed for investing in technological activities and R&D capacity (see Table 6.4).

Table 6.4 The expenditure of ProdCo on R&D and R&D staff during recent years

Years	Expenditure	Employees	Years	Expenditure	Employees
2001	€175 million	1390	2005	€204 million	1420
2002	€203 million	1500	2006	€222 million	1160
2003	€238 million	1400	2007	€208 million	1082

(Source: The ProdCo company's reports).

Thus, it can be noticed that significant amounts have been spent on R&D, where the number of R&D staff has reached more than 1000 during recent years. It has indicated that 47% of these amounts are usually directed to Exploration and Production division (ProdCo's report, 2007). Moreover, data from the 2009 EU industrial R&D investment Scoreboard shows that ProdCo is ranked as 85 in ranking of the top 1000 EU companies by level of R&D investment. In 2008 its R&D investment was €216 million and R&D/Net sales ratio was 0.2% and change 08/07 was 3.8 (European Commission, 2009: 58). In this context, available information confirms that global R&D intensity (R&D expenditure as a

proportion of sales) was broadly similar during 2007- 2008 at 3.3% of sales (BIS, 2008). This is the global average; but it differs from sector to sector. For example, in the oil and gas sector, it has historically observed that oil and gas operators companies spend less on R&D than technological services suppliers companies (Neal *et al.,* 2007). Overall, this still indicates that the expenditure of ProdCo on R&D is higher among operating companies in the oil and gas industry.

The significance of this expenditure and ProdCo's commitment to R&D activities can be seen from the wide range of its patent capacity. For example, in 2006, 53 patents were documented, 39 of which were for products and 14 for processes. These patents are increasing, 26 in 2005, 53 in 2006 and 69 in 2007 (*Source:* ProdCo's annual reports, 2005, 2006, 2007). This R&D intensity has resulted in obtaining several prizes for its leading innovative achievements. In 2008, ProdCo obtained The National Prize for Innovation (ProdCo report, 2008).

6.3.3 The function of corporate R&D: beyond the boundaries

ProdCo always intends to effectively manage one of the biggest challenges for international oil companies, which is recently the need to meet rising energy demand while mitigating the environmental impact deriving from the use of hydrocarbons and risks of climate change. This has led ProdCo to be continuously investing in technological innovations. The following statement demonstrates the recent directions of its corporate R&D; 'We are funding R&D projects targeting a more efficient exploration of renewable energy sources (e.g. solar, biofuels), the development of processes for the capture and geologic confinement of CO_2 (technically feasible but still requiring testing for proving efficacy, cost efficiency and safety in the long term) and biofixation of CO_2' (*Source:* ProdCo's annual report, 2007: 71). From a technical perspective, these objectives can be advanced only by ongoing R&D into all aspects of the exploration, drilling, completion, production, and engineering and construction processes. It is very clear that ProdCo should have engaged in a wide range of R&D activities in order to overcome this varied difference in R&D fields.

Considering the organisational R&D structure of ProdCo, its aspects represent that each of its business divisions has its own R&D department which engages in R&D associated with its operations located at corporate headquarters in Italy. At the same time, to support these R&D departments, each department has laboratories and core technology centres located in

different areas in Italy and some others located outside the home country, mainly in Europe. For example, corporate R&D activities of the Petrochemicals division is concentrated much at the Research Centre in Mantua which continuously updates the processes and the portfolio of the products and has a secondary unit at the Ravenna plant and core technology centre in the UK. In most of these technology centres, at any given time, more than 100 projects are active at various development stages from concepts to commercialisation. This clearly indicates the intensity of innovative projects, which can mean that this company is really a technology-based company.

As consequences of corporate R&D strategy, *"the company promotes technological excellence, based on the exchange of experience, expertise and know-how, as essential factors in competition and economic and industrial sustainability"* (*Source:* BD manager interview). For example, in 2003, ProdCo consolidated the new model of technological innovation with the aim of supporting growth and continuing expansion. This entails the integration of R&D skills with industrial applications, focusing innovation efforts on strategic processes capable of generating long-term competitive advantages and advanced performance systems (*Source*: ProdCo's website, accessed on 20/06/2009). One of its strategies to build a good corporate R&D capability is a merger with and acquisition of leading industrial research institutions and turns their capabilities into the company's R&D projects. It has recently acquired one of Italy's leading industrial research centres, which has been established since 1941, engaging in the R&D of innovative technologies in various fields of chemistry (catalysis, polymers and fine chemicals) and taking advantage of extensive competence in molecular modelling, organic and inorganic chemical synthesis, the production of new polymers as well as the technologies for their characterisation (*Source:* ProdCo's fact book, 2006).

The research centres' R&D activities are directly coordinated by ProdCo's Strategy and Development Department and 'many of them are carried out in collaboration with universities and research centres in Italy (e.g. the Polytechnics of Turin and Milan), in Europe (e.g. the Universities of Warsaw and Porto), in the United States (e.g. Massachusetts Institute of Technology), and (other research institutions in some countries where the company has involved working) with which the company has built, and intends to expand, an effective scientific network' (*Source*: ProdCo's website). In line with this orientation, ProdCo signed exclusive agreements with some technology leaders. For example, as part of the development of technologies aiming at the enhancement of fuel quality and at the conversion of heavy crude and fractions into light products, ProdCo in

2007 signed an agreement with Petrobras, which is the world's leading company in the large-scale production of bio-ethanol. The two partners have combined their proprietary technologies to jointly develop projects for the production of bio-fuels in other countries. In addition, they have been studying joint projects to assess the application of ProdCo Slurry Technology (EST) in Brazil in the framework of a broader partnership involving both upstream and downstream joint initiatives (*Source*: ProdCo's annual report, 2008).

Bio-fuels have assumed significant importance globally as the world addresses changing patterns in energy supply and demand (Muok, *et al*., 2008: 1), ProdCo is continuing to make progress on projects to develop bio-fuels. Here, it is useful to provide some examples of these research developments, but more useful it shows that ProdCo is internationalising its R&D activities beyond developed countries. For example, two of the largest corporate R&D projects being conducted in technologically underdeveloped countries are in Congo, when ProdCo signed two agreements in the early of 2008 and started working on them. The one is for the exploration and exploitation of non-conventional oil in bituminous sand in two areas; Tchikatanga and Tchikatanga-Makola, which covers 1, 790 square kilometres and show signs of enormous potential. While the next one is for introducing a Food Plus Biodiesel project, involving collaboration in plants to use vegetable oil from the cultivation of palms on approximately 70 hectares of land situated in the Niari region in the north-west of The Congo (*Source:* ProdCo's website). These two examples can demonstrate the emergence of new trends with regard to TNCs' strategies for biotechnology R&D, and began to carry out this new high technological research at periphery.

As the oil and gas sector expands into new frontier areas, and growing focus is placed on the development of increasingly complex projects, the availability of highly-skilled staff in R&D may become of critical importance. In this regard, ProdCo recognises the challenges related to the mobility of engineers and scientists. To ensure having good technical skilled staff, and spreading the innovation culture among its employees, it established Corporate University in Italy. This university manages orientation, recruitment, selection, training and knowledge management. It is ProdCo's institutional point of contact with the Italian and international academic world. Thus, there is no doubt that these processes represent another important element in upgrading ProdCo's technological and knowledge capability. They can contribute to supplying a significant number of the technicians and engineers. These processes support the trends towards an emerging global race for talents. By this kind of academic facilities, ProdCo facilitates the mobility of scientists and engineers.

ProdCo believes that corporate R&D activities are the key factor for future development, which it initiated to bring the integration of R&D skills with industrial applications. This is to make them applicable on platforms and to raise the R&D efficiency and effectiveness. Therefore, ProdCo is continuing in the reorganisation of its corporate R&D structures by proceeding with M&As and other forms. This is being carried out in an international R&D programmes with other major oil companies, supporting of partnerships with international universities and centres of excellence. Furthermore, the cooperation is also underway on R&D projects related to specific areas to boost ProdCo's technological innovations. Of course, *"the one of the distinguished elements of the company's R&D system is the ability to develop technologies, where much of ideas came from the collaboration with the most prestigious international R&D laboratories"* (*Source*: BD manager interview). Indeed, ProdCo has been working with a variety of open innovation enablers and sources of innovation, on which many of its new products and technologies are based, as a result of these collaborative efforts. In addition, it is going to internationalise its R&D activities even at periphery.

6.3.4 Emergence of ProdCo in Libya

The emergence of ProdCo could be associated with the discovery of oil in Libya during the late 1950s. ProdCo's history book reveals that ProdCo established distribution facilities in Libya in 1958 and later in 1965; an agreement was reached with the Libya government for the supply of natural gas. It has been operating in Libya since 1959 in the exploration field, when the Libyan government awarded this company Concession 82, situated in the south-east part of the Sahara desert, and the commencement of its production operations was in 1962. In 1966 a second agreement, Concession 100, was signed for an area next to Concession 82, and in 1968 the giant Bu' Attifel oil field was discovered in Libya by ProdCo, and came into production in 1972.

In the 1970s and 1980s, ProdCo signed several contracts and sharing agreements with NOC relating to onshore and offshore areas off the coast of Tripoli. One of the significant operations resulted in the discovery of the Bouri oil field, which represents the Mediterranean's largest oil field, and ProdCo regards it as a strategic oil field on the basis of large potential oil in this area. Since that time ProdCo together with NOC have developed and updated this field, and in 1995, the production reached nearly 150,000 bbl/d (24,000 m^3/d). However, this was later followed by a sharp decline to become 60,000 bbl/d (9,500 m^3/d) in 1998. This decline was largely as a result of the country's inability to

import enhanced oil recovery equipment under UN sanctions, which banned Libya from importing refinery equipment. The situation has improved since the UN sanctions lifted in 2003. This is an example where the technological activities of ProdCo in Libya have been influenced by those UN sanctions. This political factor has contributed to hinder the international transfer of technology into Libya.

Since the 1970s, ProdCo has realised the strategic importance of working in Libya and the opportunity to develop its operations there. This led it to placing more technological efforts into increasing and developing the size of its operation. For example, in 1971, ProdCo's new technology was applied in Libya, which enabled the first Libyan Liquefied Natural Gas (LNG) to arrive at the Panigaglia regassification terminal. 'It was the first contract signed with a foreign country in the liquefied natural gas sector and guaranteed the supply of five million cubic metres of LNG, corresponding to around three billion cubic metres of natural gas. Libyan gas was a heavy gas, which means it was made up of 70% of methane, the rest being other hydrocarbons such as propane and butane' (*Source*: ProdCo's website, accessed on 20/01/10).

This statement indicates that Libya is one of the main natural gas suppliers to Italy, and accordingly more emphasis is placed on developing its operations there to keep this strategic upstream of gas. This importance came from that Libya in 1971 became only the second country in the world to export LNG (The Oxford Princeton Programme, 2009). Further, under this early engagement in applying new technologies of LNG in Libya, ProdCo by joint venture with NOC has expanded these exports to Italy and beyond, where the gas flowed to the Italian mainland and then onwards the rest of Europe. This means that there is considerable room for growing Libyan gas production.

Based on the special relations between Libya and Italy, ProdCo has utilised this relationship to expand its operations in the Libyan market by gaining new contracts and licences in different fields, even during the sanctions and embargo period. For example, in 1997 an important discovery was made in the NC-174 area, in the Murzuk Basin, 800 kilometres south of Tripoli, which resulted in oil production starting up in the Elephant oil field in January 2004. In addition, to keep its projects in upgrading and technologically developed, ProdCo and NOC signed further agreements between 1996 and 1999 for projects to develop the Wafa gas, oil and condensate deposits, situated 520 kilometres

south-west of Tripoli, and the Bahr Essalam offshore field situated 110 kilometres north of Tripoli in the Mediterranean.

However, the considerable growth in its operations in Libya was more present after lifting the sanctions. Different phases of development in its operation have been applied, and several oil and gas fields have been maintained and updated. For example, in 2004, the start-up of the Western Libyan Gas Project, the first major project to valorise the gas produced in Libya through export and marketing in Europe. In 2005, one year after the start-up of Wafa onshore field, the first well in the offshore Bahr Essalam gas field came onstream within the integrated Western Libyan Gas project. In all these projects, ProdCo has applied and developed several advanced technologies in its operations.

In 2007, ProdCo signed a major agreement with NOC for the extension of ProdCo's mineral rights in Libya. The rights in the agreement include oil properties until 2042 and for gas properties until 2047, and the launch of large projects aiming at monetising substantial gas reserves and overhauling offshore exploration activities. Furthermore, this agreement has been enhanced by six exploration and production sharing contracts, which were signed in 2008 between ProdCo and NOC, thereby converting the original agreements that regulated ProdCo's oil and gas operations in the country. This deal definitely further strengthens its competitive position in Libya and will enable it to efficiently develop its long-life fields over the long-term through the application of its advanced technologies for maximising the recovery factors.

Libya is confirmed as one of the ProdCo's largest oil and gas producing countries and has indicated ProdCo had established a long-term strategic partnership with NOC granting it 50% of all its rights and obligations related. This would be an advantage and give ProdCo priorities to have the share of lion in the oil Libyan market. Indeed, ProdCo plans to develop its operations in Libya. 'The projects include re-launching export activities in areas with the most potential, exploiting additional natural gas reserves by increasing the capacity of the GreenStream gas pipeline by three billion cubic metres per year and constructing a liquefaction plant for five billion cubic metres per year of LNG equivalent, destined for global market' (*Source:* ProdCo's website, accessed on 10/07/2009). This indicates that a growing increase and diversity in ProdCo's operations in Libya is very highly expected. For that, the use of high-tech innovations are advised in these operations and its technological capability in Libya needs to be upgraded. Overall, the agreement

reached between ProdCo and NOC 'emphasises the solid nature of our business relations and establishes the basis for important industrial initiatives that will consolidate our company's objective of increasing production in Libya' (*Source*: ProdCo's website, accessed on 10/07/2009). Thus, this statement implies the potential influence of this agreement on diversifying and expanding ProdCo's activities in Libya.

In the light of these potential developments, ProdCo has recently focused upon conducting some reservoirs' engineering operations as BD manager states:
"We have started with exploration operation and then production operation in oil and gas. Recently we have been involved in reservoir engineering operations" (*Source:* BD manager interview).

Generally, this engineering process can be used for oil refinery, petroleum and petrochemical industries, edible oil industries, and lubricating oil industries. This can imply that there is a tendency for ProdCo to expand its operation in Libya into this process which covers the wide range of oil industries. Overall, one can argue that with the long-life agreement that ProdCo made and in addition to the bright successes that have been achieved, the company will definitely be conducive to developing more technological activities as well as technological diversification in Libya.

6.3.5 Development path of its business development in Libya

First of all, it is very useful to identify the nature of ProdCo's activities in the Libyan office. As it operates in the oil and natural gas extraction industry, its main operations include the exploration and production of oil and natural gas, and it also provides technical services in engineering and construction related to exploration and production fields. The oil and gas extraction industry can be classified into four major processes (EPA, 2000:15):

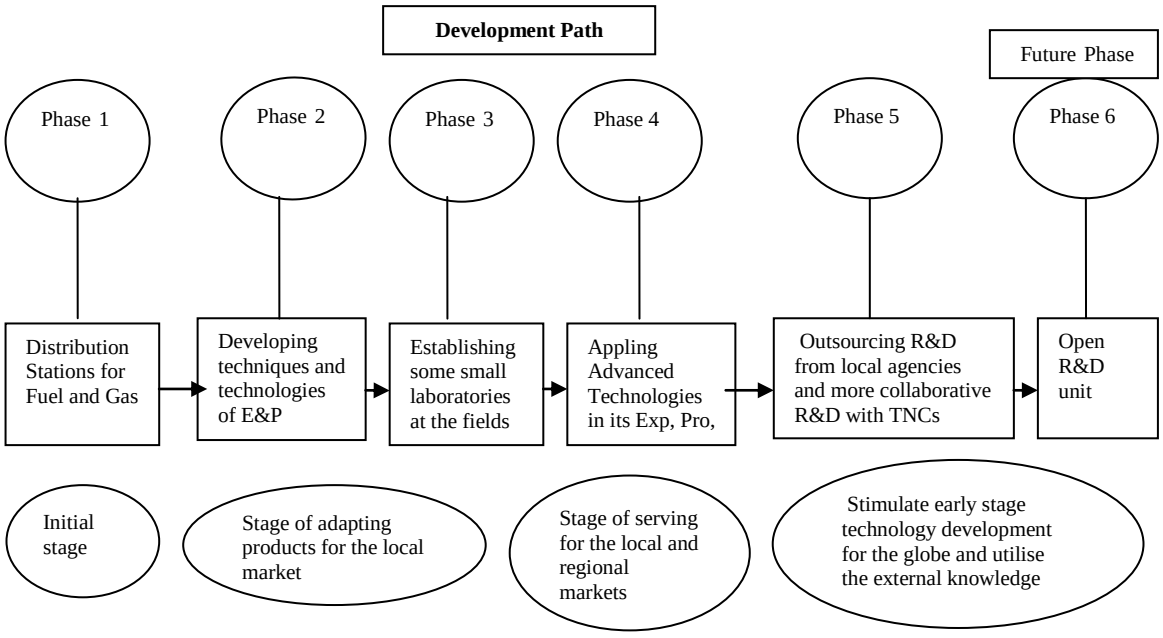
1. *Exploration involves the search for rock formations associated with oil or natural gas deposits, and involves geophysical prospecting and/or exploratory drilling.*
2. *Well development occurs after exploration has located an economically recoverable field, and involves the construction of one or more wells from the beginning (called spudding) to either abandonment if no hydrocarbons are found, or to well completion if hydrocarbons are found in sufficient quantities.*
3. *Production is the process of extracting the hydrocarbons and separating the mixture of liquid hydrocarbons, gas, water, and solids, removing the constituents that are non-saleable, and selling the liquid hydrocarbons and gas.*

4. *Site abandonment involves plugging the well(s) and restoring the site when a recently-drilled well lacks the potential to produce economic quantities of oil or gas, or when a production well is no longer economically viable.*

Thus, there is a long sequence of many processing steps required in order to extract the oil and gas from the land, and make it ready for use. These processes largely involve the application of geological and chemical process engineering to drilling, and construction. A technical team from at least four fields (Chemical, Mechanical, Geological and Geophysical Engineering) is needed to deal with this activity. Overall, the technological innovation in this field requires a long-term vision and a heavily significant investment in facilities, testing equipment, research scientists and application engineers (UNEP, 1997).

The reflection of how ProdCo has been running and improving advanced technologies in its operations in Libya can provide a useful insight into studying the development path of its business growth in terms of the technological dimension. The Libyan office has grown in scope, tasks and ambition, and it is expected to take a crucial role in efficiently applying and developing technology. Figure 6.2 shows the phases of this development, both in terms of what has the case achieved so far and the next phase expected.

Figure 6.2 Development paths of ProdCo in Libya



It can be seen from Figure 6.2, and as it has been mentioned in the previous section that ProdCo started its operations with sales activity as do most TNCs. Although its activity was distributing final products (Phase 1), it may provide an interesting and informative

case. This is partly because of the nature of these products, where they are orientated to both consumer and industrial markets, which means that introducing the brand of the company in a wide range context and then from this door, expanding its operations in a vertical integrating manner. This is what happened later.

From a technological capability perspective, the operation of the oil and gas stations does not need a high technological capability, because it does not involve extensive technical knowledge or expertise. It also does not involve highly complicated technological equipment and tools. However, at this stage, some kind of simple research activities might be expected to be conducted on the storage and delivery of these products in the local market. At any rate, this would not go beyond taking some readings on the related observations to this process. Although this initial stage does seemingly require only limited assets even from human resources and technical knowledge, specific technical skills and knowledge have to be employed in order to fix any technical problems in used facilities.

With the exploration of oil in Libya in the latter 1950s, when ProdCo already existed in the Libyan market with its oil and gas distribution stations, the conditions were very conducive to the expansion of its operations into the oil exploration field. In addition, ProdCo already had good experience in this field, and knew well how it could exploit the available opportunities in the Libyan market during that time. Since then, ProdCo has been expanding its operations to include more developed fields. This development represents Phase 2 (see Figure 6.2), when ProdCo started to use and later develop techniques and technologies of E&P. Indeed, once ProdCo started its exploration activities, it means that its technological activities have been upgraded at least to the basic level of intensity, both human resources and technological equipment. With the increase of its activities and the continuous development of exploration technology, in many cases, during that stage, it would find itself facing application of new technologies related to its operations. Applying new technologies often requires specific technological competences. It usually involves some kind of R&D activities, mainly experimental development and in some cases, even applied research. Although there is no first-hand knowledge to which extent these activities were conducted, it can be realised that ProdCo faces growing need for such activities, which has resulted in establishing small laboratories in the oilfields. This represents the beginning of Phase 3 in developing of its technological activities.

The purpose of establishing some small laboratories at its main fields in Libya can be linked to conduct prime experiments and tests associated with applying technologies of drilling and others. It needs to be done at the processes of applying technologies (Phase 3). As a result, more technological competences need to be supplied than in Phase 2. However, it is not probably at a high level of technological capacity. The simple tasks of these small labs have been described by giving the following example from the Bouri field: *"There is a small laboratory for the analysis and characterisation of air, water, mud, soil, sediments and waste. Further, it also maintains a level of excellence through participation in numerous national and international Inter laboratory Test circuits"* (*Source:* BD manager interview).

The nature of these labs' activities is very simple with limited technological capabilities. Thus, considering these small labs' characteristics, R&D activities can be run by 10 or fewer geological analysts and chemical engineers and perform a limited suite of analyses for some technological activities. This reflects a low intensity of R&D activities in terms of staff involved and limited expected outputs in general. However, the significance of these small labs can be derived from the nationality of staff, as the geologists manager says: *"These laboratories have a good technological experience to deal with some critical problems related to Libyan operational environment. In fact, most of engineers and technicians are Libyan and they have been working for the company for a long time"* (*Source:* BD manager interview).

This statement can imply that the local workers have an important role in the technological activities of the Libyan office. Therefore, with the current training programmes for young Libyan engineers, it will definitely contribute to upgrading the technological capability of this office to be involved in more levels of technological activities. Further, the technological experience of the Libyan office has been supported and upgraded by regular technical training programmes. This is in order to develop skills of technical staff and stimulate their technological knowledge to be more innovative. For example, as ProdCo continued the training and the development of young Libyan graduates, in 2007, 40 persons were hired and 20 graduates were selected to start their training in 2008. There is a regular programme for developing and improving the technical skills for new local engineers and promoting the technological capability of the Libyan office. Generally, with accumulating the practical experience, it is highly expected to promote its technological activities to include exploiting this experience to apply advanced technologies. Many

reasons can lead to that. The main one could be the growing competition in the Libyan market. This indicates the beginning of Phase 4.

In Phase 4 (Figure 6.2), there are significant technological efforts in terms of applying advanced technologies in Libya. It has been pointed out that 'In 2003 the company started an important R&D project aimed at developing innovative technologies and/or advanced processes able to manage the disposal and possible exploration of high amounts of acid gas and sulphur that are produced with hydrocarbons, while respecting safety and the environment. At the same time, other innovative processes were being studied for the injection of hydrogen sulphide into the field and its monitoring' (*Source:* ProdCo's Securities and Exchange Commission report, 2003). In this regard, it is important to mention that the developed technologies and techniques were widely applied in order to maintain and upgrade the oil and gas fields. For example:

"In the Bouri oil field, where the project for reducing gas flaring is being developed, the applied research is also being carried out into the possibility of developing the residual reserves in the field by drilling in the western part of the reservoir" (*Source:* BD manager interview).

In some cases, the technical nature of activities may require conducting the applied research in the oilfields. This could be during the resolving of technical problems or applying new technologies. Perhaps, to survive the marginal wells, it needs to conduct some sort of applied research and experimental development, which targets to keep them producing for more years. This means that technical reasons were behind this sort of R&D activities, because it comes in the light of developing the productivity of oil and gas fields. These activities are developmental research. This supports the idea that development activities are more globalising than research activities by TNCs. BD manager confirms this orientation by describing R&D activities of ProdCo in Libya:

"Much of R&D activities done are related to research of developing the techniques in the oil field, and they are mainly in the exploration and production fields. Also, experimental development activities are sometimes undertaken to maintain the oil fields for keeping them effectively productive. Indeed, some agreements with host countries clearly state conditions where the company has to do this kind of activities" (*Source:* BD manager interview).

Hence, these R&D activities are likely to be at a low level of technological activities and also do not often involve a high level of experts. If anything, R&D staff are technicians and

technical staff. An indication of this is that all the complicated technological phases are usually sent outside the company and even outside Libya. As BD manager mentions that:
"*Many complicated technical problems are resolved by our main R&D laboratories in Italy. Also, in Libya for example, in some cases, the company deals with some famous TNCs that provide technological services in the oil and gas industry. These are such as Halliburton, Baker Hughes, and Schlumberger"* (*Source:* BD manager interview).

The efforts of current labs can be described as a small scale activity and technologically non-advanced. Although ProdCo has been conducting corporate R&D activities for a long time in Libya, these activities can be considered as technology support adaptation activities. This conclusion can be supported by the BD manager's statement:
"The company has been involving in corporate R&D activities for a long time. The initiatives were sometimes from the company and in some cases were from our partners or others. In this regard, we have worked in different forms, but the main form was agreements of technical support to our partners" (*Source:* BD manager interview).

Considering the potential capacity for R&D efforts within the Libyan office, which may just allow some technical problems to be resolved, and providing opportunities for testing and evaluating new technology as well as providing viable technical solutions for applying technologies. However, there is an opportunity to collaborate with leading technology services suppliers in the Libyan market and to exploit the external technological knowledge that could spillover from them. This can be considered as a starting point for further innovative and technological efforts. ProdCo has done so, which represents Phase 5 (Figure 6.2) to its technological activities, as they are partially based upon R&D outsourcing. This is especially after ProdCo signed an agreement to extend its licences in Libya up to 2042 for its oil activities and up to 2047 for its gas activities. Accordingly, the plan for ProdCo expanding its operations in Libya includes implementing important initiatives in the gas sector, aimed at supplying the local market, and developing the Mellitah hub with programmes to increase the capacity of gas exports. In addition, ProdCo intends to concentrate its efforts on maximising production from its established deposits by applying advanced technological programmes, introducing more sophisticated technology for the assisted recovery of hydrocarbons (injection of CO_2 and water alternate gas), and commencing a new drilling campaign in nearby fields (*Source:* ProdCo's website, accessed on 15/07/2009).

These technological activities need a high level of technological capabilities which may lead to increase the size of corporate R&D activities. In this respect, the BD manager admits that there is a desire to increase the size of corporate R&D activities in Libya, but has linked it to some conditions. He says:

"Yes, the company is willing to increase its corporate R&D activities when there is a need to do that, especially when some specific problems have occurred. The level of these activities may differ from time to time, from charging of professional person to charging of specialised company in these problems. In fact, the situation is depended upon the nature and condition of the problem" (*Source:* BD manager interview).

This statement indicates that ProdCo relies in some circumstances on external resources for supplying it technological services. As mentioned in the previous statement, there are some leading TNCs in the field of supplying technology services. In addition, ProdCo deals in some cases with local research centres, mainly, the Oil Research Centre, especially, after the company made a partnership with the ONC, and it began owning a big share in the Libyan office. This would have impacted on the corporate strategy of the R&D activity. The situation and conditions of cooperation to exploit available opportunities in conducting corporate R&D activity have been explained by the BD manager as follows:

"To exploit available opportunities concerning corporate R&D activities in Libya, our company attempts as much as possible to exploit the available possibilities in relevant Libyan research centres and collaborate with them to fix some technical problems. By the way, ONC as a partner does not allow the company to take any kind of technical research that can be locally done. In this regard, the shearing agreement gives a right to ONC to check the nature of required research works and give approval to be conducted outside Libyan research centres" (*Source:* BD manager interview).

To determine the technological level of corporate R&D activities conducted by ProdCo in Libya, it can be concluded that these activities are still limited, for example, in dealing with simple technological issues. The following statement can support this implication:

"Many complicated technical problems are resolved by main R&D laboratories in Italy. Also, in Libya for example, the company deals with some famous TNCs that provide technological services in the oil and gas industry. These are such as Halliburton, Baker Hughes, and Schlumberger" (*Source:* BD manager interview).

The collaboration with local research centres and TNCs working in Libya can contribute to stimulate the technological knowledge of the Libyan office. Benefiting from that and

utilising the experience of the whole company, the Libyan office has provided technological products and services with highly reliable, maintainable and performance technology. The best example is that the innovative technology has been used in implementing the GreenStream gas pipeline across the sea that links the Bouri field in Libya with the plants in Italy. Accordingly, these achievements in applying new technologies can give ProdCo the confidence to rely more on the Libyan office in achieving more significant technological levels. This success may motivate ProdCo to increase the intensity of R&D activities in this office (Future Phase). As ProdCo tends to collaborate with several institutions in the Libyan market, there is a need to establish a R&D unit to organise these processes and ensure a high efficiency of the process of knowledge production. It is not surprising that ProdCo conducts more sophisticated technological activities in Libya, as ProdCo has done so in some technologically underdeveloped countries, where domestic R&D capacities might be less and the business environment conditions are not, in general, better than Libya, such as Congo.

6.3.6 Rationale and strategy of corporate R&D activities in Libya

From ProdCo's point of view, it is necessary to locate some degree of R&D activities in Libya to facilitate its operations there. This is done by providing technology services to resolve some technical problems and requirements in the oil and gas fields. The processes of exploration and production of oil and gas are very high technologically complicated, and many of the technical problems need to be fixed within the operational processes, otherwise the situation would be more costly to fix. The rationale is that as ProdCo started expanding and diversifying its operations in Libya, increasingly sophisticated R&D facilities here and are useful in helping the subsidiary to apply advanced technologies and upgrade the productivity of oilfields.

From Section 6.3.2, it can be realised that ProdCo adopts a corporate R&D strategy, which involves deploying the open innovation approach. As a result, the tendency to exploit the available external technology resources is highly expected. Given that there are some TNCs working in the Libyan market in the same field or in other relevant sectors, ProdCo can augment its knowledge base in order to enhance its existing technological capabilities. It might also create new competencies throughout benefiting from the potential knowledge spillover by collaborating with these TNCs. These processes can provide it with an opportunity to identify new technologies to improve its operations. Not just in Libya, rather they can be used in other locations.

To maintain a competitive edge, ProdCo is forced to undertake a series of initiatives. Among of them, it needs to apply highly developed and advanced technologies in its operations, which must be increasingly more inevitable and econ-compatible in terms of the quality and costs. Therefore, the presence of other TNCs that provide added value could be a rational motive for ProdCo to increase corporate R&D operations in Libya. This is especially that ProdCo has considered the competitive advantage dimension in its research policy. One of its manager says; 'Our significant research and innovation activities are coherent with our strategy, which puts technology as a key factor to increase our competitive advantage over the long term, promoting sustainable growth and profitable partnerships with producing countries' (*Source:* ProdCo's Fact Book, 2007). Further, ProdCo's perspective on the role of international competition in compelling TNCs to conduct corporate R&D activities in Libya has been explained in more detailed by BD manager, as he says:

"Based on our experience in the oil and gas field, I can say that Libya has a wide area in which the oil may exist in everywhere. Further, the Libyan government started encouraging FDI in general and in the oil and gas industry in particular. Thus, many TNCs have involved in the exploration operations, and it is definitely that within these operations, TNCs will find themselves in many cases to be compelled to conduct some sort of R&D activities, particularly, research related to reduce the costs of exploration and production. This is due to an extreme competition between TNCs. In general, the situation represents an opportunity to oil TNCs to conduct research that may be exploited in their operations in other similar regions" (*Source:* BD manager interview).

This statement implies that ProdCo is conducting corporate R&D activities, as it wants to keep its position in the Libyan market. Thus, it is driven by a market seeking strategy. However, there is a significant element in this case. Where most studies that have mentioned the market seeking as strategy tend to justify this by the remarkable size of the host country market, in this case, in addition to that, reducing the cost of the operational processes in order to enter the market has taken a priority. Obtaining a footprint in the Libyan market needs wining the bargain. In order to be the winner, it has to have more proven advanced exploration technology. Then, according to those experimental tests, it can have an indicator to provide a competitive offer to conduct the exploration operation. From a technical point of view, full-scale tests must be empirically completed before any technology can be proven and the market will accept it (Neal, *et al.*, 2007: 1). Overall, this can be a push factor derived from the extreme competition in the host country's market.

There are some reasons that were behind ProdCo's involvement in the current corporate R&D operations in Libya, as BD manager says:

"The company has a good experience in doing R&D in several fields of oil and gas industry. Thus, to exploit and upgrade this experience, the company does adopt a corporate strategy of R&D activities based upon a partnership or collaboration with excellent institutions in the oil and gas industry research around the world. Basically, we conduct corporate R&D activities to have more knowledge background on new techniques and technologies related to the oil and gas industry. Moreover, the company is sometimes compelled to conduct corporate R&D outside the home country when it may face some technical problems that need to be fixed at the workplace due to some specific technical conditions" (*Source:* BD Manager Interview).

This statement implies that reasons can be linked to a knowledge seeking strategy. In addition, it reflects that ProdCo tends to adopt the open innovation and open R&D approaches, which are based highly upon a partnership and collaboration with the external knowledge-created bodies and external innovation enabler sources. The last part of this statement can confirm that a technology seeking strategy can be relatively applied, especially as mentioned in the previous section that ProdCo employs many local engineers who would be involved in fixing these technical problems.

However, it cannot be ignored that it still serves as a knowledge seeking, especially when these operations are mainly involved in technological issues. As a result, ProdCo will improve its technological knowledge capability by these operations, especially if these operations resulted in significant solutions to complex technical problems. But the technology seeking can be applied in a case when ProdCo has an opportunity to collaborate with the leading innovative TNCs in the field of technological services. Indeed, it has done so. The following statement shows that:

"Many complicated technical problems are resolved by main R&D laboratories in Italy. Also, in Libya for example, the company deals with some famous TNCs that provide technological services in the oil and gas industry. These are such as Halliburton, Baker Hughes, and Schlumberger" (*Source:* BD manager interview).

This statement suggests that the presence of the technology leaders in the host country may be as an attractive factor for conducting corporate R&D activities by collaborating with them or buying their technology services. This is in order to access their technological

knowledge capabilities, because ProdCo can benefit from the tacit knowledge that is generated during the technology service-after selling.

There are some attractive factors linked to the Libyan business environment, which can work as motivations to attract ProdCo to conduct corporate R&D activities in the Libyan office. In this regard, BD manager says:
"In fact, as Libyan government has a big share in this company, we have usually got financial support from it to finance R&D projects in Libya. This is sometimes to conduct projects alone and in other cases jointly with some local research centres" (*Source:* BD manager interview).

Thus, one can say that this will definitely have a positive influence on the corporate R&D processes. It is a very helpful factor in keeping the intensity of conducting corporate R&D activities, especially in bad financial times like financial crisis, where the industrial R&D spending is an easy target for cost cutters. Generally, this can serve as an enabling factor to attract FDI involving R&D. Further, based on this support, ProdCo should utilise this by increasing the scale of R&D activity in the Libyan office.

In this context, ProdCo realises the comparative advantage that the Libyan market has, which may result in making it a more targeted destination for TNCs to conduct corporate R&D activities. This recognition has been expressed by BD manager, as he says:
"I think that Libya may differ from other African countries in the oil and gas industry, in that Libyan crude oil is the best in Africa and one of the best qualities in the world. Thus, this has made TNCs very willing to invest in the Libyan market in the field of exploration and production. In fact, it is expected to follow these activities research activities as there are many attendant technical problems that may face these companies during their operations in Libya" (*Source:* BD manager interview).

This can encourage FDI involving R&D inflows into Libya in general and in the oil and gas sector in particular. In addition to that, ProdCo realises other enabling factors that Libya has, as BD manager states:
"As our company has practical experience in most of the African oil produced countries, I can say that Libya has more advantages than other countries in the region. This is in terms of the political stability and safety and ability to finance R&D projects" (*Source:* BD manager interview).

Empirical evidence suggests that the availability of R&D funds can influence R&D investment decisions. It usually has a positive impact on attracting FDI related to R&D. Further, the stability of political situation and the high degree of the country's safety have in general a big influence on attracting any kind of FDI. Overall, one can conclude that the rationale to undertake corporate R&D activities in Libya could be derived from some special advantages that Libya has compare with the other oil producing countries in the region. Some other enabling factors have been mentioned as follows:

"Libya has established several research centres in different sectors. One of the recent state' initiatives is that orientation to establish several businesses Incubators for adopting the ideas of innovators and supporting small innovative projects which targets exploiting the local raw materials" (*Source:* BD manager interview).

Indeed, the existence of excellence centres and active businesses Incubators will be an attractive factor for TNCs to conduct overseas R&D, especially when these activities are driven by knowledge and technology seeking. In this context, BD manager adds other important aspects may attract TNCs to undertake R&D activities in Libya:

"I think there are future opportunities in the corporate R&D activities in Libya, particularly in the petrochemical field, as the Libyan government is going to expand this industry and now it has a good local capability to develop it" (*Source:* BD manager interview).

This statement implies that there is a rationale to conduct corporate R&D activities in the petrochemical field, especially after the Libyan office expanded its operation to include the reservoir engineering, which already includes the petroleum and petrochemical industries. Thus, in order to improve its position in this new initial stage, it is highly advisable to undertake corporate R&D activities in this field.

Overall, the tendency of ProdCo to increase the portfolio of its corporate R&D activities is highly expected. Many implications extracted from the previous analysis can strongly suggest that. There is some push, pull, and enabling factors can have a role. Even though the scope of its corporate R&D activities is still very modest at present, it admitted that it had got good fruits from these activities. BD manager says:

"From our experience in conducting corporate R&D activities in Libya, we have learnt many lessons. The more influent one in managing the oil potentials" (*Source:* BD manager interview). Indeed, this may definitely encourage ProdCo to expand its R&D activities in Libya.

6.3.7 Possible obstacles to corporate R&D activities in Libya

From ProdCo's point of view, there are several possible obstacles that may hinder the evolution of corporate R&D operations in Libya. These represent several insufficiency aspects in the Libyan business environment. The level of domestic capability of R&D activity has already affected the R&D internationalisation process. For example, it has been pointed out that ProdCo is a partner to NOC and thus, according to the sharing agreement between them, ProdCo must conduct its research operations locally, when there is a possibility to do that in the local research centres. However, it seems to be that in many cases, required research work is out of the competences of local research centres. These circumstances have been mentioned by BD manager, as he says:

"To exploit available opportunities concerning corporate R&D activities in Libya, our company attempts as much as possible to exploit the available offers in the Libyan research centres and collaborate with them to fix some technical problems. By the way, NOC as a partner does not allow the company to undertake any kind of technical research outside which can be done locally. The sharing agreement gives a right to NOC to check the nature of research work and give approval to be conducted outside of the Libyan research centres. But in many cases, these centres are often not able to provide or deliver our research requirements" (*Source:* BD manager interview).

In this context, he has expressed ProdCo's point of view about the Libyan domestic R&D capability and their implications for the globalisation of corporate R&D activity in Libya.

"We think that the size of domestic R&D capacity is very limited in the scale and scope. Although we might not say that this does absolutely have negative reflections upon the internationalisation of R&D in Libya, it has definitely contributed in losing many opportunities that might be exploited in case there is domestic R&D capability enabling to absorb the technological knowledge spillover from this process" (*Source:* BD manager interview).

This statement suggests that the domestic R&D capability is at a low level of intensity. This reflects the limitation of technological competences in general, which might be as a consequence of the lack of advanced technological tools and equipment, poor technological and management experiences, a lack of skilled engineers and scientists, a lack of creative and innovative ideas, and many others. In addition, it might be a result of the weak linkages among the knowledge created-bodies and a lack of coordination between their efforts. Overall, the relevant information in Chapter Four confirms all these aspects.

Improving the domestic R&D capability is not a simple challenge, and it is by no means a simple process. It requires improvements in several different levels and may also involve

creating new policies and institutional frameworks. Without a strong NIS, it is not expected to have a good domestic R&D capability. In this regard, ProdCo regards that the major future R&D collaboration challenges are based on these issues:

"About the future of R&D collaboration with local research centres, we think that the main challenge faces Libya is how to increase domestic R&D capacity and improve the quality of the national innovation system" (*Source:* BD manager interview).

It is a strong statement, because of the quality of NIS means the necessity to change many elements, promote many policies and improve the quality of many institutions. Based on evidence form Chapters Four and Five, one of the biggest gaps in this system lies in the weaknesses of institutional mechanisms which should promote the linkages among the research centres. This issue has negatively impacted on the image of conducting the corporate R&D activities in Libya. BD manager says:

"Yes, the institutional framework had definitely some negative effects upon conducting corporate R&D activities. As we have worked in Libya for a long time, we have observed that there is no clear institutional framework for organising research activities on the country level. In fact, it might be found that two research centres, one investigates the technical problems, another has already done experiments on them and had got information to resolve these problems" (*Source:* BD manager interview).

There is no doubt that the cost of this insufficiency is very expensive, wasting time and destroying the research efforts. The issue might go further to imply that this weak linkage has implications for IPRs, as it has mentioned in Chapter Four that IPRs in Libya is weak. In this regard, some evidence suggests that TNCs usually avoid conducting significant corporate R&D activities in countries where there is no a strong IPRs. Overall, all these institutional issues reflect the absence of several important elements in the Libyan NIS.

The issue of NIS in Libya takes several different aspects and dimensions. Some of them have not only hindered the globalisation of corporate R&D process, but they also have made losing possible benefits from this process. In this regard, some policy issues have been indicated by BD manager:

"We think that Libya needs a good S&T policy, which must consider promoting and improving all relevant components of the national innovation system, and increasing the absorptive capacity to greatly benefit from the globalisation of R&D activity. Also, a strong linkage between S&T and industrial policy must take place for ensuring a high degree of positive interaction, which can be reflected in developing the manufacturing sector" (*Source:* BD manager interview).

It is a comprehensive statement of many implications concerning the obstacles to the globalisation of corporate R&D. The absence of good S&T policy could result in many negative consequences. For example, a low quality in education system outputs, technological trajectories are not clear, an exploitation of the many different resources of knowledge production, a low level of domestic R&D capability, the narrow diffusion of innovation culture in the society. Hence, these may have an influence on the trust in scientific co-operation and agreement, especially at international levels. Thus, one can conclude that these aspects will make TNCs unwilling to conduct corporate R&D activities in Libya or at least they would be very hesitant to make such decisions.

The second part of the statement also raises an important issue that might be an obstacle in attracting TNCs conducting corporate R&D activities in Libya. Indeed, the weak linkage and the absence of coordination between S&T and industrial policies may result in inefficiencies of many factors related to corporate R&D activities. These include: the collaboration between the industry and the research centres and universities, commercialisation of knowledge and innovations, funding of R&D projects, and technical training programmes. At any rate, TNCs are interested in identifying patterns of these elements in the country, because the level of these elements highly impacts on the domestic R&D capability, which is one of the determinants in conducting corporate R&D activity in a country. This is to exploit knowledge spillover from this capability.

6.3.8 Conclusion

As ProdCo is an integrated energy company, it has been involved in a wide range of technological and innovative activities with a high level of technological internationalisation and diversification. Its corporate R&D process extended even to technologically underdeveloped countries. With this high portfolio and a wide network of corporate R&D activities, it is now able to reap many significant innovative achievements. Indeed, observations made indicate that, ProdCo utilises open innovation approach, by collaborating with different knowledge created bodies and even competitors.

The analysis of the development path (Figure 6.2) to its technological activities in Libya reveals that ProdCo has upgraded these activities in a wide range, from developing technologies to applying new advanced technologies. However, these activities are still modest and limited to a large extent in fixing technical problems and some experiments to

upgrade the productivity of oil and gas fields. Most of R&D activities conducted are as a result of the conditions of technical requirements. In this regard, ProdCo is now in Phase 5 (Figure 6.2) and trends indicate that its corporate R&D activities could be increased and grow in the coming years.

As Libya is one of the highest oil producing countries, it has made ProdCo's corporate R&D activities there mainly driven by a market seeking strategy. The knowledge seeking can also have a possible role. This is related relatively to the nature of its operations, most of which are amongst ProdCo's core technological competence (exploration and production) and the potential of Libyan market in this activity. In addition, there is no doubt that the existence of some leading companies, as oil and gas technology services suppliers, has an important role for attraction and promotion of its corporate R&D activities. It has already found ways to collaborate with them or buy their technological services. Finally, it cannot be ignored in this regard the role of the pressure from NOC as a partner to push it into conducting corporate R&D activities there.

From ProdCo's perspective, there are several different obstacles in the Libyan business environment that may hinder its corporate R&D activities and the R&D globalisation process in general. These obstacles can be grouped briefly into three categories; the first one is institutional factors, which includes, for example, a non-integrated NIS, weak IPRs, weak linkages between the industry sector and research centres, poor communication and coordination between research institutions, the planning myopia in S&T and industrial policies, and the poor integration between S&T policy and industrial policy. The second one is technological capability factors, which include for example, the limitation of domestic R&D capability, unclear technological trajectories, and the low technological capability of local research centres. The third one is human resource factors, which include for example, a low quality of education outputs, the lack of skilled scientists and poor innovation culture.

6.4 Cross case studies analysis

6.4.1 Introduction

In the context of technologically underdeveloped countries, little is known about the extent to which TNCs develop and upgrade their technological activities, the nature and patterns of corporate R&D, relevant strategies adopted and the obstacles may hinder their R&D

activities there. This part discusses these issues by a cross case study analysis of the findings of the empirical study on two TNCs presented in the previous parts in this chapter.

6.4.2 Characteristics of the analysis

The objectives that this cross case study analysis attempts to cover, in general, are to identify the principal obstacles that might be faced or hinder the R&D globalisation process of both international and joint R&D projects in Libya, from the TNCs' perspective. In addition, further objectives are also targeted to be partially covered, including: 1) identifying the nature and patterns of corporate R&D activities, which are conducted in Libya, 2) evaluating the capability of R&D activities in Libya and the ways that have been used to foster it, 3) examining the impact of Libyan S&T and industrial policies on R&D subsidiary evolution and corporate R&D activities, and 4) ascertaining the institutional mechanisms which have been applied to encourage and attract foreign R&D activities.

In this analysis, the focus is upon the two case studies, which will address the objectives mentioned. Table 6.5 shows the portfolio of these cases, where one can note the similarities and differences in relevant trends and indicators.

Table 6.5 Some aspects of cases studied' portfolios

Phases	**Case: ServCo.**	**Case: ProdCo.**
The home country	America	Italy
Sector	Oil and gas industry	Oil and gas and energy industry
Nature of activities	Providing technological services for the oil and gas industry (oil equipment service and distribution)	Extraction and manufacturing of oil and natural gas and marketing related products
Internationalisation	Operates in 90 countries (2007)	Operates in 70 countries (2007)
Business history (back to)	1900s	1920s
Number of employees	35,800 (2007)	76,000 (2007)
Net sales	€7,133 million (2007)	€ 87,256 million (2007)
R&D net sales ratio %	3.6 (2007)	0.2 (2007)
R&D staff	1500 (2007)	1082 (2007)
Emerging in the Libyan market	2003	1959
Nature of current work in Libya	Providing technological services to local and international companies in the oil and gas industry field	Exploration and production of oil and gas by shearing agreement with NOC

Source: Based on the companies' annual reports and EU industrial R&D investment Scoreboard 2007.

As can be seen from Table 6.5 the activities of these companies cover the whole oil and gas industry field and they can be considered as complementary activities. Both companies have a high level of technological capability and capacity as well as a high degree of R&D intensity, so they are well known innovators in their technology field. The data related to R&D activity reflects the fact that in these companies, R&D activity plays a vital role in sustaining and growing their businesses and well integrating R&D into their business operations. With their large number of R&D staff, both companies seem to do well, getting R&D people to use their creative talents for maximising the benefits of the company. Thus, they show a great ingenuity in obtaining a high position in the global market. For example,

ServCo as a result of its early R&D success, it became the largest and most successful company in supplying the first class technology services for the oil and gas industry. ProdCo has been leading several specific advanced technologies in the oil and gas industry. However, it can be noted that the ratio of R&D expenditure to net sales for ProdCo is relatively low compared to ServCo. This is generally obvious because technological service supplier companies tend to spend more on R&D than production ones, where the latter often relied on the technological services companies in technology development (Neal, *et al.*, 2007).

There is a significant difference, which may not simply lie especially, in more radical notions of the business between them. In this regard, it has been found that ServCo placed more emphasis on business in a few technological areas, while ProdCo, as a vertically integrated company, was involved in a wide range of technological areas. The analysis clarifies that ProdCo more relies upon the external source of knowledge and collaboration for conducting corporate R&D. This is in line with the situation, which the knowledge of critical problems generally resides within the operating companies responsible for the actual exploration and production of hydrocarbon resources. However, the required technical expertise can be found in technological services companies, research centres, universities labs, entrepreneurial firms (Neal, *et al*., 2007: 23). In addition, as the nature of ServCo's activities, some part of its activity can be applied to the international trade in R&D related services. This is especially when it provides the technological consultancies and fixing technological problems related to its process of selling spare parts. The business of technological service supplier companies can reflect the trends on trade in R&D services, where some of their activities are relatively a new indicator of international knowledge and technology flows. This considers the tendency toward conducting their R&D activities on a global scale.

6.4.3 The nature and patterns of corporate R&D activities in Libya

From reviewing the development paths to the two companies' technological activities (Figure 6.1 and 6.2), one can confirm without any doubt that, corporate R&D activities conducted by these companies in Libya are still at a limited level. According to where these companies are now on the phases of these development paths, it can be concluded that the firms' parents control the core technological activities, while their Libyan offices are involved in applying some new technologies and fixing simple technical problems. They have built up a limited innovative capability, as mentioned in several statements that

complex technical and technological problems are sent to be fixed at headquarters. Although some significant technological achievements have resulted from applying new technologies in their offices in Libya, their technological activities can still be characterised by a high level of technological dependence on the headquarters.

Both TNCs studied have established small labs in Libya, which generally result in activities related to R&D differ in the case of establishment of the development centres. The scope of these labs' activities can be seen from their responsibility in applying new technologies and fixing technical problems. At the same time, they do take samples, analyse and test for some technical issues. However, most technological activities being conducted by these companies' labs in Libya are more related to the development phase of R&D rather than advanced research. The description of these activities is that most of them were limited to a number of developmental projects to tailor product services to the requirements of local market standards and environment.

At the current state of knowledge, one can provide primary general indicators about the nature and the type of R&D that may be performed by foreign laboratories in their host technologically underdeveloped countries. It could be by linking the level of technological activities of these companies in Libya with given indicators (Table 6.6), where from a technological stages' point of view; there are often at least seven technological levels:

Table 6.6 The level of technological stages and nature of global R&D activities

Technological Stage [The rank 1= first level, 2= second level, ……..etc]	**Level**	**Degree of the globalisation** [The rank 1= less spread, 2= more spread, ……..etc]	**Motivating dimension**
Marketing support	1	7	Market requirement
Manufacturing support	2	6	Process efficiency
Advanced development	3	5	Process efficiency
Exploratory development	4	4	Process efficiency
Applied research	5	3	Technical feasibility
Basic research	6	2	Technical feasibility
Pure science	7	1	Technical feasibility

Source: Adapted from (Boutellier, et al. 2008: 54; Helble, 2004: 86; Amsden and Tschang, 2003: 555; Medcof, 1997: 306).

Therefore, it is clear that most of their technological activities are not beyond the third level of the technological stages. Even when it comes to some applied research that has been conducted for applying new technologies, it was driven by process efficiency motivations, except in some few cases relevant to ProdCo, where some R&D activities have targeted the applied research focusing upon technical feasibility to use some new advanced technologies. In line with the third level (Table 6.6), most of R&D operations were carried out for a market support in the case of ServCo and manufacturing support in the case of ProdCo. The focus was often upon improvement capabilities for a process

efficiency purpose. Applying new technologies is further developed and improved. According to Amsden and Tschang (2003: 555), the advanced development activity aims to deliver immediate market results. Techniques used may include engineering design tools including simulation and testing. R&D personnel usually have an engineer level and unnecessary with PhD degree, where they are usually supported by people-related management skills and process know-how. Indeed, in both companies, the people working in labs were engineers and technicians.

In general, conducting some applied research by ProdCo can reflect the fact that priority in these technological stages is not necessary and it is more dependent upon the technological activity required to be done, for example to fix the technical problem. This kind of research has been undertaken by ProdCo in Libya for fixing some technical problems related to applying new technologies or developing some operating processes. At any rate, this does not reflect that ProdCo has more technological capability in Libya than ServCo, rather it can refer to the nature of their activity in Libya and the need to carry out such kind of this research at the oilfields. On the other hand, ServCo has reached the level of exploratory development, where designing and developing sub-systems process has taken place in its R&D operations. However, it was just some successful attempts based on technological limitations, which has just led to creating an operating prototype process. It is clear that outputs of this process can be also linked to the advanced development level. Thus, it can be concluded that corporate R&D conducted by both companies can be highly linked to the advanced development level.

It should be mentioned that these differences in the technological stages among these companies' technological activity in Libya can be linked to the different development paths being followed by them, which were highly influenced by nature of the company's activity in general and R&D strategy. Hence, the comparison between these companies can lead to the conclusion that (in terms of development paths of technological activities) ServCo is faster in developing its R&D activity than ProdCo. In addition, its R&D activity in Libya is at higher and more advanced levels than ProdCo. In contrast, ProdCo is more outsourcing more R&D activities from the local research centres and more collaborative R&D activities with domestic and TNCs than ServCo.

However, it is significant to mention that both companies have arrived at what is highly expected to be the next phase in the development paths of opening a separate R&D unit.

Assuming that, growing technological activities in scale and scope need a separate management unit to organise and manage R&D activity. This evolutionary phase can actually be observed in both companies. They have recently begun conducting some development projects and applying some new advanced technologies in their operations in Libya. Furthermore, based on the development paths of ServCo and ProdCo, it can be noted that the two companies have a different research agenda entirely. ProdCo is increasingly reaching outside the lab walls to collaborate in R&D with other TNCs and the Oil Research Centre in Libya, while ServCo tends to collaborate with their customers and competitors in Libya. However, in both companies, the degree in which this collaboration has taken place is still at a low level. It is driven by a situation where the company finds itself facing some complicated technical problems and in response to the requirements of terms and conditions relevant to the contracts with NOC as well as helping customers further by technical support agreements, as in the case of ServCo.

Regardless of the different technological functions that may be performed, the geographical scope can also reflect relatively the degree of significance of these R&D activities. Three main scopes can be identified namely; local, regional, and global, where the local scope refers to R&D outputs, which is targeted specifically for the operation of these companies in the Libyan market. The regional scope refers to R&D outputs for (e.g. MENA), where as a global scope logically implies an R&D output applicable to the global market. Thus, based on the development paths of ServCo and ProdCo in Libya, the current scope of their R&D activities mostly targets the local scope, as applying technology for operations in the Libyan market. However, ServCo is targeting the regional scope by exploiting successful new technological applications in the Libyan market to other similar geological areas in the region in which ServCo operates. What this can mean is that based on the benefits from the Libyan subsidiary's experience, if applying these technological applications were successful, it would be reflected on upgrading technological activities in this subsidiary to promote its capability to meet the relevant expectations.

6.4.4 The TNCs' strategies for corporate R&D in Libya

It is useful to have a brief introduction on the important elements that may reflect the significance of the Libyan oil market and factors related entry. Based on relevant information provided in Chapter Four, Libya has a geographic location at the door of Europe. It is considered a high quality oil province consisting largely of sweet crude oil and characterised by low cost of production. Limited opportunities for access by foreign oil

companies to high quality reserves elsewhere has increased Libya's attractiveness especially that the country is relatively under-explored due, in part, to the imposition of sanctions which limited exploration activity (Fattouh, 2008: 4). Thus, there is currently extreme competition on the Libyan oil market and the growing presence of leading TNCs in the oil and gas industry. Based on this situation, the best way to monitor and copy these developments and tap into possible knowledge spillover is through establishing strong R&D facilities in Libya. This can effectively help them to increase their potential to innovate, or provide an opportunity to cooperate with leading TNCs in their industry field.

The cross case analysis shows that in both companies, political stability, regulations related to the contract conditions and governmental factors (mainly represented in the pressures from NOC) have a strong impact on the involvement of these companies in conducting corporate R&D activities in Libya. Moreover, the international relations have also an impact on corporate R&D operations. The analysis shows that the good relationship between Libya and Italy has helped the ProdCo to expand its operations in Libya, which can indicate that historical ties are important in accessing and remaining in the markets for the long-term and had made a significance to investing in R&D. This preference supports the existing idea that states the importance of geographical and good international relations as important factors for establishing collaboration, and even in value chain activities such as R&D activity. Thus, it is crucial to place an emphasis on these issues, as these have factors that are rarely mentioned in the literature on the globalisation of R&D related to the location decision where to set up international R&D activity. Hence, this enhances the perspective based on high consideration which should be given to these factors, when it comes to the location decision of corporate R&D activity outside home countries.

Overall, the cross case analysis shows that in both companies, the drivers behind conducting corporate R&D activities are mainly related to the market seeking strategy, where knowledge seeking and technology seeking can also have a role. What is important here is that the knowledge seeking has a possible role even in technologically underdeveloped countries. This may be as a result of most of the operations of the exploration and production of oil and gas having been conducted in these countries. Thus, as much of the potential tacit knowledge can be generated at the operations places, the companies would target this kind of knowledge and other external knowledge might spillover in those places. In this regard, it is significant to indicate that the growing importance of knowledge seeking can be partially explained by the influences of increasing

costs and complexity of technological development, where most oil and gas TNCs find themselves facing the growing need to expand technology sourcing and interaction with different and geographically dispersed actors endowed with complementary knowledge. This explanation is based on Johansson and Loof's (2006) conclusion in their study as one of the several overlapping factors.

6.4.5 Obstacles to corporate R&D activity in Libya: TNCs' perspective

The cross case studies analysis shows that the obstacles to conducting corporate R&D activity in Libya for TNCs are greater than other economic activities. It is highly expected because the determinants of internationalisation of R&D activity differ in several aspects from the internationalisation of other economic activities. As special and specific requirements need to exist and to be accessible for users. These requirements match aspects of the society; economic, social, political, cultural, and technological, where it focuses mainly upon the country's technological capability and competencies. In this context, the cross case analysis shows that both companies studied have indicated that the Libyan business environment includes several deficiencies. One of the main aspects (which represents big influences) is the problem of corruption and managerial illiteracy. For example, on behalf of the TNCs working in Libya, Chazan (2009) indicates that the British TNCs in the oil and gas industry face massive bureaucratic obstacles in the Libyan market.

Another serious issue which has been indicated by both companies is the limitation of domestic R&D capability and local technological competences. The evidence suggests that the domestic R&D capability is at a low level of intensity, scale and scope. This means that the limitation is in the technological competences in general, which has been as a consequence of the lack of advanced technological tools and equipment, the poor technological and management experiences, a lack of skilled engineers and scientists, the lack of creative and innovative ideas, and many others. In addition, it has been the result of the weak linkages amongst the knowledge created-bodies and the lack of coordination between their efforts. In other words, these issues can be linked to the factor of country-specific characteristics of NIS, which requires improvements in several different levels and may involve the necessity of creating new policies and institutional frameworks and improving as well as upgrading existing ones.

Regarding the NIS, it has been indicated by both companies that some of the biggest gaps in this system lies at the weakness of institutional mechanisms which should promote the

linkages among of the local research centres, a weak of IPRs and a weak linkage and the absence of coordination between S&T and industrial policies. More precisely, it has been noted by both companies that, there are some issues related to FDI involving R&D, as FDI policies do not facilitate the process of partnership between local knowledge created bodies and domestic companies and TNCs, a planning myopia in FDI, S&T and industrial policies and inefficiencies in the legal frameworks. In addition, it has been indicated that there is a lack of the technological infrastructure base in Libya, with which any TNC may face increased barriers into internal knowledge transfer due to inter-unit geographical and technological distance (transaction cost).

As has been previously mentioned, the attempt is made here to provide other evidence regarding the possible obstacles hindering the R&D globalisation process, which have been derived from other oil and gas TNCs working in Libya. In this regard, it is significant to mention that people interviewed from the three other TNCs have addressed the fact that their companies are conducting technological activities related to technology development and some applied research in the labs in the oilfields. In addition, their companies are willing to increase the size of R&D activity in an attempt to exploit the possible and available opportunities in the Libyan market. They strive to increase their marking share and their R&D activities are mainly driven by a market seeking. In this context, BD manager of one company says:

"We do not conduct pure R&D activities rather we undertake some services related to R&D by technical licences and technological support agreements" (*Source:* BD manager interview).

This statement implies that several different forms have been used by TNCs in Libya regarding the corporate R&D activity. However, they have raised several obstacles, many of them similar to what have been addressed by the previous two TNCs. Several statements indicate different issue related to these obstacles. One of the most important issues was raised by one of the managers interviewed, as he says:

"I think that there is no clear political attitude toward R&D activities, and this has impacted on the priority to the economic activities that the Libyan government has focused on" (*Source:* BD manager interview).

This represents a critical issue, which makes, in many cases, the TNCs not invest heavily in the R&D field. Consequently, R&D programmes are not progressing smoothly. Related issues have been indicated by another BD manager:

"I have noted that there are deficiencies and mis-management of R&D resource, as there is no clear plan by the Libyan government regarding the R&D projects, which our companies can rely on or think to participate in by collaboration or other forms" (*Source:* BD manager interview).

This statement supports the fact that the management body in Libya suffers from the problems of planning myopia in policies and managerial illiteracy. In this context, another BD manger adds:
"We have realised that there is no stability in procedures and measures regarding the contract of collaboration in R&D activities" (*Source:* BD manager interview).

In this respect, another manager adds an important issue related to this situation. He says: *"There is no a specific body which can be dealt with regarding the collaborative and cooperative R&D projects and programmes or even for funding such of these activities"* (*Source:* BD manager interview).

In general, institutional issues can have a link to previous ones as a cause or consequence, and all of them would negatively impact on corporate R&D activity in any form. Furthermore, the managers interviewed have mentioned the issue of the low level of domestic R&D capability and capacity as an obstacle to corporate R&D activity. One of them provides an example related to this issue by saying:
"We have noted that one issue related to the domestic R&D capacity is there are some un-exploitable R&D teams. It is represented in that academic staff at the Libyan universities are often teaching rather than conducting research projects even in the applied sciences areas" (*Source:* BD manager interview).

This statement clearly indicates deficiencies in the Libyan S&T policy or implementation of this policy as well as the mis-match of this policy with industrial policy, which have been indicated by the managers interviewed in the two main case studies. This can make TNCs not trustworthy in the ability of any Libyan universities staff. Another example has been given by BD manager in one of these companies, can be related to the previous issues and it reflects the deficiencies in NIS as the whole. He says:
"We have noted that there are some good postgraduate research in the engineering fields that have been done by the Libyan student in the local universities, but when we attempt to exploit these research by making a partnership with these universities, we face several managerial barriers that represent mainly in absence of one specific body or department within these universities to deal with" (*Source:* BD manager interview).

In this context, one can say that although these examples do not add new dimensions to the obstacles of the globalisation of corporate R&D, they deeply complement the story provided in the two main case studies. Overall all these statements and examples can contribute to improving our understanding of the roots and nature of the possible obstacles hindering corporate R&D in Libya.

6.5 Conclusion

This chapter has presented the cases of two TNCs working in Libya in terms of their technological activities and other issues related to them. In this context, the cross case analysis clarifies that some of the leading TNCs in the oil and gas industry have established limited R&D facilities with different forms of corporate R&D activities in Libya. Although these companies have begun to internationalise their R&D activities at the periphery by establishing small labs and R&D outsourcing by collaboration, their strategic R&D and core technological activities are still kept at their headquarters. Thus, the emergence of some corporate R&D activities in technologically underdeveloped countries (even if these activities are still limited in pattern) reflects a development in the locational structure and conditions of conducting the global R&D activities.

To describe the nature of corporate R&D activity conducted by the TNCs in Libya, one can conclude that the operations in this regard are confined in many cases to one way of technology transfer and, in the best cases, are orientated towards resolving and fixing technical problems and in some cases to adapt technological products to the local environment. Indeed, they are still mostly at the development level and do not involve core competencies at a high level of the technological and innovative capability. In addition, there is evidence to suggest that the corporate R&D conducted by TNCs in Libya and their collaboration efforts in this regard are at a modest level and often driven by operational and technical reasons. They are based mainly on the market seeking strategy, though with a possible role for a knowledge seeking strategy.

In this context, it is important to highlight that the significance of using development paths as an analytical tool in analysing the development of TNCs' technological activities in Libya. Indeed, the construction of development paths is a form of analysis that has enabled us to show that:

- The corporate R&D of both TNCs studied is mostly developmental, (but it is advancing and changing) and not fixed.
- Both TNCs studied have upgraded their technological activities in a wide range, from developing technologies to applying new advanced technologies. However, TNCs in technology service sector can be faster in this upgrade than production ones.
- Both TNCs studied have reached quite a similar point on their development path. This probably reflects conditions in Libya and the current state of the Libyan NIS.
- Corporate R&D in Libya is still limited, but with a possibility to grow in the field of oil and gas industry, as it is mainly driven by a market seeking strategy.
- Host country policies (such as FDI, S&T and industrial policy) have a direct impact on progressing and upgrading the technological activities of TNCs in the host countries.

Thus, it is becoming clear the value of using the development paths in determining the nature and pattern of corporate R&D activities in Libya and the prospects of their growth in both scale and scope.

The cross case analysis shows that both companies face significant barriers and obstacles hindering their corporate R&D operations in Libya. In this regard, there is a significant body of evidence -derived from the case analysis which suggests that, there is a big gap and deficiencies in the Libyan NIS. This has impacted negatively on the R&D globalisation process in Libya, resulting in creating many obstacles that are hindering corporate R&D activities of TNCs. These obstacles can be grouped into three categories. The first one is institutional factors, which includes a weak IPR regime, weak linkages between the industry sector and research centres, poor communication and coordination between research institutions, a planning myopia in FDI, S&T and industrial policies, poor integration and coordination between S&T and industrial policy, an inefficiency in legal frameworks, corruption at different levels with a low rate of transparency and managerial illiteracy in different levels. The second one is technological capability factors, which includes the limitation of domestic R&D capability, unclear technological trajectories, and the low technological capability of local research centres. The third one is human resource factors, which includes a low quality of education outputs, a lack of skilled scientists and a poor innovation culture.

Chapter Seven

Conclusion

7.1 Introduction

The purpose of this chapter is to represent the conclusion drawn from this research. It is based upon overview of research as an approach to the conclusion and then presenting and discussing the principal findings as well as providing policy implications. In addition, this chapter clarifies the limitations of this research and suggests further research on the research's topic. The last section of this chapter represents the value of this research and the most significant contributions to knowledge have been made by this research.

7.2 Overview of research

Previous research on the R&D globalisation process provides some insight into the nature of global R&D activity and networks as well as technological activities undertaking by TNCs outside their home countries. However, a review of the literature reveals that little consideration has been given to the implications of R&D globalisation beyond developed countries and recently, to a few so called emerging economies. Little is known about the R&D globalisation process in technologically underdeveloped countries and the nature of the technological activities of TNCs in these countries. In addition, little is presently known about the technological capability and capacity in these countries and their impact on the international R&D business and organisation.

In this context, some studies highlight several barriers, which may influence the R&D internationalisation processes, but the empirical studies have traditionally focused on the nature of these barriers in developed countries. Nothing significant has been undertaken concerning the technologically underdeveloped countries. Generally, these studies provide general insights into the characteristics of the business environment, where TNCs are often and increasingly attracted and prefer to undertake corporate R&D activities outside the home country. Little is known about the obstacles to the globalisation of corporate R&D activity. The relevant literature places a more emphasis upon examining the factors that keep the most important R&D activities in the home country (centripetal forces) and the factors that contribute to transfer and spread these activities in the host countries (centrifugal forces).

Therefore, this thesis aims to provide a first step in this unexplored and relatively neglected research area and to further stimulate interests in this important topic. In particular, it sought to identify possible obstacles that may hinder the R&D globalisation process at periphery, from both TNCs and host country perspectives. It also provides policy implications, which can help technologically underdeveloped countries by illustrating possible improvement opportunities to overcome these obstacles. The technologically underdeveloped country in this study is Libya, which is among a few related countries in which TNCs have undertaken some sort of corporate R&D activities. Several important factors may have played a decisive role in fostering such R&D activities. Thus, this thesis attempts to achieve the following objectives:

- Identifying the nature and patterns of corporate R&D activities that are conducted in Libya.
- Evaluating the capability of R&D activities in Libya and the ways that have been used to foster it.
- Examining the impact of Libyan S&T and industrial policies upon R&D subsidiary evolution and corporate R&D activities.
- Ascertaining institutional mechanisms that have been applied to encourage and attract foreign R&D activities.

7.3 Discussion of principal findings

This section presents and discuses the important findings, which are related to the aim and objectives of this research. These findings are highlighted in five themes. The following themes represent these findings:

1- The findings of this research provide platforms to evaluate the capability of R&D activities in Libya and ways that have been used to foster these activities. The following points demonstrate these aspects:

- At the macro level, the analysis of the nature of R&D activity in Libya shows weak yields for most indicators. Despite the relatively high GDP of Libya, the Libyan innovation and R&D performance is not faring well in comparison to that taking place in the rest of the world. The picture is also negative when attention is turned to the output of scientific research in terms of publications and patents, as well as the number of researchers working to produce them and the estimated value of Libyan spending on R&D. This is reflected by the weak intensity of research at the

sectors and national level, a limited number of the scientific publications, patents recorded, existing research and technological centres, and the weakness of accompanying structures, weak institutional frameworks and mechanisms as well as the low level of technological readiness. Overall, the situation can be described as a weak NIS, a weak R&D capability, limited technological competences and a limited domestic R&D capacity. As a result, the capacity for innovation is very limited.

- At the micro level, the analysis of R&D practice within the Libyan organisations demonstrates that R&D is a non-traditional activity, especially within the industrial firms. In just a few years, R&D activity has taken place as a separate activity and in separate organisational units. Moreover, although many of organisations studied have a separate R&D unit, they do not have sufficient budgets for R&D activities, and this activity is conducted mainly by technicians and a few scientists and engineers. Overall, the trends on how R&D activity is fostered indicate low levels of financial and organisational attention. With the low level of technological capability and R&D staff capacity, the significant outcomes of R&D activity were limited to resolving and fixing technical problems and improving some products and services as well as modest contributions to quality improvement. Most of the R&D processes can be linked to the development side of R&D and few to applied research even at the research centres. Current R&D practices give relatively low benefits and a limited value. Indeed, the innovation of new products and services was a remote possibility for most of the Libyan organisations.
- At the corporate level, all Libyan organisations studied practise collaborative R&D activities with a tendency to collaborate with foreign partners in the case of the industrial firms. There are many collaborative R&D projects. The level of collaborative R&D activity may be quite high, but little benefit or value is derived from it. It mostly takes the form of fixing technical problems and training R&D staff. No significant forms of patents or licensing etc. were in evidence. The significance of these activities is still confined to technical support, training programmes and to some extent helping in products development in the case of industrial firms. Based on these conditions and with the low level of absorptive capacity, Libyan organisations failed to fully benefit from R&D collaborative projects. Overall, the R&D collaboration provides little positive interactions.
- Based on the findings from this research, it can be concluded that the Libyan NIS suffers from major weaknesses and limitations, which represent obstacles that can

hinder the R&D globalisation process in Libya. The main aspects of these weaknesses and limitations are reflected in institutions and the linkages and interactions between the relevant institutions. The following table highlights key salient handicaps:

Table 7.1 The limitations and weaknesses of NIS in Libya

Aspects	Limitations and weaknesses
Labour market	• Shortages of high skilled people • Brain drain • Lack of creativity and entrepreneurs • Weak educational system at all levels
R&D base	• Weak public S&T infrastructure • S&T not responsive to industry needs • Low capacity for innovation • Limited financial support • Lack of R&D co-operation
Institutional issues	• Lack of proper coordination between S&T and industrial policies • Absence of proper correlation among variety of R&D activities • No specific direction of R&D • Narrower and blurred vision for technological trajectories • Lack of incentives and motivation for R&D • Inefficient industry-research linkages

2- The findings of this research reveal that some TNCs have developed their technological activities in Libya and already begun to conduct some sort of corporate R&D activities. There has been a modest inflow of corporate R&D activity from TNCs into Libya via FDI. TNCs are setting up R&D facilities there and seem to have moved beyond merely adaptation for the local market. While it is quite difficult at this stage to quantify R&D activity by type, the nature and patterns of corporate R&D activities undertaken by them can be summarised as follows:

- The nature of corporate R&D activity conducted by TNCs in Libya can be described as operations confined in many cases to one way technology transfer and in best cases to being oriented towards resolving and fixing technical problems and in some cases to adapting technological products to the local environment. These operations are still largely limited at the development side of R&D and do not involve core competencies at a high level of technological and innovative capability. They have built up little or no innovative capability, as the complex technical and technological problems are often sent to be fixed at headquarters.
- The corporate R&D conducted by TNCs in Libya and their collaboration efforts are at a modest level and they are often driven by the pressure from Libyan government in the case of local research centres. While others are often driven by operational and technical reasons and based mainly on a market seeking strategy. In addition,

geographic proximity to presence of leading innovation companies in the same sector has made a possible role to adopt a knowledge-seeking strategy in Libya.

- Based on the development paths of TNCs' technological activity in Libya, the current scope of their R&D activities is mostly targeted at the local scope, applying technology for operations in the Libyan market. However, in some cases, it is targeting the regional scope by extending successful new technological applications in the Libyan market to other similar geological areas in the region.
- Most of the corporate R&D conducted by TNCs in Libya was not beyond the development phase. Generally, in terms of the development of technological activities, it was noticed that oil and gas technology services companies seem to be faster in developing technological activities than production companies.
- In Libya, the foreign R&D activities are conducted in the form of market and technology support units, through small labs and by a small number of R&D staff, mostly engineers and technicians. However, the establishment of small labs found in Libya by some global players in the oil and gas industry might have acted as a signal for investment by other global firms.

3- The findings of this research show a negative impact of the Libyan S&T and industrial policies on FDI involving R&D in general and the evolution of R&D subsidiaries in particular. The following points demonstrate these aspects:

- S&T and industrial policies have failed to provide concrete ways and means to reinforce the role of R&D activity in promoting industrial development, economic competitiveness and attracting FDI involving R&D. These policies have also failed to support R&D activity in strategic sectors that may have technological innovation content. At the corporate level, these policies did not target the promotion and strengthening of R&D collaboration in terms of sharing knowledge and technological experiences for industrial development as well as improving the technological capacity and capability of industrial sectors.
- The review of the recent Libyan S&T policy reveals that there are no indications of R&D incentives or conditions for attracting FDI involving R&D activities. These are such as the establishment of S&T parks, promoting R&D collaboration among local firms and institutions and TNCs operating in Libya, applying or imposing R&D requirements as a condition to TNCs for entry into the Libyan market. Similarly, reviewing the Libyan industrial policy reveals the lack of measures and

tools that encourage and foster the indigenous production and innovation capabilities. Although this policy indicates some concern about the clusters, the empirical evidence demonstrates that inter-organisational relationships, collaboration and networks in practice of R&D activity are at low levels and very weak. Furthermore, this policy does not indicate any measure to support entrepreneurship and foster the emergence of technology start-up SMEs.

- The evidence derived from the findings of this research generally indicates a lack of practical policy measures, in terms of S&T, industrial and FDI policies that have been undertaken to bridge the technological gap and integrate Libya's NIS into the global R&D network.

4- The findings of this research clarify the manner in which institutional mechanisms have been applied to encourage and attract foreign R&D activities. The following points demonstrate these aspects:

- The findings reveal that little consideration has been given to the importance of IPRs in Libya. Although there is an institutional framework dealing with IPR, it can be considered weak as has been described by TNCs that status of IPRs in Libya can be one of the obstacles hindering the growth of corporate R&D activity.
- Libya does not pay sufficient attention to the international dimension of corporate R&D activities. Indeed, the findings from Chapter Four, Five and Six show the absence of adequate institutional framework for the regional and international cooperation in corporate R&D activity.
- The deficiencies of institutional mechanisms can be seen from the relevant aspects of the business environment in Libya. The findings show that there is no an appropriate physical infrastructure for setting up technological facilities, a gap between demand and supply of qualified professionals working in the R&D field and no high ranking research centres, a weak IPR regime and a lack of the fiscal incentives to foreign R&D activity. The implementation of current S&T policy has clearly failed to improve these factors.
- The findings from Chapter Four show a lack of coordination between FDI policy and industrial policy. This can indicate deficiencies in the institutional structure within which FDI and industrial policies can be promoted. This has also negatively impacted on attracting foreign R&D investments, as TNCs indicated that this issue may hinder the corporate R&D activity.

- Based on implications derived from Chapter Four and Five, one can note that S&T and industrial policies have failed to improve the institutional mechanisms for adapting imported technology, and promoting R&D to meet industrial needs. One of the notable observations is that the manufacturing sector has not expanded substantially and not effectively contributed to Libyan's economic growth. In addition, the limitation of coordination between S&T policy and industrial policy has led to the lack of consideration to the strategic importance of investment in human capital as an avenue for the industrial and technological development.

5- The findings from this research reveal a range of obstacles that are hindering the process of globalisation of corporate R&D in Libya. Most of these obstacles are inter-connected and can be linked to pull, push, enabling, and policy factors. In addition, these obstacles reflect the major weaknesses and limitations of Libyan NIS. To summarise, the following points represent major obstacles from the host country (Libya) perspective:

- The institutional factors, which mainly represent in deficiencies in FDI, S&T and industrial policies, and a lack of government support for R&D activity.
- The technological capability factors, which mainly represent in the limitation of R&D capacity and domestic R&D capability, and the absence of the role of private sector in the practice of R&D activity.
- The human resource factors, which mainly represent in the lack of specialised and high qualified people, working in R&D fields and the lack of innovation culture and creativity.
- The management and financial factors, which mainly represent in a lack of experience to manage corporate R&D activity, a lack of funding and support to corporate R&D and the absence of the role of private sector in funding R&D.

While TNCs' perspective includes the following obstacles:

- The institutional factors, which mainly represent in a non-integrated NIS, a weak IPRs system, weak linkages between the industry sector and research centres, poor communication and coordination between research institutions, the planning myopia in FDI, S&T and industrial policies, a poor integration between S&T policy

and industrial policy and the absence of adequate FDI policy targeted at FDI involving R&D.

- The local technological capability factors, which mainly represent in unclear technological trajectories, limitation of domestic R&D capacity and the low technological capability of local research centres.
- The human resource factors, which mainly represent in low quality of education system outputs, the lack of skilled scientists and poor innovation culture and a lack of innovation, creativity and entrepreneurs.

7.4 Policy implications

In this section, an attempt is made to provide some policy implications that can help both scholars and policy-makers. Indeed, the focus of this research is not only to explore the obstacles that are hindering the globalisation of corporate R&D in technologically underdeveloped countries, but also to provide good and actionable insights into possible improvement opportunities for making these countries to be able to join the global R&D network. The following represents policy implications suggested for Libya:

1- There is a pressing need for the active development of NIS at all levels in Libya, where the education system urgently needs improvements in several ways. Most business enterprises are ill prepared to act at the international competition level. Some other important organisations of NIS such as technology transfer units do not exist at all and technological businesses incubators just established in the last few years. Overall, many observations confirm that the individual elements of NIS (such as education, industrial and financial systems) are not linked through mutual relations and networks of interaction that could lead to the establishment of strong functioning innovation system. One of the main reasons behind this situation is the high level of state-ownership and uncompetitive business environment. Thus, one of the policy options to improve the institutional factors of NIS would be privatisation to make them more competitive.

2- As the findings of this research reveal that innovating commercial products are still a remote possibility for most of the Libyan organisations. Thus, to foster an innovation culture within the organisations, several considerations must be taken into account. This may need improvements at both the micro and macro levels. The starting point for change is most likely be activation of the role of S&T community and creating the institutional frameworks to motivate the innovation as well as implementing mechanisms to promote

the creativity and innovation culture within the whole society. This may contribute to make an attractive factor for upgrading the competencies of these firms and attractiveness of FDI involving R&D. In addition, privatisation can make these firms more competitive.

3- It is clear that Libya has a low GDP ratio of national R&D expenditures and its weaknesses is shown in several aspects of S&T production. The landscape of R&D operations in Libya indicates that most of these operations are mostly based upon technology acquisition or in a few processes of product development. The challenge here is how to raise overall depth of S&T literacy. Thus, if Libya was to enhance and improve its domestic R&D capacity and upgrade its technological capability, it is advisable to increase its S&T intensity further to be able to conduct indigenous R&D. This should include for example common innovation infrastructures and factor input conditions such as research centres and universities as well as information and telecommunications networks. In addition, it is advisable to support the establishment of industrial R&D units to promote the technological upgrading of firms. Therefore, mandatory applications of R&D requirements and support schemes shall be set up in this regard to nurture and boost R&D within the Libyan large industrial firms. The Libyan government may also set up science parks, establish business incubators, support centres for technology transfer. Furthermore, the Libyan government is advisable to create and develop mechanisms by which making TNCs' subsidiaries to be more linked to its NIS. This can secure more benefits from possible knowledge spillover and technology transfer processes. An effective way to link foreign R&D to domestic firms is to support the building of clusters.

4- It became relatively true that English is already the lingua franca of international business, where most of external knowledge that R&D staff may need is documented in the English language. This need rises at engaging in international scientific communications, cooperate with international partners, learn from transferred technology process, and observe knowledge spillover from foreign companies. Thus, if the Libyan organisations were to seek engaging in corporate R&D activity with foreign partners, they are advised to improve and develop the English language skills for their R&D staff.

5- Based on evidence that suggests that R&D incentives are highly correlated with the growth of FDI involving R&D, the Libyan government is advised to establish and enact some legislation in favour of fiscal incentives and schemes for R&D and innovation, if it was to seek foreign R&D activities. To encourage emerging corporate R&D activity in

TNCs' subsidiaries and benefit from, the economic development policy of countries should foster subsidiary technology upgrading as a part of initiatives to increase international technology transfer (Medcof, 2007).

7.5 Limitations and directions for further research

The emergence of foreign R&D activities in technologically underdeveloped countries is still in its infancy. The opportunity to carry out research on these countries in a manner equivalent to those performed in technologically developed countries has been virtually non-existent. However, several issues related to the R&D globalisation process in technologically underdeveloped countries can be certainly investigated. In this context, this research has contributed to this field, but at the same time, it has several limitations. The following points present these limitations and some suggestions for further research:

1- First of all, the question could be posed as a major limitation of this thesis is why study Libya? Is it valid and appropriate to use Libya as an example of a technologically underdeveloped country? In fact, there are several reasons why Libya might not be a very good example. These include:

- Libya is only one country.
- The political environment is (a.) not typical and 'a unique regime', (b.) subject to change and uncertainty, and 'even perhaps a dysfunctional state'.
- It has been subject to severe international pressure e.g. US and UN sanctions for two decades.

However, against these points, one could argue some factors that make Libya appropriate as the focus of the study. These include for example:

- Libya belongs to MENA and this is a region that has not been widely studied/ researched in terms of technological development.
- Libya is in the 'middle' in terms of its stage of development i.e. it is not growing rapidly like Brazil, but nor is it very poor like some African countries.
- Libya is at the 'cross-roads', between a highly developed region: Europe and a relatively underdeveloped region: Africa.
- There has been quite a bit of research on countries subject to 'resource-dependency' (i.e. oil rich ones) and the problems they have in achieving good

economic growth and development, and this study makes a contribution to this issue.

- Finally, 'with the Arab Spring of 2011', one could argue that economic development in the Middle East is at an important turning point and a study of a country like Libya is therefore most appropriate.

Thus, choice of Libya is not necessarily a limitation and can be valid in this context.

2- This thesis shows that there are significant obstacles to the R&D globalisation process in Libya, which may indicate situations and relevant conditions in other technologically underdeveloped countries, but it must be admitted that naturally this is a very preliminary effort on these countries. Indeed, this thesis suffers from a few limitations, which further research may attempt to overcome:

- The data set is quite limited and biased towards: 1) one country, 2) two TNCs, and 3) TNCs from the oil and gas industry field. Thus, the limitation of the sample must be solved by systematically screening large number of TNCs and from different industry sectors, working in technologically underdeveloped countries. In addition, taking Libya as a case study may have offered greater in-depth analysis, but may limit the potential to generalise the findings. Similar research needs to be carried out in other countries, at least of similar economic development and growth, such as Arab Gulf countries. This thesis opens doors for further research to study roots and causations of these obstacles and explain them in more depth. Much remains to be done to establish a more comprehensive measurement and monitoring system of such obstacles in different countries.
- The focus on the industrial R&D and R&D collaboration is not a sufficient proxy for the whole R&D globalisation process. There are other aspects that should be included, such as the mobilisation of international students, the international cooperation in S&T activities, the international trade in high techno-products and services. The obstacles surrounding these aspects may differ from those relating to corporate R&D by TNCs.
- The idea of analysing the development paths, based on the technological dimension to TNC's activities, is very useful in such studies. Thus, as this research is still preliminary in its analysis to these paths, subsequent studies should consider this limitation, and can develop more accurate techniques, which should take into

account the patterns of the movement from technological stage to another, and how these technological activities are organised and managed in reality. It would also be of great interest to further examine the technological capability upgrading of R&D subsidiaries in technologically underdeveloped countries. More studies analysing this phenomenon are necessary to confirm some findings of this study.

7.6 Research value and contribution to knowledge

This research makes important contributions to ensuring useful knowledge is at the forefront of any technologically underdeveloped country that has a desire to join the global R&D network. Any researcher who wants to stimulate his/her knowledge on the development of the R&D globalisation phenomenon can benefit too. Indeed, some of the discussions and findings of this thesis can be viewed as significant academic contributions to the debate about the globalisation of corporate R&D activity and relevant issues. Overall, with providing fresh insights, this research contributes to the literature, mainly on the International Business, R&D Management, Innovation Management and Regional Development studies. Thus, the main values and contributions of this thesis can be summarised as follows:

1- The potential originality and value of this research comes from that its topic was not previously a focus of study. Beginning with a review of literature on the international R&D business, it showed that we have very limited first-hand knowledge of TNCs and host countries perspectives together on the obstacles to the R&D globalisation process in technologically underdeveloped countries, where such host countries perspectives have been less scrutinized. Although this review might be far from a true historical and comprehensive analysis, this research represents the first empirical study that sheds light on Libya.

2- To the best of my knowledge, this research may be the first study that focuses upon the topic of obstacles to the globalisation of corporate R&D activity in technologically underdeveloped countries and redresses the balance in literature by providing a host country and TNCs perspectives on these obstacles.

3- Some findings of Chapter Six indicate a possible role of knowledge seeking strategy in undertaking corporate R&D activity in Libya. Thus, as this is not in line with the assumptions of knowledge seeking strategy, this thesis provides evidence that the presence

of leading TNCs in the host country even at periphery is an important factor driving knowledge seeking strategy.

4- This research uses a new approach to analyse the patterns and forms of foreign R&D activities at periphery. It introduces the development paths to analyse the development of TNCs' technological activities there and determines the most important factors that might have influenced this development as well as how these factors have contributed to shape these patterns and forms. Thus, it represents a significant contribution, as the first study uses the development paths in investigating the nature of overseas R&D activities, and addresses the significance of development paths in such topics.

5- Since the reality of regime change in Libya looks forward to building new Libya on the right foundations and it is expected to attempt moving its economy toward a knowledge-based economy. In such case, this thesis can be a reference to help in designing some necessary processes to do so. This thesis addresses the main limitations and weaknesses of NIS[1] and provides several lessons learnt to overcome these deficiencies in NIS as well as improving the Libyan economy environment in several aspects. Indeed, this research is particularly timely since it highlights these limitations and weaknesses that are perhaps a function of the old regime, and thus, this research can provide valuable insights for new S&T and industrial policies. Overall, this thesis can guide any specific efforts that would encourage the improvement of technological capability and research capacity within relevant Libyan institutions, while facilitating cross-border technological collaborations. This thesis also provides an important vehicle for demonstrating several different barriers and areas in which reforms can have a significant impact on improving prospects for emergent corporate R&D activities.

[1] These limitations and weaknesses have been summarised in Table 7.1 in p. 207.

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Appendix (1) - Letter Asking for Questionnaire Survey Participation

The job code/ organization code

Date ……

Ali Mossa Omar
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Dear Sir/ Madam,

I am a PhD student from Nottingham Business School, Nottingham Trent University, UK, and I am conducting a research project about '**Obstacles to the Globalisation of Corporate R&D in Technologically Underdeveloped Countries**'. The focus of my work is on investigating the principal obstacles that may hinder the corporate R&D internationalisation process of both international and joint R&D projects. Also, I intend to identify some methods and avenues that can help to overcome these obstacles. In the empirical phase, I have decided to focus upon Libya as a case study, in order to provide a technologically underdeveloped context, and as part of my research, I would like to invite you to complete this questionnaire.

I would very much appreciate your participation in this survey, and welcome any views that you may express. The data obtained from this questionnaire will only be used for academic purposes, will be given complete confidentiality, and no information will be disclosed with a specific link to a specific organisation. Results will only refer to the whole sample and not to any individual.

I would like to thank you very much in advance for your kind cooperation. In return for your efforts, I am happy to provide you with a report of the study's research findings free of charge once the study is completed. This report will give you insights into the nature and aspects of obstacles to the R&D globalisation process.

I look forward to receiving from you the questionnaire with completed answers. Thus, please do take enough time to read and find out the appropriate answers and if you have any further questions about, please do not hesitate to contact me.

Please note that I will be in Libya during next two months. Thus, I hope that you can complete this questionnaire within this time. I will be pleased to collect it by hand.

With very best wishes,

Yours faithfully

Ali M. Omar

Appendix (2) - R&D Practice Survey of Libyan Organisations

Please answer all of the following questions by ticking and writing the appropriate ones.

Section (a): general questions about some of the organisation's characteristics.

Q1- How long has this organisation been established? (……years)

Q2- What is your organisation's business field? (……)

Q3- (Relevant to the manufacturing organisations), where does your organisation market its products?

- In local market ☐
- In global market ☐
- In both markets ☐

Q4- (Relevant to the research organizations), where does the organization market its research? To domestic organisations ☐ To foreign organisations ☐ To both ☐

Q5- How much is the current capital of the organisation? (……).

Q6- What is the number of employees in your organisation? (……).

Q7- Has the organisation obtained an ISO certificate?

- Yes ☐, specify which (…….).
- No ☐, please go to Q9

Q8- When was it obtained? (…….).

Section (b): questions about a nature of the management and practice of R&D activities.

Q9a- In the organisation, is there a separate organisational unit that fosters the practice of R&D activities

- Yes ☐
- No ☐, please go to Q13

Q9b- How many employees are there in this unit?
Number of personnel at technician level (…….)
Number of personnel at research scientist/engineer level (…….)
Number of non-technical personnel at management level (……..)
Number of non-technical personnel below management level (……..)

Q10- In which year this unit established? (……..)

Q11- Do you think that R&D activity could be developed by an independent organisational unit during the near future? Please state the reasons in both cases.

Yes ☐ No ☐

……
……..

Q12- Which fields of R&D activities are practiced in the organisation?

- Basic research ☐
- Applied research ☐
- Development processes ☐
- Other kinds, please point out ☐

……..

Q13- Which of the following types of R&D are practiced in your organisation? (Please tick as many as apply)

- R&D for improving products ☐
- R&D for improving methods of production and industrial processes ☐
- R&D for an attempt to use alternatives to current raw materials ☐
- R&D related to an attempt to innovate new products or new productivity methods ☐
- R&D for overcoming technical problems ☐
- R&D for doing modifications to tools or machines that have been used in the productivity operation ☐
- R&D related to the benefits of recycling materials ☐
- R&D related to technology transfer ☐
- Other research, please state ☐

……
……

Q14- Do you think that R&D activities which are currently practiced are suitable for the organisation's goals?

- Yes - high degree ☐
- Yes - medium degree ☐
- Yes - low degree ☐
- No ☐

Q15- Given the previous experience of R&D practices in your organisation, which of the following elements are outcomes of these practices? (Please tick as many as achieve)

- Providing new products or services ☐
- Increasing in diversification of the organisation's products or services ☐
- Increasing and improving the quality of current products or services ☐
- Finding solutions for some technical problems ☐
- Reducing the operation costs ☐
- Modifying some transferred technologies ☐
- Improving work tools or equipments ☐
- Facilitating the use of some local raw materials ☐

- Modifying some designs related to products ☐
- Other contributions, please state ☐

……
……

Q16- Has the organisation succeeded in achieving new innovations?

- Yes ☐
- No ☐, please go to Q18

Q17- Have all these innovations been translated into commercial products?

- Yes ☐
- No ☐

Q18- In the organisation, is there an independent budget for R&D activity

- Yes ☐, please go to Q23
- No ☐

Q19- Could the current amounts be enough to finance this activity?

- Yes ☐
- No ☐

Q20- Does the organisation practice some corporate activities which are related to R&D?

- Yes ☐
- No ☐, please state why, and in which way the organisation obtains its needs from R&D services

  ……
  ……
  ……
  ……

If you answered this question no, please go to Q28.

Section (c): questions related to the nature of collaboration between your organisation and foreign organisations in the R&D field.

Q21- How many partners does your organisation currently deal with in R&D activity? (Please categorise)

- Domestic (……..)
- Foreign (……..)

Q22- How much does the organisation rely on foreign partners in R&D process? (Please tick as many as apply and rank them as 1, 2, and 3 ….et. [1= the highest]

- Technical support ☐ (….)
- In research phase ☐ (….)
- In development phase ☐ (….)
- Training programmes ☐ (….)

- Supplying laboratories requirements ☐ (….)
- Others purposes ☐ (….), please specify……..

Q23- which organisations have usually been involved in R&D cooperation work with your organisation?

- Foreign organizations ☐, how many years has your organisation been collaborating with these (……..)
- Local organizations ☐, how many years has your organisation already been collaborating with these (……..)

Q24- How many collaborative R&D projects has your organisation been involved in during the last three years (approx)? (…….)

Q25- which of the following forms have these collaborations taken?

- Buying the results of some research ☐
- Contracting some research that is financed by the company ☐
- Buying some invention patents ☐
- Training employee in the R&D unit on tools for performing R&D tasks ☐
- Fixing some technical problems ☐
- Providing laboratory tools ☐
- International R&D subcontracting ☐
- Other forms, please state ☐

……
……

Q26- Do you think that your organisation has gained substantial benefits from this collaboration?

- Yes ☐
- No ☐, if so, do you think that this because

- The organisation could not optimally exploit the obtained services ☐
- R&D services were not provided in suitable time ☐
- Other reasons, please state ☐

……
……
……..

Q27- If the answer to Q32 was yes; please specify what kind of benefits has your organisation obtained?

……
……
……

Section (d): questions about problems and difficulties related to the practice of R&D activities.

Q28- which of the following obstacles do you think are hindering the practice of R&D activity in your organisation? (Please tick as many as apply)

- Human resources management obstacles:
  - Deficiency in specialised and qualified human resources ☐
  - Absence of programmes to promote employees' creativity and innovation ☐
  - Instability of highly specialized personnel in the R&D field ☐
- Technical obstacles:
  - Shortage of technological information ☐
  - Unavailability of R&D information systems ☐
- Financial obstacles:
  - High cost of R&D activities ☐
  - Lack of strong financial support ☐
- Management obstacles:
  - Lack of experience ☐
  - Absence of clear goal plans to practice R&D ☐
  - Poor trust and appreciation of R&D results by the top management, consequently making it less interested in supporting R&D activities ☐
  - Absence of appropriate organisational environment to practice R&D successfully, and poor communication and cooperation between the R&D unit and other units in the organisation ☐
- Other problems or obstacles please state: ☐

……
……
……

Q29- Does your organisation have any plan or programme to overcome these problems

- Yes ☐, please give details…….
  ……
  ……
  …….
- No ☐, please say why
  ……..
  ……
  ……..
  ……
  ……

Section (e): questions about significant issues that may hinder collaboration between your organisation and foreign organizations in the R&D activities field.

Q30- Which if any of the following obstacles have hindered collaboration processes? (Please tick as many as apply)

- Management obstacles:
  - Lack of corporate R&D management expertise ☐

- Lack of targeted incentive to attract foreign partners ☐
- Difficulty of persuading foreign partners to be involved in R&D projects ☐
- Deficiency in strategies related to encouraging foreign partners to become involved in R&D cooperation R&D activities ☐

- Human resource obstacles:
  - Dealing with employees from different cultures to work as a team ☐
  - Poor English language skills among R&D staff ☐
- National Innovation system obstacles:
  - Limitation of R&D capacity ☐
  - Weak domestic R&D capabilities ☐
- Institutional frameworks obstacles:
  - Absence of institutional mechanisms that provide explicit incentives to investors to target knowledge based activities in Libya ☐
  - Insufficient stronger intellectual property protection ☐
  - Deficiencies of communication infrastructure and linking with global knowledge networks ☐
- Financial obstacles:
  - Top management does not recognize the importance of corporate R&D activity, consequently, making no independent budget for corporate R&D projects ☐
  - Issues related to sharing risk agreements ☐
- Public Policies Obstacles:
  - Deficiencies of government policies related to FDI policy ☐
  - Deficiencies of government policies related to S&T policy ☐
  - Deficiencies of government policies related to industry policy ☐
- Other obstacles or problems, please state: ☐

…….....
……
……..

Q31- Has the organisation had any of the following problems regarding corporate R&D projects or collaboration process?

(a)- Management problems

- Yes ☐
- No ☐

If the answer was yes, please state the main problems?

……
……
……

(b)- Legal problems

- Yes ☐
- No ☐

If the answer was yes, please state the main problems?

……
……
……

(c)- Financial problems

- Yes ☐
- No ☐

If the answer was yes, please state the main problems?

……
……
……

Q32- Do you have some other things to say about the obstacles to corporate R&D activity in your organisation and how these can be overcome?

……
……
……
……
……
……

Many thanks for your participation and co-operation

Appendix (3) - Letter Asking for Interview Participation

The job code/ organisation code

Date ……

Ali Mossa Omar
Nottingham Business School,
Nottingham Trent University
Burton Street, Nottingham,
UK, NG1 4BU
E-mail: Ali.Omar@ntu.ac.uk
Tel: (0044) 7 833 598 120

Dear Sir/ Madam. ……..,

I am a PhD student at Nottingham Business School, Nottingham Trent University, UK, and I am currently conducting an academic study on '**Obstacles to the Globalisation of Corporate R&D in Technologically Underdeveloped Countries**'. The motivation behind this research stems from the fact that the technological and innovative capability gap between developed countries and developing countries in general and between developed countries and technologically underdeveloped countries in particular is tending to widen, and also, latter group of countries (including Libya) have lagged behind in terms of the involvement in global R&D network and obtaining the benefits from the globalisation of R&D activity. It is very clear that the share of technologically underdeveloped countries in R&D globalisation process is still very limited. Therefore, I am attempting to identify the main obstacles to this process, by taking Libya as a case study.

Since your organisation conducts some sort of R&D activities in Libya, you are in a good position to contribute to this research project. In view of this, I would be grateful if you would agree to be interviewed. I envisage interviews taking about 60 minutes, maximum one and half hour.

This research project is an academic study for obtaining the degree of Doctor of Philosophy in International R&D Business. The information you provide will be dealt with complete confidentiality. No information will be disclosed with a specific link to a specific organisation. Any publication will refer to the whole sample, not to any individual.

I thank you very much in advance for your kind cooperation. In return for your efforts, we would be more than happy to provide you with a report of the study's research findings free of charge once the study is completed. This report will give you insights into the current corporate R&D practices in Libya and what are the main obstacles surrounding the globalisation of R&D activity here.

I look forward to your reply and if you have any further questions, please do not hesitate to contact me.

With very best wishes,

Yours faithfully

Ali M. Omar

Appendix (4) - Open-Ended Questions (In-depth interview format)

Q1- What are the main reasons that were behind your organisation's involvement in current corporate R&D operations?

Q2- By your experience, what are the main aspects of attractive conditions for doing corporate R&D activities?

Q3- What types of R&D activities has your organisation undertaken in corporate R&D projects and under which conditions?

Q4- How long has your organisation been involved in corporate R&D projects? Was the initiative from your organisations or from your partner and in which form?

Q5- Does your organisation want to increase the size of its corporate R&D activities? And, if so, at which level is it? Also, in both cases, please state why.

Q6- In corporate R&D process, how did your organisation move from one technological stage to the next, for instance from manufacturing support to advanced development?

Q7- Where do you place the domestic capability of R&D activity (in scale and scope phases)? And how has it reflected on R&D internationalisation process in Libya?

Q8- In corporate R&D process, how important was the role of the Libyan government in helping your R&D site to upgrade and build its level of technological sophistication?

Q9- In your view, what are the advantages that Libya has to become a favoured destination to FDI involving R&D activities? Alternatively, what are the disadvantages that may make Libya is away from this situation?

Q10- In general, what are the main Libyan policy factors that have impacted on the nature and size of R&D collaboration that your organisation conducts in Libya?

Q11- For Libya, what kind of policies do you think are needed to benefit from the globalisation of R&D activity?

Q12- Do you think that the situation is different about a target destination for FDI involving R&D from Libya to other African countries? And why is it?

Q13- How has your organisation exploited available opportunities concerning corporate R&D activities in Libya?

Q14- Which countries or firms has your organisation dealt with in corporate R&D processes?

Q15- For transnational corporations, what kinds of other activities has your organisation conducted in Libya before R&D activities?

Concluding Questions:

Q1- What lessons has your organisation learnt in building up/managing the corporate R&D projects?

Q2- For Libya, what do you consider major future R&D collaboration challenges?

Q3- What are the aspects of future opportunities to expand and develop corporate R&D activities in Libya? And if you think there is nothing, please give details about.

Appendix (5) - Important Relevant Academic Resources on the Research Topic

It is significant to mention that this research utilises many published academic materials; books, articles and reports. For example, it has particularly benefited a lot from the articles existing in the special issues of the *Journal of Technology Transfer*, 'International industrial R&D- policy challenges', 2007, Vol. 33, No. 4; *Research Policy*, 1999, Vol. 28. In addition, it cannot be ignored the significance of recent reports on this field from such as (UNCTAD, 2005a), 'Transnational corporations and the internationalisation of R&D'; (OECD, 2008a), 'Internationalisation of R&D'; (UNCTAD, 2005b), 'The globalisation of R&D and developing countries'. These sources represent the most significant recent contributions in the field of International R&D Business and have been echoed in several references of this research. In fact, the most influential one is UNCTAD 2005a, the World Investment Report on transnational corporations and the internationalisation of R&D. Many citations from this source appear in this thesis. This is because of that this report has reviewed and analysed most of the previous literature on the globalisation of R&D and it is hardly to find any academic work on this subject -since 2005 and beyond- has not largely quoted from it or considered it as a principle source.

Appendix (6) - Publications and Presentations Arising from the Work

During the course of the research, presentation of the work and academic peer review took place through several channels. In the earlier stages of the research, during 2006, I presented my research proposal to (BLSS Research Student Conference 2006), which held by Graduate School on 06-07/12/2006, Nottingham Trent University: UK.

In subsequent years, I have presented some presentations derived from this thesis at BLSS Research Student Conferences as follows:

• In 2007, "Has Globalisation of R&D run into the sand?", BLSS Research Students Conference, which held by Graduate School on 05-06/12/2007, Nottingham Trent University: UK.

• In 2008, "The Globalisation of R&D: windows of opportunity or further burden?", BLSS Research Students Conference, which held by Graduate School on 10-11/12/2008, Nottingham Trent University: UK.

• In 2009, "TNCs' strategies for biotechnology R&D: lessons from the periphery", BLSS Research Students Conference, which held by Graduate School on 09-10/12/2009, Nottingham Trent University: UK.

Furthermore, a part of this research has been accepted to present at the R&D Management Conference 2010. The detail are 'Development paths to TNCs' technological activities in the periphery: A cross-case analysis', The R&D Management Conference 2010, "Information, Imagination and Intelligence in R&D Management", which held by Manchester Business School on 30/06 - 02/07/2010. The University of Manchester: UK.

Appendix (7) - General Problems Encountered During Research

A big academic project is rarely completed without some difficulties during some or all its stages. Researchers who conduct overseas fieldworks are likely to encounter problems that the average methods textbook did not prepare them for; even when the country they are visiting is familiar to them and an advance planning has been exhaustive. Thus, this section looks at some of the more surprising obstacles that cropped up during my fieldwork. Most of mangers in TNCs do not like the interview to be recorded, even though they have agreed with the consent letter thereby which the interviews have been conducted with. This has made the situation to be difficult, when I can just write notes that might not be helpful such as recording. This might not be surprising in the environment of developing countries, even it was in TNCs, but perhaps, they are working in a developing country.

What the challenge in place was it has been considered to target more TNCs, but some were unwilling to participate in such survey. I think that they consider information concerning their technological activity in general and R&D in particular is too strategically and sensitive to be disclosed. Indeed, R&D is often considered the backbone in the search for competitive advantage. Thus, gaining access to TNCs with a view to study the corporate R&D activity was, to say the least, not an easy task.

Appendix (8) - Major Issues Related to Measurement Questions

Issue Category	Fundamental Issue
Question Content	
1. Purposeful versus interesting	Does the question ask for data that will be merely interesting or truly useful in making a decision?
2. Incomplete or unfocused	Will the question reveal what the decision maker needs to know?
3. Double-barrelled questions	Does the question ask participant for too much information? Would the desired single response be accurate for all parts of the question?
4. Precision	Does the question ask precisely what the decision maker needs to know?
5. Time for thought	Is it reasonable to assume that the participant can frame an answer to the question?
6. Participation at the expense of accuracy	Does the question pressure the participant for a response regardless of knowledge or experience?
7. Presumed knowledge	Dose the question assume the participant has knowledge he or she may not have?
8. Recall and memory decay	Does the question ask the participant for information that relates to thoughts or activity too far in the participant's past to be remembered?
9. Balance (general vs. specific)	Dose the question ask the participant to generalise or summarise behaviour that may have no discernable pattern?
10. Objectivity	Does the question omit or include information that will bias the participant's response?
11. Sensitive information	Does the question ask participant to reveal embarrassing, shameful, or ego-related information?
Question Wording	
12. Shared vocabulary	Does the question use words that have no meaning or a different meaning for the participant?
13. Unsupported assumption	Does the question assume a prior experience, a precondition, or prior knowledge that the participant does not or may not have?
14. Frame of reference	Is the question worded from the participant's rather than the researcher's, perspective?
15. Biased wording	Does the question contain wording that implies the researcher's desire for the participant to respond in one way versus another?
16. Personalisation vs. projection	Is it necessary for the participant to reveal personal attitudes and behaviour, or may the participant project these attitudes and behaviour to someone like him or her?
17. Adequate alternatives	Does the question provide a mutually exhaustive list of alternatives to encompass realistic or likely participant attitudes and behaviours?
Response Strategy Choice	
18. Objectives of the study	Is the question designed to classify or label attitudes, conditions, and behaviours or to reveal them?
19. Level of information	Does the participant posses the level of information appropriate for participation in the study?
20. Thoroughness of prior thought	Has the participant developed an attitude on the issue being asked?
21. Communication skill	Does the participant have sufficient command of the language to answer the questions?
22. Participant motivation	Is the level of motivation sufficient to encourage the participant to give thoughtful, revealing answers?

Source: (Cooper and Schindler 2008, p. 338).