The Influence of Culture on Innovation in Multinational Organisations: Evidence from the Oil and Gas Industry

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Abstract

Culture is believed to have a crucial influence on innovation and the innovativeness of organisations. In order to quantitatively measure this influence, the current project explores the relationships between the dimensions of Hofstede's (1980) cultural model and the innovativeness of business units located around the world in the oil and gas industry. Innovativeness is measured by: (i) the number of patent applications filed and (ii) the number of technologies generated during a three-year period by the business unit. An online survey undertaken in collaboration with the Society of Petroleum Engineers (SPE), collected data from the research and development (R&D) centres of multinational oil and gas companies around the world. While previous studies in this area have focused on datasets from specific regions or countries, this investigation offers a snapshot that includes innovation-related activities from many countries and cultures around the world. This study also examines the influence of cultural distance between the country of the responding organisation's headquarters and the country of the responding business unit, and examines how this distance affects innovative output. The four original dimensions of Hofstede's model—power distance, individualism, masculinity and uncertainty avoidance—are used in this investigation.

The results indicate that power distance has a strong, positive influence on an organisation's innovativeness. When a company's headquarters or research centre is located in a country with a high power distance score, innovativeness notably increases. However, when the power distance score between the headquarters country and international research centre country increases, innovativeness decreases. In addition, the individualism scores of both the headquarters and local countries were positively related to the number of patents generated by overseas business units. In contrast, only the masculinity scores of the overseas R&D centre indicated a strong and positive influence on innovativeness. However, while masculinity distance was found to be highly correlated with patent outputs, it had almost no effect on the number of deployed technologies. Finally, the uncertainty avoidance scores of both the headquarters and overseas R&D centres were positively related to both measures of innovations; however, the uncertainty avoidance distance between the two countries was negatively related to the innovativeness of business units.

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

QUT Verified Signature

Signature: ______Ali Dehghan Manshadi______________________

Date: ______August 2017______________________

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CHAPTER ONE

1 Introduction

In today's intense globally competitive business environment, establishing and managing overseas research and development (R&D) centres is an important consideration for large multinational enterprises (Criscuolo 2005; Gassmann & Zedtwitz 1998; Kumar 2001). Despite the historically slow internationalisation rate of R&D activities, these activities started gaining momentum from the early twentieth century, especially in the multinational corporations (MNCs) of most advanced economies, in response to increasing technological sophistication in contemporary product markets (Serapio & Dalton 1999). Multinational companies are increasingly dispersing their R&D activities throughout different countries around the world (Ambos & Schlegelmilch 2008; Von Zedtwitz & Gassmann 2002). Earlier investigations in this area have found efforts to internationalise R&D through facilitating corporate innovation to be effective (Cantwell & Mudambi 2005; Cantwell & Zhang 2006), largely by improving the parent firm's innovative performance and sustained competitiveness (Kafouros et al. 2008). However, the geographical location of the overseas R&D centre has been shown to play an important role in the success or failure of these international efforts (Love & Roper 2001; Porter & Stern 2001).

Cheng and Bolon (1993) called attention to the growing involvement of multinational firms in foreign-based R&D, and sought to stimulate future research in this area. They observed that, despite massive growth in the foreign R&D expenditure by many large United States (US) and European firms, relatively little attention has been paid to multinational R&D. Since Cheng and Bolon's (1993) paper, numerous studies have examined this problem through different lenses, especially geographic distance (Fifarek & Veloso 2010; Hoekman, Frenken & Tijssen 2010; Phene, Fladmoe-Lindquist & Marsh, 2006). For example, Higón and Antolín (2012) performed a comprehensive study examining the internationalisation of R&D in United Kingdom (UK) manufacturing firms. They revealed that both multinationalism and foreignness are important drivers of R&D returns. However, most works that addressed the management of international R&D after Cheng and Bolon's (1993) paper were based on single-country or -region case studies, and there remains a literature gap regarding industrial settings that are more international and global. Therefore, any research in this area would be appreciated by industry and academia. Given that the oil and gas industry is an example of an industry with large firms that have large multinational R&D expenditures, any study of this industry could help fill the existing literature gap on the management of international R&D business in a global base, especially regarding cultural influences. Thus, this is the aim of the current research.

An important step in the internationalisation of R&D is understanding the parameters that may affect this process. Selecting a suitable location is one of the most important factors in this regard, as many aspects of location can influence the success or failure of R&D centres (Le Bas & Sierra 2002; Lewin, Massini & Peeters, 2009). The innovation output of an overseas R&D centre can be significantly influenced by the degree of cultural match between the original and host countries, geographical position and distance from the headquarters, national wealth and political system of the host country, differences in education systems, and availability of natural resources (Ambos & Schlegelmilch 2008). Establishing a new R&D laboratory can take several years and require significant investment to generate functional connections with the local scientific community (Perrino & Tipping 1989). Thus, it follows that selecting an unsuitable geographical location for an overseas R&D centre can have serious consequences for the firm's long-term performance (Ambos & Schlegelmilch 2008). Jones and Davis (2000) offered three primary factors to be considered when determining where to establish foreign R&D centres:

1. the motivations driving the internationalisation process—for example, are firms driven more by market (demand), technology availability (supply) or other competitive pressures to locate overseas?
2. the firm's geographic orientation regarding foreign R&D activities—for example, are their efforts oriented more locally, regionally or globally?
3. the type of activity and mission expectations of the overseas unit—for example, is the unit primarily responsible for basic research, applied research or development activities?

Hoppe (1993) added that culture also plays a significant role in the success or failure of international R&D. Prior research in this area has suggested that some national cultures have a greater tendency to support R&D and innovation-related activities, thereby offering a potential source of advantage for research centres located there (Ambos & Schlegelmilch

2008; Hofstede 2001; Jones & Teegen 2003). Nakata and Sivakumar (1996) went even further by suggesting that the selection of a national culture is among the most important factors in the success or failure of overseas R&D centres. Many more studies have also represented strong evidence of the influence of national culture on the innovation tendency of a nation (Hofstede 1980; Jones & Davis 2000; Shane 1993). In fact, research has shown that certain indicators that are culturally representative of a nation—such as trust, tolerance, corruption, civic rights, the form of governance and education—influence innovation at the national level (Fagerberg & Srholec 2008).

Beside the importance of the internationalisation of R&D activities, the overseas R&D expenditure of most MNCs is still highly concentrated in a handful of technologically advanced countries (Kumar 2001). The situation for oil and gas MNCs is even worse, as the industry is known for its slow track record in applying new technologies. However, as many technologically advanced countries cannot meet all the requirements for oil and gas research centres (especially proximity to oil and gas reserves), the internationalisation of R&D activities in this sector is more dynamic than in other industries. However, due to increasing difficulties in accessing cheap oil, oil and gas MNCs have strong motivation to improve their technological capabilities and new product development, which cannot occur without a sophisticated international R&D network.

To examine this increasingly important topic, this thesis seeks to shine additional light on the role of culture in international R&D centres with a dataset that offers a potentially more international lens than has been used previously (e.g., Higón & Antolín 2012; Phene, Fladmoe-Lindquist & Marsh 2006). This thesis studies the influence of cultural distance between the countries of the company headquarters and local R&D centres on the innovation output of oil and gas MNCs. To this end, this investigation considers two different measures to evaluate innovation output: (i) the number of patent applications filed by a business unit and (ii) the number of deployed technologies created by the business unit. In so doing, this study will improve understandings of how cultural distance influences innovation output in international R&D activities in general, and specifically within the oil and gas sector.

CHAPTER TWO

2 Theoretical Framework

2.1 Innovation in the Oil and Gas Industry

Since the early years of petroleum production, the key to increasing recoverable reserves has always been innovative technologies, which are initiated through R&D practices (Neal et al. 2007). Many of these innovative technologies in exploration and production (the name frequently applied by industry insiders to the upstream part of the oil and gas industry) have increased oil recovery levels (the amount of crude oil that can be extracted from an oil field) from a few per cent in the early years of the new technology to more than 70% after many years (Hendraningrat, Li & Torsæter 2013; Kokal & Al-Kaabi 2010; Neal et al. 2007; Tzimas et al. 2005). Underpinning the demand for these innovations is the fact that much of the world's 'easy oil' has already been brought to the market (Perrons 2014) and new technologies are required to produce oil and gas from resources that are deeper, harder to find, and in environments that are significantly more difficult to access than they used to be (Managi et al. 2004; Perrons 2014; Roberts 2004).

In this regard, companies are inspired to invest in R&D to improve their share in the market. For instance, multinational oil and gas companies invest in R&D not only to increase their sale value, but also to increase their shareholder value and maintain long-term sustainability through reserves replacement. In addition, service companies are willing to increase their market share by selling increased and improved services to the industry. They also invest in innovation and technology to develop patents, aiming to turn them into products or licensing possibilities in later stages, and subsequently return a stream of revenue to their company for many years (Neal et al. 2007).

Despite the strong need for new and innovative technologies, the petroleum industry has a reputation of being slow to adopt innovation (Perrons 2014), and the oil and gas industry has one of the lowest levels of R&D intensity of any sector. There are many reasons for this slow innovation track record in the petroleum industry, as follows:

- Technological interdependence: A well-recognised feature of the upstream petroleum industry has always been interdependence at technological and production levels. The interdependence that occurs due to the shared equity structure of many assets makes it difficult for upstream companies to keep their new innovations exclusive (Acha & Cusmano 2005; Perrons 2014).

- High cost of new technology deployment: The cost associated with applying any new technology—especially the cost associated with the failure of that new technology—is extremely high for oil and gas companies; thus, they prefer to be fast followers, rather than first users (Mody 2006; Perrons 2014).

- High risk of new technology: The risk associated with adapting new technology in oil and gas is extremely high in terms of cost, as well as entailing environmental, political and safety factors (Flin et al. 1996; Mearns & Yule 2009).

Despite the abovementioned concerns regarding sluggishness of innovation in the petroleum industry, it seems that the industry changed dramatically during recent decade, and many multinational companies consider technology as their strategic priority (Perrons 2014; Silvestre & Dalcol 2009). Such changes and investment in R&D by oil and gas companies mostly raising by collaborative works and through international research centres to share the cost and risks with others. Therefore, understanding the influence of different parameters—such as geographical location and the cultural factors of the host country for R&D centres—is crucial when establishing new overseas R&D centres.

2.2 Internationalisation of R&D in the Petroleum Industry

There is extensive research to support the notion that MNCs with a higher intensity of R&D internationalisation have greater innovation performance (Hsu, Lien & Chen 2015; Iwasa & Odagiri 2004; Penner-Hahn & Shaver 2005; Phene & Almeida 2008). For example, based on patent data from European firms, Rahko (2016) verified that more innovative firms self-select to internationalise their R&D activities, and can subsequently generate up to 50% more patent applications. In a similar work, Nieto and Rodriguez (2011) found that exploitation of foreign R&D knowledge inputs has a positive effect on innovation results, especially in the case of product innovations. However, there is also some evidence showing that a high level of R&D internationalisation may lead to a greater level of operational complexity (Gassmann & von Zedtwitz 1999), fear of knowledge leakage and increasing foreignness liability (Zaheer 1995).

However, most research has confirmed that R&D internationalisation can positively influence innovation performance by comparing the positive benefits of exploration, exploitation, learning and product development, and the negative costs of coordination and communications during the R&D internationalisation process (Chena, Huangb & Lin 2012). For example, Hsu, Lien and Chen (2015) considered both the benefits and costs of R&D internationalisation, and proposed that, while increasing R&D internationalisation may negatively affect innovation performance to a certain extent (mainly due to liability of foreignness), after a threshold, the benefits begin to outweigh the negatives in order to generate positive innovation outcomes. To minimise the negative costs of R&D internationalisation, firms need to consider the different factors (geographical and cultural) that may influence their offshore R&D centres' success or failure.

Many previous studies have been performed to assess the critical factors that should be considered when selecting a location for a new overseas research centre. The most important factors that require significant consideration are as follows:

1. cultural difference between origin and host countries (Chiesa 1996; Granstrand, Håkanson & Sjölander 1993; Hofstede 2001)
2. geographical locations of R&D centres (Fernhaber, Gilbert & McDougall 2008; Le Bas & Sierra 2002; Porter & Stern 2001)
3. proximity to existing research clusters (Ambos & Schlegelmilch 2008; Porter & Stern 2001)
4. MNCs' and host countries' existing knowledge portfolio (Ambos & Schlegelmilch 2008; Foray 2006)
5. local government's level of contribution (Ambos & Schlegelmilch 2008; Gassmann & Han 2004)
6. proximity to the main markets (Ambos & Schlegelmilch 2008).

Among the above factors, the cultural distance between the origin country of the MNC's headquarters and local country of the R&D centre could have an important effect on the success or failure of the local R&D centre (Ambos & Schlegelmilch 2008; Hofstede 2001;

Pieterse 2015). This factor was overlooked in many studies until a couple of decades ago, when many researchers began to consider this important and neglected factor regarding the management of multinational R&D centres (Cheng & Bolon 1993; Herbig & Dunphy 1998; Jones & Davis 2000). Thus, this factor has been considered in many studies (Ahmed 1998; Higón & Antolín 2012; Shane 1993); however, most of these studies used a local (single country) or limited region outlook. No previous study has examined this issue using a global and international lens and especially in an intense industry such as petroleum.

2.3 Culture and Innovation

Before examining the existing literature on the influence of culture on the innovation performance of a nation or organisation, this section presents a review of the definitions of innovation and culture.

2.3.1 Definition of Innovation

'Innovation' is a broad term with multiple meanings. It is widely referred to as a critical source of competitive advantage in an increasingly changing environment (Crossan & Apaydin 2010). Schumpeter (1934) could be considered the pioneer scholar who made a great contribution to the theory of entrepreneurship and innovation. He described innovation as 'the introduction of new goods, creating new methods of production, establishing new markets and building new supply sources' (Schumpeter 1934). Many scholars have performed fundamental studies and multi-level analyses to evaluate the various determinants and dimensions of innovation (Baregheh, Rowley & Sambrook 2009; Burns & Stalker 1961; Crossan & Apaydin 2010). For example, through cross-cultural studies, Crossan and Apaydin (2010) represented a comprehensive multidimensional framework for innovation. In their study, they integrated different dimensions of innovation and consolidated them in two main categories of 'innovation as a process' and 'innovation as an outcome'. The former category answered the question 'how', while the latter answered the question 'what'. Through these categories, they identified 10 dimensions for innovation and classified them in two categories, as shown in Figure 2-1.

For innovation as a process category, the dimensions of 'driver' and 'source' deal specifically with the question of 'how', and both can be either internal or external. An internal driver of the innovation process can be available knowledge and resources, whereas an external driver can be a market opportunity or executed regulations (Crossan & Apaydin 2010). In this category, the 'locus' dimension defines the extent of an innovation process. This extent could be a firm for a closed process, or a network for an open process. In addition, 'direction' considers the start and development stages of an innovation, whether top-down or bottom-up. Finally, the 'level' dimension distinguishes between individual, group and firm processes.

For innovation as an outcome category, there exist four different dimensions ('form', 'magnitude', 'referent' and 'type'), which are meant to answer the questions 'what' or 'what kind'. While the dimension of 'form' differentiates between product or service innovation, process innovation, and business model innovation, the 'magnitude' and 'referent' dimensions indicate the degree of newness of the innovation. The dimension of 'type' reflects a more general distinction between social structure and technology, and distinguishes between technical and administrative innovations. As indicated in Figure 2-1, the dimension of 'nature' can apply to both innovation as a process and an outcome (Crossan & Apaydin 2010).

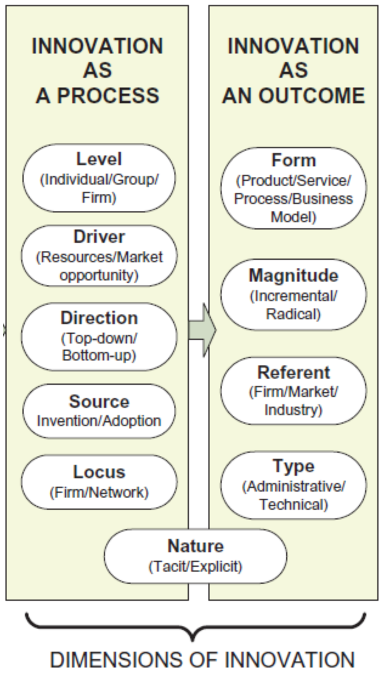

Figure 2-1 *Multidimensional framework of organisational innovation (Crossan & Apaydin 2010)*

Therefore, it is clear that innovation and being innovative can be a very complicated process, with many dimensions. Different people and nations may have different approaches to innovation and its different dimensions. These different approaches are influenced by cultural background, and may facilitate or impede the innovation.

2.3.2 Definition of Culture

Understanding culture and its definition is probably the first challenge in conducting any research with cultural involvement. The world 'culture' itself has several meanings and is used in everyday language to explain a number of different concepts, especially the concepts of civilisation (the way of life of a particular area) or refinement of the mind. The first classical definition of culture was presented by Edward Tylor (1871) as a: 'complex whole which includes knowledge, belief, art, morals, laws, custom, and any other capabilities and habits acquired by man as a member of society'. However, the modern definition of culture presented by Hofstede (2001) is: 'the collective programming of the mind which distinguishes the members of one group or category of people from another'. Hofstede (2001) also stated that: 'culture determines the identity of a human group in the same way as personality determines the identity of an individual'. Many other scholars in different disciplines have their own definitions of culture (e.g., Kroeber & Parsons 1958; Schein 2010; Trompenaars & Hampden-Turner 2011), yet all refer to culture as the shared norms, standards, values, beliefs and attitudes that differentiate one group of people or a nation from another.

Among all the definitions and dimensions for culture—such as those by Schwartz (1994), GLOBE (House et al. 2004) and Trompenaars and Hampden-Turner (2011)—Hofstede's definition is the most widely accepted by scholars in different disciplines, and is used as the basis of the research in the current work. The GLOBE definition is the second most important alternative to Hofstede's cultural classification, yet is merely an expansion of Hofstede's theory, performed in a very large empirical study conducted by the GLOBE group (House et al. 2004). There are also many similarities between Trompenaars and Hampden-Turner's (2011) cultural definition and dimensions and those of Hofstede. In terms of citation and academic application, Reis, Ferreira and Santos (2011) examined the bibliometric techniques of the papers published in the top-ranked international business journals and found that Hofstede's (1980) classification of culture is the most cited and has strong linkages to several streams of research. Therefore, it is appropriate to consider Hofstede's cultural definition and classification as the basis of the current work.

However, it should be noted that despite the popularity of the Hofstede framework for measuring the national cultural values, it has been the subject of many criticism in recent years. Firstly, Hofstede developed his research design to generalise his findings. Moreover, Hofstede's study was based on a comfort sample of employees in a single American organization – IBM, which has a strong organizational culture. Such single-organizational design has advantage to minimize the effects of external factors (Hofstede, 2002). However, this approach can also severely limit data generalizability to the broader population (Taras, Steel, & Kirkman, 2012). In another wok, Venaik and Brewer (2013) indicate that "the items used to measure *national dimensions are not positively and significantly correlated at the individual or organizational level and therefore do not measure an individual or organizational level construct/characteristic, cultural or otherwise*". They also disclosed that the international cultural differences in Hofstede (as well as Globe) framework are exaggerated. However, as there is no commonly accepted alternative to the Hofstede's cultural dimensions, it is still the most common survey system for measuring national culture and has been used in this study as well.

2.4 Hofstede's Cultural Dimensions

Based on some fundamental issues in human societies, Hofstede (1994) empirically derived four cultural dimensions to classify the cultural norms of different nations:

- power distance—related to inequality
- uncertainty avoidance—related to dealing with the unknown and unfamiliar
- individualism–collectivism—related to interpersonal ties
- masculinity–femininity—related to emotional gender roles.

He later added another two dimensions:

- long-term orientation—related to deferment of gratification
- indulgence—the degree to which small children are socialised (Hofstede 2001, 2006).

The final dimension (indulgence versus restraint) was obtained from the cultural dimensions recently extracted by Hofstede, Hofstede and Minkov (2010).

Hofstede's cultural dimensions reveal the rules by which people in different societies and cultures think, feel and act in the community, school, organisation and family. Based on a specific formulation, the score of each dimension for every country has been calculated and ranked. These scores are known as 'cultural dimension values' and are used by scholars to measure and compare the cultural values of different nations. The latest score for every dimension and every country is available from Hofstede's website and publications (Hofstede 2016; Hofstede, Hofstede & Minkov 2010). By referring to these publications, scholars are able to retrieve and compare the cultural dimensions scores for every country. For example, Figure 2-2 shows these dimensions for the US, the UK and Indonesia. It is clear that, while these three countries have similar scores on some dimensions (such as masculinity and uncertainty avoidance), they have very different scores on other dimensions (such as power distance and individualism).

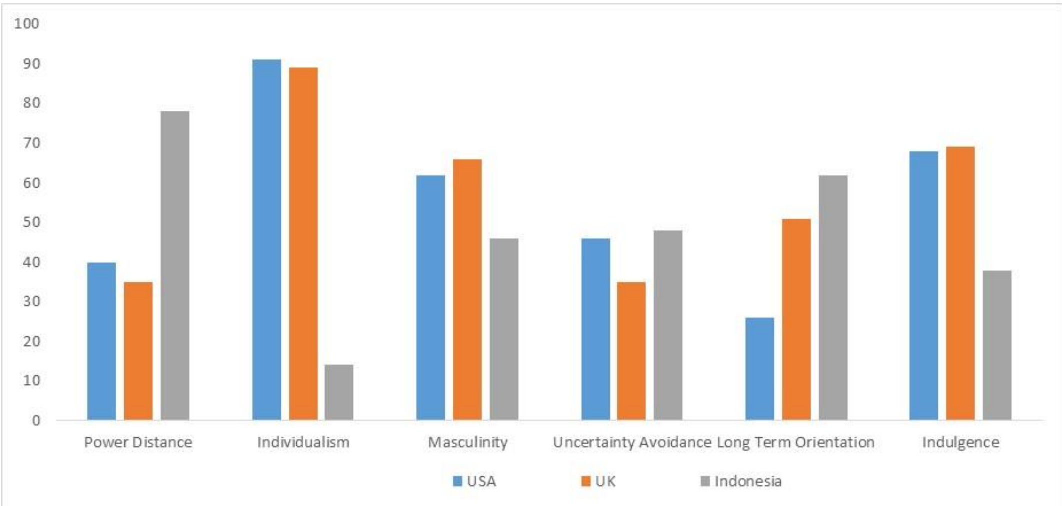

Figure 2-2 *Hofstede's cultural dimensions for the US, the UK, and Indonesia*

2.4.1 Power Distance

Power distance can be defined as 'the extent to which the less powerful members of institutions and organizations within a society expect and accept that power is distributed unequally' (Hofstede 2001). Inequality in a society is visible in the existence of different social classes. Power distance indicates a dependence relationship in a country or society.

In low power distance countries, the power holders (leaders/managers) expect initiatives from people and community members. In contrast, community members are expected to find their own success path. However, in high power distance countries/organisations, people do not take their own initiative, but wait for power holders to give them instructions. Table 2-1 displays some key differences between societies with low and high scores in power distance (Hofstede 2001).

Table 2-1 *Key differences between high and low power distance societies (adapted from Hofstede 1997)*

High Power Distance Societies	Low Power Distance Societies
1. Centralised authority and power 2. Dictatorial leadership 3. Paternalistic management style 4. Many hierarchical levels 5. Large number of supervisory staff 6. Acceptance that power has its privileges 7. Expectation of inequality and power differences	1. Decentralised authority and decision-making responsibility 2. Consultative or participative management style 3. Flat organisational structures 4. Small proportion of supervisory staff 5. Lack of acceptance and questioning of authority 6. Rights consciousness 7. Tendency towards egalitarianism

2.4.2 Individualism versus Collectivism

This cultural dimension determines the importance of the individual in comparison with collective goals and efforts: Individualism describes the relationship between individuals and refers to societies in which everyone in the society is expected to look after himself/herself. Based on the definition of individualism, societies are categorised as ‘individualist’ or ‘collectivist’. In individualist societies, great emphasis is generally placed on high independence, individual achievement and the freedom to make decisions (Ambos & Schlegelmilch 2008). In collectivist societies, strong ties exist between the members of the group. Table 2-2 summarises the key differences between individualist and collectivist societies.

Table 2-2 *Key differences between individualist and collectivist societies (adapted from Hofstede 1997)*

High Individualism Score Societies (Individualist)	Low Individualism Score Societies (Collectivist)
1. Individual interests are more important than collective interests 2. Everyone has a right to privacy 3. Everyone is expected to have a private opinion 4. Laws and rights should be the same for all 5. Self-actualisation by every individual is the ultimate goal	1. Collective interests are more important than individual interests 2. Private life is taken over by the group 3. Opinions are predetermined by the group 4. Laws and rights differ by group 5. Harmony and consensus in society are the ultimate goals

2.4.3 Masculinity versus Femininity

The distinctions between masculinity and femininity in Hofstede's model focus on the gender-related characteristics of a culture. Masculinity represents a preference in society for achievement, heroism, confidence and material rewards for success (Hofstede 2001). Femininity pertains to social gender roles overlapping, whereby both men and women are expected to be modest, caring and concerned with the quality of life. Table 2-3 summarises the key differences between masculine and feminine characteristics in this dimension of the Hofstede model.

Table 2-3 *Key differences between masculine and feminine societies (adapted from Hofstede 1997)*

High Masculinity Score Societies (Masculine)	Low Masculinity Score Societies (Feminine)
1. Gender roles are clearly distinct 2. Men should be confident, tough and focused on material success 3. Does not place great importance on kindness 4. Places importance on the value of ability (of jobs, nature, people, etc.) Dominant values in society are material success and progress	1. Social gender roles overlap 2. Both men and women should be modest, tender and concerned with the quality of life 3. Desired traits in husbands are the same as desired traits in boyfriends 4. Emphasises non-materialistic aspects of success Dominant values in society are caring for others and preservation

2.4.4 Uncertainty Avoidance

Uncertainty avoidance is defined in Hofstede's (1994) model as 'the extent to which the members of institutions and organizations within a society feel threatened by uncertain, unknown, ambiguous, or unstructured situations'. Similar to the other cultural dimensions, there are differences between strong and weak uncertainty avoidance countries and societies (Table 2-4).

Table 2-4 *Key differences between strong and weak uncertainty avoidance societies (adopted from Hofstede 1997)*

Strong Uncertainty Avoidance Societies	Weak Uncertainty Avoidance Societies
1. Avoidance of risk 2. Clearly defined structures, written rules and standardised procedures 3. Promotions based on seniority or age 4. Lack of tolerance for difference 5. Strong need for harmony 6. Need for predictability (planning is important) 7. Time is money	1. Risk taking 2. No more rules than strictly necessary (low degree of structure and few rules) 3. Tolerance of differing behaviours and opinions 4. Flexibility 5. Promotions based on merit 6. Time is a framework for orientation

2.4.5 Long-term versus Short-term Orientation

Long-term orientation describes the importance attached to the future, while short-term orientation describes the importance of the past and present. Societies with a low score on this dimension prefer to maintain time-honoured traditions and norms, while viewing societal change with suspicion. In contrast, societies with a high score of long-term orientation take a more realistic approach and encourage building the economy and efforts in contemporary education as a way to prepare for the future (Hofstede 2016).

2.4.6 Indulgence versus Restraint

Indulgence indicates a society that allows relatively free enjoyment of basic and natural human drives related to enjoying life and having fun. Restraint indicates a society that suppresses enjoyment of needs and regulates enjoyment via strict social norms (Hofstede 2016).

2.4.7 Summary of Hofstede's Dimensions

Hofstede (2016) stated that the values that distinguish countries' cultures from each other can be statistically categorised into the first four groups, and these four groups became the Hofstede dimensions of national culture. However, the fifth (long-term orientation) and sixth (indulgence) dimensions were added later, based on an additional international study. These dimensions are in the early stages of research, and scores are not available for every country. Therefore, in the current work, only the first four dimensions (power distance, individualism, uncertainty avoidance and masculinity) are used to measure the influence of culture and cultural distance on innovation in the oil and gas industry.

2.5 How Does Culture Influence Innovation?

After discussing the definitions of the terms 'innovation' and 'culture', the important question for this research is: how and to what extent can national culture influence an organisation's innovativeness? Further, after considering the different cultural dimensions of the Hofstede model: do some dimensions of culture have a stronger influence on innovativeness than others?

The innovation and development of new products or services is a common dialogue among all companies who understand the importance of innovation for business success. However, as innovation is always linked to risk and cost, only limited companies are actually undertaking innovative activities (Ahmed 1998). One important feature of a society or organisation that has a profound influence on its innovative capacity is its culture. Some aspects of culture—such as social organisation—may either foster or prevent innovations and technological development (Herbig & Dunphy 1998).

The influence of culture on innovation has also been a subject of debate throughout the past few decades. For instance, Hofstede (1980) pointed out that many people from cultures with weaker uncertainty avoidance scores are prone to accept more risks, and are subsequently better able to tolerate opinions and behaviours that are different from their own—which in turn contributes to the process of innovation. In addition, Hofstede found that societies with stronger uncertainty avoidance scores show resistance to new technology and discourage innovation.

Rothwell and Wissema (1986) studied the relationship between new technology development and culture, specifically noting several important ways in which the two domains intersect:

1. 'Innovation only comes about when there is a need for it' (Rothwell & Wiseman 1986). Rothwell and Wiseman (1986) identified some mechanisms for this characteristic, including a few that are culturally bounded, such as:
    a. public support—including funding for and acceptance of new technologies
    b. any innovation has a time of no return (there is a threshold time for a new innovation to be accepted by the community; afterwards, all community members will use the innovation).

2. 'Most innovations and certainly the major ones, require prior clusters of inventions' (Rothwell & Wiseman 1986). This characteristic is less directly bound to the culture of a nation, but is indirectly affected by this culture, as development of innovation clusters are affected by culture (Tracey & Clark 2003).

3. ‘The adoption of new technology often requires social change’ (Rothwell & Wiseman 1986). Societies and cultures that have less resistance to change will accept new technologies with greater ease than others (Bruce 1993).

4. ‘New technologies are only adopted if there is a driving force behind them’ (Rothwell & Wiseman 1986). This characteristic is not necessarily directly bound to culture, but culture can have a significant influence, as some cultures show less resistance to change and new technologies; thus, less driving force is required to adopt new technology by the society (Foster 1962).

Through a comprehensive study on the effect of Japanese and American cultures on their innovative capability, Herbig and Miller (1991) found a significant influence of culture on innovation acceptance by a nation. They argued that individualism, entrepreneurism, risk taking and openness are strong characteristics of American culture, and explained the tendency of American people to seek innovation and to apply creativity through radical innovation (innovations that have a significant effect on the market and economic activity of firms) and invention. However, the weak cultural aspects of America (small teamwork and low tolerance) discouraged process innovations (innovations that are used in manufacturing processes) in their society. In contrast, the Japanese culture’s strengths (teamwork, loyalty, homogeneity and a long-term outlook) improved process and evolutionary innovations in their society, yet diminished radical innovation and invention.

In another study, Westwood and Low (2003) examined the relationship between culture, creativity and innovation, and claimed that culture can and does affect the perception and clarification of creative and innovation processes; however, no single culture is optimal for innovation and no single culture can claim a superiority of ideas. Based on different cultural features, they found that personality and cognitive factors have a strong effect on creativity. In addition, a cultural propensity to promote innovation has been linked to high levels of education, low levels of centralised government, positive attitudes towards science and frequent travel (Lee 1990).

While culture has been shown to have a significant effect on innovativeness and the innovation process, it is important to note that culture is not a single-dimension behaviour or characteristic—it is a complex construct comprising many dimensions and nuances

(Hofstede 2001; House et al. 2004; Javidan et al. 2006; Tung & Verbeke 2010). Thus, it is important to understand the influence of each individual cultural dimension on innovation. To this end, this thesis evaluates the influence on innovativeness of each of the cultural dimensions (both individually and collectively) from the widely researched Hofstede model of cultural behaviours. The following chapter summarises the available literature on the influence of each individual Hofstede cultural dimension on nations' innovation and innovativeness, and derives the research hypotheses.

CHAPTER THREE

3 Hypothesis Development

As mentioned in Chapter One, the aim of this work is to understand the cultural factors influencing the internationalisation of R&D activities in the oil and gas industry. Culture is not a single-dimension characteristic and can be a patterned as way of thinking, feeling and acting, which represents the behaviour and attitude of the majority of members of a particular group (Hofstede, Hofstede & Minkov 2010). Thus, every community, group and nation has its own cultural specifications and values, which differ to those of other nations. Such differentiation in countries' cultural values can influence the behaviour of members in different aspects of life and work, including their approach to innovation and invention (Ahmed 1998; Everdingen & Waarts 2003; Herbig & Dunphy 1998). Therefore, in respect of the aim of this study, the following research questions arose:

1. Does the culture of the country in which the worldwide headquarters of the oil and gas company is located have any influence on the success or failure of the international R&D centres?

2. Does the culture of the local country in which the international business R&D centres are located have any influence on the success or failure of international R&D centres?

3. How can the cultural distance between the country of the headquarters and country of the overseas R&D centres influence the innovation output of those R&D centres?

3.1 Culture of Headquarters Country

When a company in established in a community or country, and the people who work for the company come and live in the surrounding community or country, there is a valid expectation that the culture of the company (organisational culture) will be affected and eventually form based on the community (national) culture. Previous research has shown a tight relationship between national culture and organisational culture (Hofstede 1985; Pothukuchi et al. 2002). Therefore, to understand the cultural influence of an organisation on its innovation behaviour, the first step is to understand the cultural behaviour of the nation or community surrounding that organisation. In this regard, this research began by examining the cultural influence of the country in which MNCs' headquarters offices were located. The first study hypothesis was based on this notion:

> **Hypothesis one**: The culture of the country where the headquarters are located can influence the innovation output of the organisation.

As stated before, to analyse the cultural value of any nation, Hofstede, Hofstede and Minkov (2010) defined dimensions for culture and related the cultural behaviour of members of each nation to those dimensions. Power distance, individualism, uncertainty avoidance and masculinity are the most important dimensions of culture that can directly or indirectly influence innovation output.

According to Hofstede's (1994, 2001) definition, power distance represents the extent to which the members of a society or nation create unequal distribution of power in their organisations and institutions. Having different social classes for different members of society is normal (even necessary) in power distant societies, and it is very difficult to move from one social class to another. In contrast, societies with low power distance have faith in shared power, equality and social mobility (Hofstede 2001). Shane (1992) stated that, in countries with low power distance, organisations prefer to be smaller and more organic. They have high information processing capabilities, most of the communication between superiors and juniors is informal, and control systems are based on trust. As a result, such organisations are more innovative than their competitors in high power distance countries.

Through a comprehensive study, Shane (1992) argued that power distance influences the number of issued patents (per capita) as a measure of innovativeness. He found that the power distance score of a nation has a negative influence on the number of patents issued by that nation. In other words, as the power distance score of a nation increases, the possibility of generating patents decreases. In another work, to determine the link between nations' cultural values and innovation output, Shane (1993) employed institutional theory and the fact that organisations are influenced by the societies in which they operate, and exhibit their values. He argued that:

> As organizational characteristics reflect societal values, managers might find that the organizational behaviours that promote innovation (identified in the

> management literature under the broad rubric of organic) are easiest to develop in uncertainty accepting, individualistic, non-power distant societies, and these behaviours, in turn, might help to increase national rates of innovation (Shane 1993).

Similar results regarding the influence of power distance on innovation have been reported by many researchers (Kwon, Kim & Koh 2016; Rinne, Steel & Fairweather 2012; Shane 1992; Sun 2009) who found a negative relationship between power distance and innovation. However, a recent study by Efrat (2014) found no significant influence of power distance on innovation. Efrat (2014) claimed that 'this influence may diminish over time' from previous studies by Shane (1992, 1993, 1995). Therefore, the real influence of power distance on innovation remains controversial, and different parameters—particularly the measuring tools of innovation and the study domain (national or organisational level)—may have a significant influence on the results.

Typically three different measuring tools (or aspects) could be employed for innovation measurement. a) Input into innovation process such as R&D expenditure, b) patent counting as an intermediate output and c) direct measure of innovation output (Bain & Kleinknecht, 2016). Among these three aspects patents contain rich and timely information on inventive activities and have always been the most important measuring tool for innovation output. This indicator still is frequently used and considerable literature is available about its validity for this purpose (Brouwer & Kleinknecht, 1999; Dang & Motohashi, 2015).

However, patent statistics have some limitation and on its own cannot considered as perfect measure of innovation, as not all innovations are necessarily patentable or patented, and also patent quality varies (Dang & Motohashi, 2015). This generally treated by controlling for industry differences, which largely explains variations in patenting tendency. Also, as not all patented ideas go towards new products and/or new production processes, other measure of innovation are necessary to evaluate the innovativeness of any industry or organisation. Therefore, understanding the fraction of the patents that go beyond the IP protection and apply to the real industry, may be a good value for measuring the innovation output. In this regards, the number of technologies which principally developed by an organisation could be a better (or complementary) factor to the number of patents.

Therefore, in this study "number of patents" and "number of deployed technologies" have been used as innovation measurement tools.

*Hypothesis 1a: A greater **power distance** score of the country where the headquarters are located will result in proportionally fewer patents.*

*Hypothesis 1b: A greater **power distance** score of the country where the headquarters are located will result in proportionally fewer deployed technologies.*

Hofstede (2001) stated that individualism has a strong influence on nations' innovation nature. He claimed that countries with high individualism scores have a strong tactical orientation that enables and motivates innovation. In addition, some scholars have suggested that cultures with high scores in individualism should have better performance in technological innovation. However, a limited number of cross-national studies exist that studied the relationship between individualism and innovation. For example, Shane (1992) found a positive relationship between individualism and the number of patents issued in a nation. In addition, Rinne, Steel and Fairweather (2012) revealed a strong positive relationship between nations' individualism scores and innovation outputs.

In a more comprehensive work, Taylor and Wilson (2012) analysed the influence of nations' individualism and innovation by analysing patents and publications, as well as forward citations, in order to control for the quality of the innovation. They suggested that individualism has a strong, significant and positive effect on nations' innovation output. Recent studies by Efrat (2014); Sun (2009); and Kwon, Kim and Koh (2016) also found a positive influence of high individualism on innovation output. A similar positive relationship between individualism and national innovativeness was reported by Lynn and Gelb (1996) as well as by Everdingen & Waarts (2003). Therefore, there is more support for a relationship between innovation and individualism, compared to power distance.

*Hypothesis 1c: A greater **individualism** score of the country where the headquarters are located will result in proportionally fewer patents.*

Hypothesis 1d: A greater ***individualism*** *score of the country where the headquarters are located will result in proportionally fewer deployed technologies.*

Shane (1993) found that trademarks (as a measure of innovation) produced by a nation are negatively affected by the uncertainty avoidance score of the nation. However, Rinne, Steel and Fairweather (2012) found no relationship between nations' uncertainty avoidance and innovation output. Overall, research supports a positive linkage between uncertainty avoidance score and innovation output (Efrat 2014; Hofstede 2001; Kwon, Kim & Koh 2016; Shane 1995).

Hypothesis 1e: A greater ***uncertainty avoidance*** *score of the country where the headquarters are located will result in proportionally more patents.*

Hypothesis 1f: A greater ***uncertainty avoidance*** *score of the country where the headquarters are located will result in proportionally more deployed technologies.*

Masculinity is probably the Hofstede cultural dimension that has received scholastically less attention as a determinant for innovation within a nation. Shane (1993) indicated that nations with a high score in masculinity have a greater tendency for innovation. Similar trends were recently stated by Efrat (2014). However, Efrat (2014) found that, while some aspects of innovation were encouraged by a high masculinity score, other aspects were negatively affected by a high masculinity score. Claiming that femininity is necessary to form partnership and this partnership has contribute to innovation, Efrat (2014) found that masculinity was strongly related to patent generation but inversely affected scientific publications. She related this influence to the fact that publications mostly relay previous findings and existing knowledge frameworks, while patent generation has little resemblance to previous innovation. Therefore, patent generation is strongly associated with the characteristics of masculinity, while academic publication is strongly influenced by femininity (Efrat 2014). In addition, Everdingen & Waarts (2003) found a significant influence of masculinity on innovation through research on the effect of masculinity index's on nations' adoption of enterprise resource planning.

> *Hypothesis 1g: A greater **masculinity** score of the country where the headquarters are located will result in proportionally more patents.*

> *Hypothesis 1h: A greater **masculinity** score of the country where the headquarters are located will result in proportionally more deployed technologies.*

3.2 Culture of the International R&D Centre Location

One important factor affecting the success or failure of an overseas R&D centre is the correct selection of the centre location. The culture of the host country for international R&D centres, particularly the culture's innovation tendency, has a significant influence on the innovation output of the centres (Chena, Huangb & Lin 2012; Chua, Roth & Lemoine 2015; Hofstede, Hofstede & Minkov 2010). Therefore, similar to the previous section, this research examines the influence of each individual cultural dimension on both patents and deployed technology according to the following hypotheses:

> **Hypothesis two**: The culture of the country where the overseas business units of oil and gas multinational companies are located can influence the innovation output of those companies.

> *Hypothesis 2a: A greater **power distance** score of the country where the business units are located will result in proportionally fewer patents.*

> *Hypothesis 2b: A greater **individualism** score of the country where the business units are located will result in proportionally more patents.*

> *Hypothesis 2c: A greater **uncertainty avoidance** score of the country where the business units are located will result in proportionally more patents.*

> *Hypothesis 2d: A greater **masculinity** score of the country where the business units are located will result in proportionally more patents.*

*Hypothesis 2e: A greater **power distance** score of the country where the business units are located will result in proportionally fewer deployed technologies.*

*Hypothesis 2f: A greater **individualism** score of the country where the business units are located will result in proportionally more deployed technologies.*

*Hypothesis 2g: A greater **uncertainty avoidance** score of the country where the business units are located will result in proportionally more deployed technologies.*

*Hypothesis 2h: A greater **masculinity** score of the country where the business units are located will result in proportionally more deployed technologies.*

3.3 Cultural Distance between Two Countries

One obvious potential cultural dynamic in the topic of international R&D activities lies in the cultural differences between the country of origin (where the company headquarters are located) and local country (where the international business unit will be established). These differences are collectively referred to as 'cultural distance' in the literature (Berry, Guillén & Zhou 2010; Brouthers & Brouthers 2001; Kim & Gray 2009; Kogut & Singh 1988; Tihanyi, Griffith & Russell 2005; Yeganeh 2011). Therefore, as well as the single cultures of the origin country and local country, the cultural distance between the two countries can influence the innovation output of the organisation. When the cultural distance between two countries is wide, individuals may feel uncertain of success in innovation (Chua, Roth & Lemoine 2015). When the cultural distance is close, individuals may be less concerned about cultural differences and subsequently more likely to support innovation. Difficulties in innovation and the acceptance of innovative ideas may arise when a cultural distance exists between two nations. For example, Dachs and Pyka (2010) found that cultural distance between a company's home and foreign host country can significantly decrease cross-border innovation activities.

Hypothesis three: The cultural distance between the country where the worldwide headquarters are located and the country where the overseas business units are located can influence the innovative output of the organisation.

As mentioned earlier, this research employs Hofstede's four cultural dimensions to study the cultural values of nations. Therefore, the following hypotheses were created based on two innovation measure of 'patent' and 'deployed technology', as well as Hofstede's four cultural dimensions:

Hypothesis 3a: Overseas business units will generate proportionally more patents in countries whose ***power distance*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3b: Overseas business units will generate proportionally more patents in countries whose ***uncertainty avoidance*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3c: Overseas business units will generate proportionally more patents in countries whose ***individualism*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3d: Overseas business units will generate proportionally more patents in countries whose ***masculinity*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3e: Overseas business units will generate proportionally more deployed technologies in countries whose ***power distance*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3f: Overseas business units will generate proportionally more deployed technologies in countries whose ***uncertainty avoidance*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3g: Overseas business units will generate proportionally more deployed technologies in countries whose ***individualism*** *score is closer to that of the country where the company's headquarters are located.*

Hypothesis 3h: Overseas business units will generate proportionally more deployed technologies in countries whose ***masculinity*** *score is closer to that of the country where the company's headquarters are located.*

Culture consists of different dimensions that may vary from nation to nation, but the culture of a nation refers to the overall behaviour of that nation. Therefore, as well as the influence of each individual cultural dimension, it is beneficial for this research to understand the effect of overall cultural difference (distance) between the headquarters and local countries on the innovation output of R&D centres.

Hypothesis four: The overall cultural distance between the country where the worldwide headquarters are located and the country where overseas business units are located can influence the innovation output of the organisation.

Hypothesis 4a: Overseas business units will generate proportionally more patents in countries that are separated by a smaller ***overall cultural distance*** *from the country where the company's headquarters are located.*

Hypothesis 4b: Overseas business units will generate proportionally more deployed technologies in countries that are separated by a smaller ***overall cultural distance*** *from the country where the company's headquarters are located.*

CHAPTER FOUR

4 Methodology

4.1 Data Collection

The data presented in this thesis were originally collected during a larger data collection process that examined different aspects of innovation in the upstream oil and gas industry. Much of the data collected during this earlier phase of the research project were analysed and published elsewhere (Perrons 2013, 2014; Perrons & Donnelly 2012). However, in the interests of brevity and focus, several interesting research questions examining the relationship between culture and innovativeness were not pursued in these earlier publications. Thus, this thesis examines the unused data to attempt to answer the highly relevant research questions.

As outlined by Perrons (2014), the data were collected via an online survey undertaken in collaboration with the Society of Petroleum Engineers (SPE) to answer a wide range of research questions. With more than 110,000 members in 141 countries, the SPE is the largest individual-member organisation in the upstream oil and gas industry in the world. A data firewall was established so that the researchers did not have access to the participants' names or other types of identifying information.

Although the upstream oil and gas industry includes several large multinational firms, companies in different countries often have notably different approaches to managing innovation and new technologies throughout their global operations. For example, Shell's Smart Fields digital oilfield program has notable differences in deployment strategy in different regions, while BP's use of the WITSML (well-site information transfer standard mark-up language) drilling data exchange protocol in the North Sea is markedly different to what the company does in the Gulf of Mexico (Perrons 2014). To capture these region-by-region differences, this survey asked questions about how technology and innovation-related activities are managed at the business unit level. Smaller companies and organisations that develop and deploy upstream oil and gas technologies in a consistent manner throughout all their operations around the world were instructed to consider their entire organisation as a business unit for the purposes of this survey (Perrons 2014).

Consultancies, universities and governments also play a potentially valuable role in the innovation and R&D processes in the upstream oil and gas industry. Thus, this survey also included these groups. Throughout the survey, the business unit of the universities or governments related to the part of their organisation that interacted with the upstream oil and gas companies in their region.

Consisting of 23 questions—of which only a few were used in this thesis—the survey asked respondents about several aspects of their business unit’s R&D and innovation-related activities. The survey also asked for several self-reported measures of R&D output from the respondents’ business units. The respondents were informed before completing the survey that their results would be made anonymous and aggregated with data from other respondents, thereby removing any incentive to distort their responses or provide untrue data.

The survey and corresponding delivery strategy were created according to the principles outlined in Dillman’s (2000) ‘tailored design method’. However, one practical concession was a clear departure from the prescribed formula—while Dillman (2000) recommended a four-contact model to maximise survey return rates, the SPE was uncomfortable with contacting its members so many times. Instead, the SPE allowed three contacts: (i) an official e-mail from the SPE inviting people to answer questions about the explanatory variables, (ii) a reminder one week later and (iii) a final e-mail two weeks after the survey began to ask questions about the dependent variables and close the survey. Questions asking about explanatory and dependent variables were separated in time to minimise the effect of common method bias (Podsakoff et al. 2003).

Prior to its release, the survey was tested by six people—three from the oil and gas industry and three from academia who were familiar with questionnaires and survey-based research. The survey’s questions were iteratively refined and improved based on this feedback, thereby reducing the potential for measurement error in the survey instrument (Maier, Franco & Lindner 2001). At the end of the survey, the respondents were asked if they would object to being asked a few clarifying questions about their responses. Several respondents agreed, and five follow-up discussions were undertaken later to deepen the researchers’ understandings of the survey results.

4.2 Sample

Potential respondents were initially identified from the SPE membership records. These individuals had indicated in their SPE profiles that their positions were somehow related to R&D or technology. From this subset of the SPE population, 469 individuals were invited to participate in the survey. The invited participants were typically high-ranking managers who played a significant role with regard to R&D and/or technology deployment in their business unit. Only one potential participant was chosen from each business unit, yet several large organisations had respondents from multiple business units in different parts of the world. The candidates were invited to participate via an e-mail sent from the SPE. Upon clicking a link in the e-mail, the respondents were directed to a web-based survey.

Of the 469 people invited to participate, a total of 199 people completed both the explanatory and dependent variables within the survey, yielding an overall usable response rate of 42.4%. The extrapolation method (Armstrong & Overton 1977) was used to test for nonresponse bias. The respondents were grouped as early (first 20%) or late (last 20%) in the timing of their reply, and the responses from the two groups were compared using t-tests (Lindner, Murphy & Briers 2001). No significant differences were found between the two groups' responses; thus, the results can be reasonably generalised to the target population (Miller & Smith 1983). However, it should be noted that this pool of respondents does not provide a comprehensive picture of the entire industry's R&D activities, and the statistics captured herein do not reflect the totality of the industry's output with regard to innovation and new technologies. Nonetheless, the survey does provide a potentially valuable snapshot of the industry's R&D-related activities around the world.

4.3 Variables and Measures

4.3.1 Dependent Variables

This survey used five proxies to measure innovativeness, of which two are used here in order to answer the research questions on the influence of culture on innovation output:

1. Number of awarded patents in last three years by the respondent's business unit: Patents are a common indicator for assessing productivity with regard to technological innovation (Archibugi 1992b).

2. Number of new technologies deployed in the last three years by the respondent's business unit: Patent counts have been questioned as a faithful reflection of innovativeness (Archibugi 1992a; Hagedoorn & Cloodt 2003); thus, following Hagedoorn and Cloodt (2003), a count of deployed technologies was also used as an alternative measure. In the survey, 'deployed technology' was defined as an innovation that has successfully undergone field trials, and is ready to be used in revenue-generating activities.

4.3.2 Independent Variables

To shed light on the influence of local culture on the innovative output of oil and gas companies and their overseas business units, the survey captured a number of independent variables, as follows:

1. the country in which the world headquarters for the respondent's company or organisation resides
2. the country in which the local headquarters for the respondent's business unit resides
3. the number of employees in the respondent's worldwide organisation—this is conceptually similar to Laursen and Salter's (2006) 'LOGEMP' variable, which represents the firm size (expressed in logarithms)
4. the number of employees in the respondent's business units—this variable is also similar to Laursen and Salter's (2006) 'LOGEMP' variable.

The first two variables combined with Hofstede's score for every cultural dimension were used as the variables to measure the cultural value of each case.

4.4 Sample Analysis

Table 4-1 shows the location of the worldwide headquarters for the respondents' employing organisations, while Table 4-2 shows the geographic location of the respondents' business units. Beyond merely showing the countries indicated by the respondents, as presented by Perrons (2014), these tables add additional information about Hofstede's (2001) cultural values of power distance, individualism, uncertainty avoidance and masculinity for each of the indicated countries. It is important to note that a large number of respondents were located in the US and European countries, while only a small number were located in countries with high conventional reserves of oil and gas (such as the Organization of the Petroleum Exporting Countries and Middle Eastern countries).

Figures 4-1 and 4-2 plot the distribution of the number of respondents based on the power distance and individualism scores of the respondents' countries. These figures indicate that a large number of respondents were located in countries with power distance scores between 31 and 40, which includes the US and most of Europe. Of particular interest is that the individualism scores were in the range of 70 to 100. A comparison of Figures 4-1 and 4-2 indicates that, while the US and European countries had similar scores in power distance, they were very different in their individualism scores. Similar differences were also found between the two regions' cultural dimensions of masculinity and uncertainty avoidance. These differences led to a high-level question that underpins many of the hypotheses in this thesis: how and to what degree do these cultural differences contribute to the innovative output of the respondents' organisations? To answer this overarching question, several research hypotheses were developed to analyse the effect of each cultural dimension individually, as well as considering how these dimensions may work interactively with each other.

Table 4-1 *Breakdown of respondents by the country where their employing organisation's global headquarters was located*

Country	Number of Respondents	Percentage (%)	PDI	IND	UCA	MAS
Australia	4	2	36	90	61	51
Austria	3	1.5	11	55	79	70
Canada	23	11.6	39	80	52	48
China	2	1	80	20	66	40
Denmark	6	3	18	74	16	23
India	6	3	77	48	56	40
Italy	3	1.5	50	76	70	75
Malaysia	2	1	104	26	50	36
Netherlands	23	11.6	38	80	14	53
Nigeria	4	2	77	20	46	54
Norway	8	4	31	69	8	50
Oman	4	2	--	--	--	--
Pakistan	3	1.5	55	14	50	70
Switzerland	3	1.5	34	68	70	58
United Arab Emirates	4	2	80	38	52	68
United Kingdom	18	9	35	89	66	35
USA	71	35.7	40	91	62	46
Other	12	6				
Total	199	100				

Note: PDI = power distance, IND = individualism, UCA = uncertainty avoidance, MAS = masculinity.

Table 4-2 *Breakdown of respondents by the country where the business units were located*

Country	Number of Respondents	Percentage (%)	PDI	IND	UCA	MAS
Australia	7	3.5	36	90	61	51
Austria	2	1.0	11	55	79	70
Brunei	3	1.5	--	--	--	--
Canada	26	13.1	39	80	52	48
Denmark	3	1.5	18	74	16	23
France	2	1.0	68	71	43	86
India	7	3.5	77	48	56	40
Indonesia	2	1.0	78	14	46	48
Malaysia	8	4.0	104	26	50	36
Netherlands	10	5.0	38	80	14	53
Nigeria	4	2.0	77	20	46	54
Norway	6	3.0	31	69	8	50
Oman	7	3.5	--	--	--	--
Pakistan	3	1.5	55	14	50	70
Qatar	2	1.0	--	--	--	--
United Arab Emirates	3	1.5	80	38	52	68
United Kingdom	18	9.0	35	89	66	35
USA	74	37.2	40	91	62	46
Other	12	6.0				
Total	199	100.0				

Note: PDI = power distance, IND = individualism, UCA = uncertainty avoidance, MAS = masculinity.

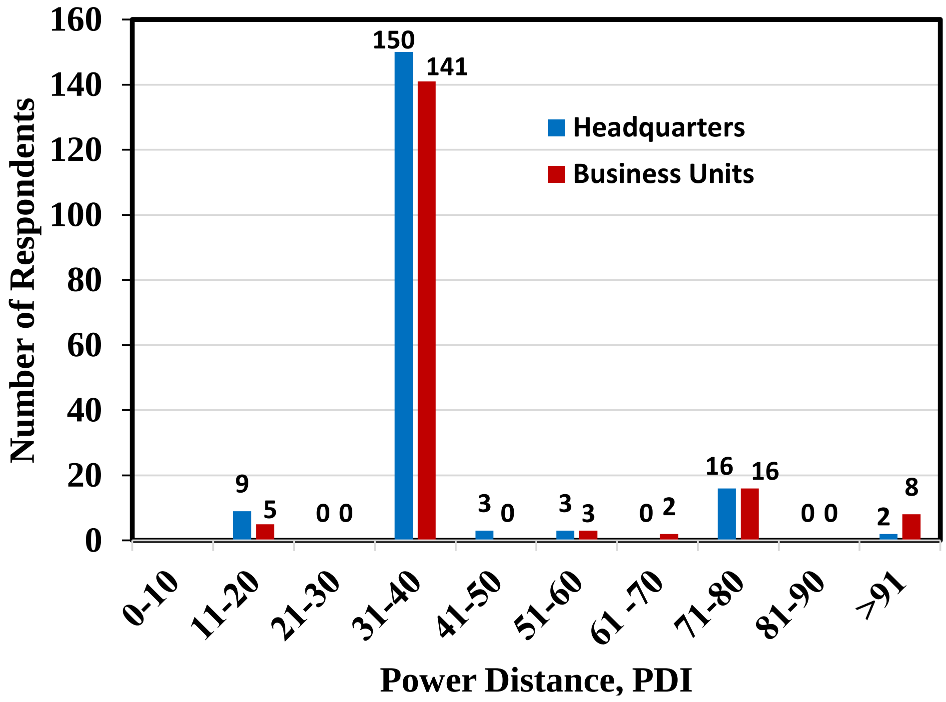

Figure 4-1 Distribution of respondents based on the power distance score of the country where they were located

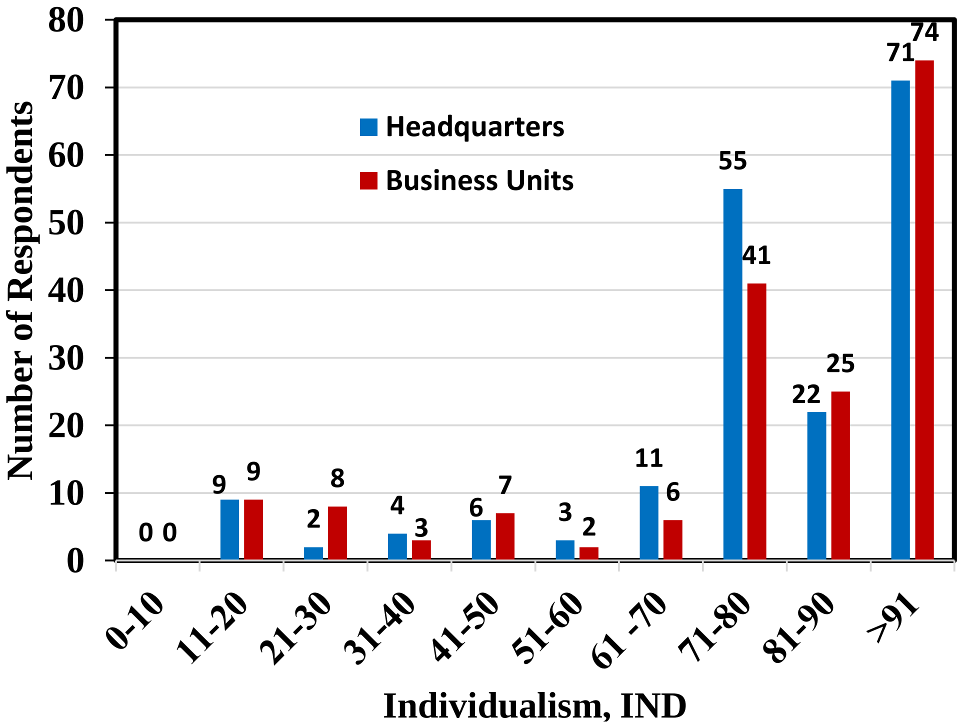

Figure 4-2 Distribution of respondents based on the individualism score of the country where they were located

4.5 Cultural Distance

As stated previously, the cultural distance between the countries where headquarters and research centres are situated can influence the innovation output of research centres. Different models and concepts have been developed to measure the cultural distance between two different countries and organisations (Berry, Guillén & Zhou 2010; Brouthers & Brouthers 2001; Kim & Gray 2009; Kogut & Singh 1988; Tihanyi, Griffith & Russell 2005; Yeganeh 2011). Kogut and Singh's (1988) cultural distance index model has been widely applied in a range of different disciplines, from marketing (Nakata & Sivakumar 2001) to international management (Lenartowicz, Johnson & White 2003), finance and accounting (Karolyi 2016; Siegel, Licht & Schwartz 2011). This model is used in the current study to measure the cultural distance between the country of the headquarters and research centre location.

In this model, cultural distance is defined as the degree to which the cultural standards in one country or community are different to those standards in another country or community. The model is a composite of Hofstede's dimensions of national cultural: power distance, individualism, masculinity and uncertainty avoidance. Mathematically, this distance is represented as:

$$CD_j = \sum_{i=1}^{4} \{(I_{ij} - I_{iu})^2 / V_i\} / 4$$

In this equation, *CD* indicates the overall cultural distance between the two countries, I_{ij} is the index for the i^{th} cultural dimension of the j^{th} country, I_{iu} is the index for the i^{th} cultural dimension of the u^{th} country, and V_i is the variance for the i^{th} cultural dimension. The values for all cultural dimensions are available from Hofstede's publications (Hofstede, Hofstede & Minkov 2010).

In addition to using the above formula to aggregate the overall distance based on all four dimensions, this study employed Kogut and Singh's (1988) approach to measure the cultural distance between two countries with regard to only one cultural dimension. For example, the individualism distance between countries *i* and *j* can be calculated as:

$$IND_{ij} = \{(IND_i - IND_j)^2 / V_{IND}\}$$

where IND_i is the individualism score for country i, IND_j is the individualism score for country j, and V_{IND} is the variation for the individualism score.

To shed light on the influence of culture on international R&D activities—both one dimension at a time, and when multiple dimensions are considered together—this investigation examined:

1. the culture of the country where the worldwide headquarters of the company was located
2. the culture of the country where the respondent's business unit (R&D centre) was located
3. the cultural distance between these two countries.

CHAPTER FIVE

5 Results

5.1 Non-cultural Geographic Effects

As noted earlier, this investigation sought to assess to assess the degree to which culture has an influence on the innovative output of companies. However, before considering the cultural aspects of this question, Table 5-1 reveals an important finding with regard to the simple geography of the participating business units. This table suggests that the respondents working in business units that were in the same country as the organisation's worldwide headquarters were proportionally responsible for a smaller fraction of the deployed technology initiation, compared with more remote counterparts. Over two-thirds (67.3%) of the respondents were working in business units located in the same country as the organisation's world headquarters, yet this group was responsible for only half (50.4%) of the total number of deployed technologies during the three-year period. In contrast, less than one-third (32.7%) of the respondents were working in a different country to their world headquarters, yet this group was responsible for the other half (49.6%) of the deployed technologies. Thus, *business units in the same country as the organisation's world headquarters generated fewer deployed technologies*.

However, Table 5-1 presents a very different outcome for patent generation. While 67% of the respondents were located in their headquarters' countries, they produced 88% of the total patents. In other words, business units located in their headquarters' countries were proportionally responsible for generating more patents than the more remote units. Such difference between patent generations by respondents in headquarters' countries and overseas countries is expected. While most of the headquarters of multinational oil and gas companies are located in the first world economic, they have extensive collaboration and support from other research centres and universities. This help them to be able to produce/contribute on a large number of patent generation. In contrast, the overseas business units are mostly located in regions close to the oil and gas reserves and more directly are dealing with production and technology, increase the chance of developing new technologies.

Table 5-1 *Summary of survey outcomes*

Respondent's Business Unit in Same Country as Organisation's World Headquarters?	Number of Respondents	Percentage of Respondents	Deployed Technologies in Past Three Years	Total Deployed Technologies in Past Three Years (%)	Patents in Past Three Years	Total Patents in Past Three Years (%)
Yes	134	67.3%	625	50.4%	6,860	88%
No	65	32.7%	615	49.6%	914	12%
Total	199	100.0%	1240	100.0%	7,774	100%

However, the main aim of this study was to evaluate the influence of cultural values (through Hofstede's cultural dimensions) on innovation output. In this regard, the influences of each individual cultural value (power distance, individualism, uncertainty avoidance and masculinity) were studied. The Poisson regression analysis was used as the most appropriate tool to evaluate each individual hypothesis.

5.2 Data Refinement

A preliminary analysis of the data revealed a significant skew in the innovation-related outputs of the responding business units. As shown in Figure 5-1, many respondents reported no innovations or patents whatsoever throughout the targeted three-year period, while a small number of business units reported many.[1] Only 18 business units from the 199 responses contributed more than 35 technologies and/or patents. Thus, in the interest of ensuring that these 18 prolific innovators did not overwhelm the entire sample, they were removed from further analysis, thereby reducing the sample from 199 to 181 business units. However, to understand the innovation output performance of those 18 hyper-innovative cases, a separate analysis is performed at the end of this chapter.

The data related to the selected 181 cases were then analysed using Stata software and Poisson regressions as the most appropriate tool. The variables in this case study (the

[1] A follow-up round of questioning after the survey confirmed that this was likely a faithful reflection of how the industry works, with a small number of oilfield service companies typically responsible for a high number of deployed innovations and even higher levels of patent activity (Perrons 2014).

number of patents and deployed technologies) were the counted number of occurrences, and the distribution of counts was positively skewed, with many observations in the data set having a value of zero; thus, applying the Poisson regression model was the most suitable tool for analysing the data (Zeileis, Kleiber & Jackman 2008).

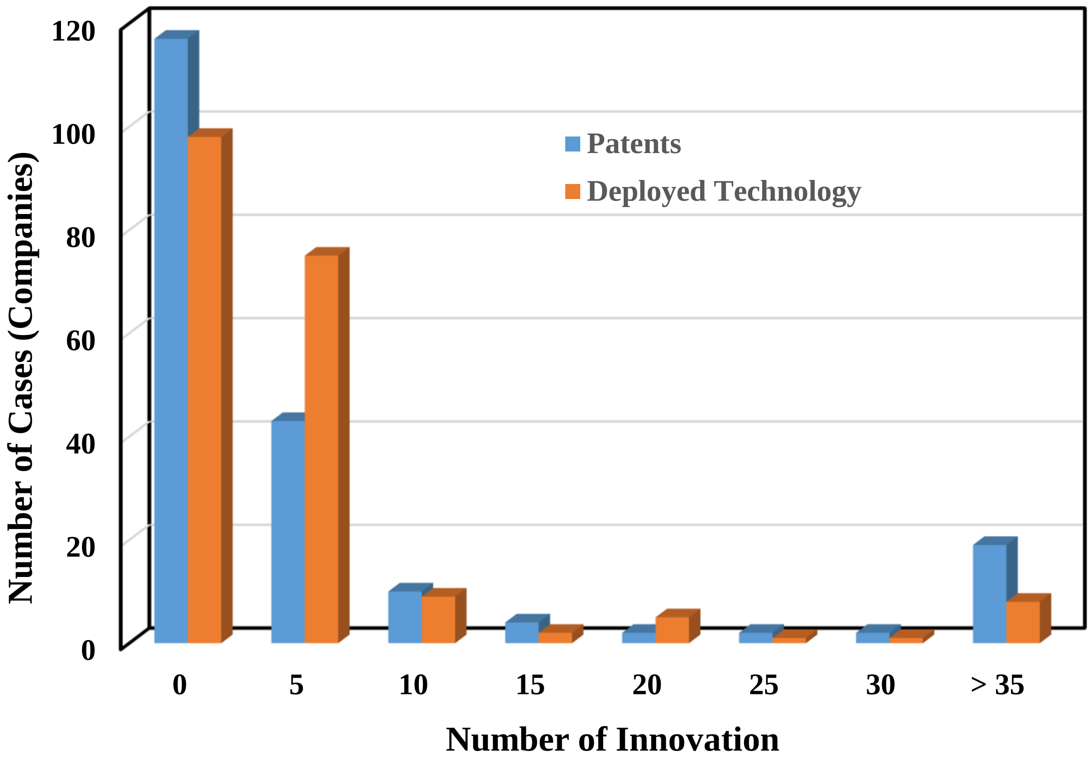

Figure 5-1 *Relationship between number of cases in database as a function of number of innovations*

5.3 Cultural Effects of Location of Headquarters

Table 5-2 presents the results for the effect of the cultural dimension values of the headquarters countries on the generation of patents by the research centres.

Table 5-2 *Poisson regression results to model the effect of cultural dimensions of headquarters country (origin) on the patent generation of oil and gas business units*

```
Poisson regression                              Number of obs     =        175
                                                LR chi2(4)        =      68.92
                                                Prob > chi2       =     0.0000
Log likelihood = -883.24766                     Pseudo R2         =     0.0375
```

patents	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PDI_Origin	.0311048	.0047021	6.62	0.000	.0218889	.0403208
IND_Origin	.0167415	.0039188	4.27	0.000	.0090608	.0244222
MAS_Origin	-.0014459	.0026597	-0.54	0.587	-.0066588	.0037671
UCA_Origin	.007484	.0035634	2.10	0.036	.0004998	.0144682
_cons	-1.886122	.5175044	-3.64	0.000	-2.900412	-.8718322

Note: PDI = power distance, IND = individualism, UCA = uncertainty avoidance, MAS = masculinity.

Table 5-2 illustrates that each cultural dimension score (power distance, individualism, uncertainty avoidance and masculinity) had a different level of influence on the predicted number of generated patents. As the most important value in this table, the significant level ($P > |z|$) indicates that the masculinity score had a P-value of > 0.05 and could not significantly predict the number of patents generated. However, all other scores were significant ($P < 0.05$) and the model could expect their influence on the predicted number of patents generated.

In addition, the difference in the estimated Poisson regression coefficients (*Coef.*) indicated that power distance with a larger *Coef.* value had the strongest influence on the predicted number of patents generated. In other words, if all other cultural dimension scores (individualism, masculinity and uncertainty avoidance) are held constant, by any one unit increase in the power distance score, a 3.1% score increase is expected in the number of patents generated. This is a significant increase in patent generation expectation. This increase in the expected number of patents generated is only approximately 0.7% with a one score increase in the uncertainty avoidance score of the headquarters country.

To see how and to what extent each Hofstede cultural dimensions of the headquarters countries could influence the expected number of patents generated, the margins were plotted in Stata software for all cultural dimensions (Long & Freese 2014). As aforementioned, the masculinity score could not significantly affect the predicted number of patents generated; thus, the margin plots were extracted for the other three dimensions (Figure 5-2).

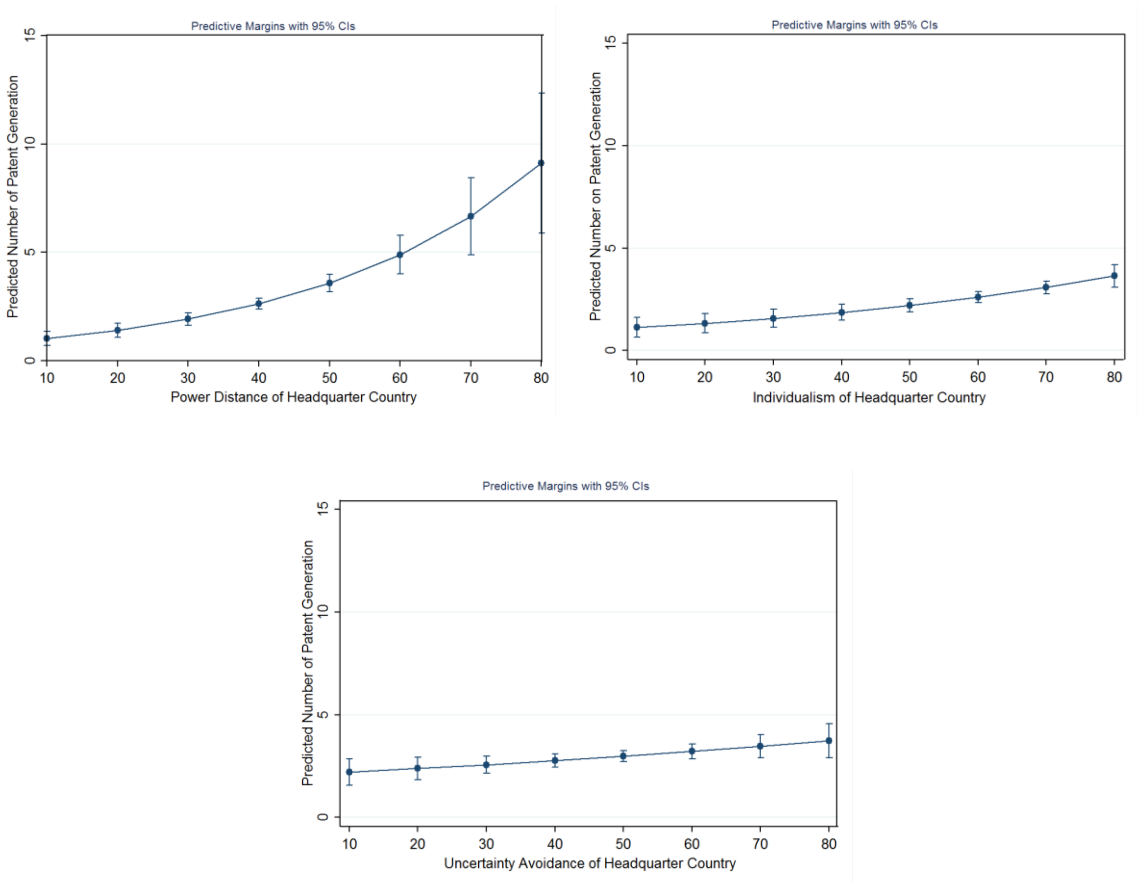

***Figure 5-2** Marginal plots to predict the effect of headquarters country's cultural dimension scores on number of patents generated by oil and gas business units*

Figure 5-2 indicates a considerable effect of the power distance of the headquarters country on the predicted number of patents generated. This figure illustrates that, while the headquarters countries with low to medium scores in power distance had a low influence on the predicted number of patents generated (power distance < 40), the influence grew for countries with larger scores on this cultural dimension. In contrast, as expected from Table 5-2, the influence of individualism and uncertainty avoidance scores on the predicted number of patents generated was very small for all score ranges. As a summary of Table 5-2 and Figure 5-2, the results of the current study strongly reject Hypothesis 1a, but moderately accept Hypotheses 1c and 1e. The analysis was unable to evaluate Hypothesis 1g.

Alongside patent generation, this study also evaluated deployed technology as a measure of innovation output. Similar to the previous section, Poisson regression analysis was performed on the survey data to determine whether Hofstede's cultural dimension scores of the headquarters country had any effect on the predicted number of deployed technology initiations by the oil and gas business units. Table 5-3 and Figure 5-3 show the Poisson regression results and margin graphs for the influence of the headquarters country's cultural dimensions on the initiation of deployed technology by the business units.

Table 5-3 *Poisson regression results to model the effect of cultural dimensions of headquarters country (origin) on deployed technology of oil and gas business units*

Poisson regression			Number of obs	=		175
			LR chi2(4)	=		24.82
			Prob > chi2	=		0.0001
Log likelihood = -552.08332			Pseudo R2	=		0.0220

technology	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PDI_Origin	.0156072	.0052916	2.95	0.003	.0052359	.0259786
IND_Origin	.014927	.0043621	3.42	0.001	.0063774	.0234766
MAS_Origin	.0041773	.0030718	1.36	0.174	-.0018434	.010198
UCA_Origin	.0136553	.0046597	2.93	0.003	.0045225	.0227882
_cons	-1.97925	.6043443	-3.28	0.001	-3.163743	-.7947567

As indicated in Table 5-3, the power distance, individualism and uncertainty avoidance scores of the headquarters countries could significantly predict the deployed technology initiated by the business units of the oil and gas companies. However, the masculinity score had a significance value ($P > |z|$) larger than 0.05, and subsequently could not be considered in this study's model for its influence on deployed technology initiation. In contrast, the values of the estimated Poisson regression coefficients (*Coef.*) for all dimensions of power distance, individualism and uncertainty avoidance were very close; thus, their influence on the predicted number of deployed technology initiations should be very similar. To examine this similarity, Figure 5-3 plots the marginal graphs for the predicted number of deployed technologies as a function of the headquarters country's cultural dimensions. This figure illustrates that the power distance and uncertainty avoidance scores had very similar influences on the predicted number of deployed technology initiations. However, the influence of individualism was slightly lower. As a summary of Figure 5-3 and Table 5-3, the results of the current Poisson regression model rejected Hypothesis 1b, accepted Hypothesis 1d and f, and could not evaluate Hypothesis 1h.

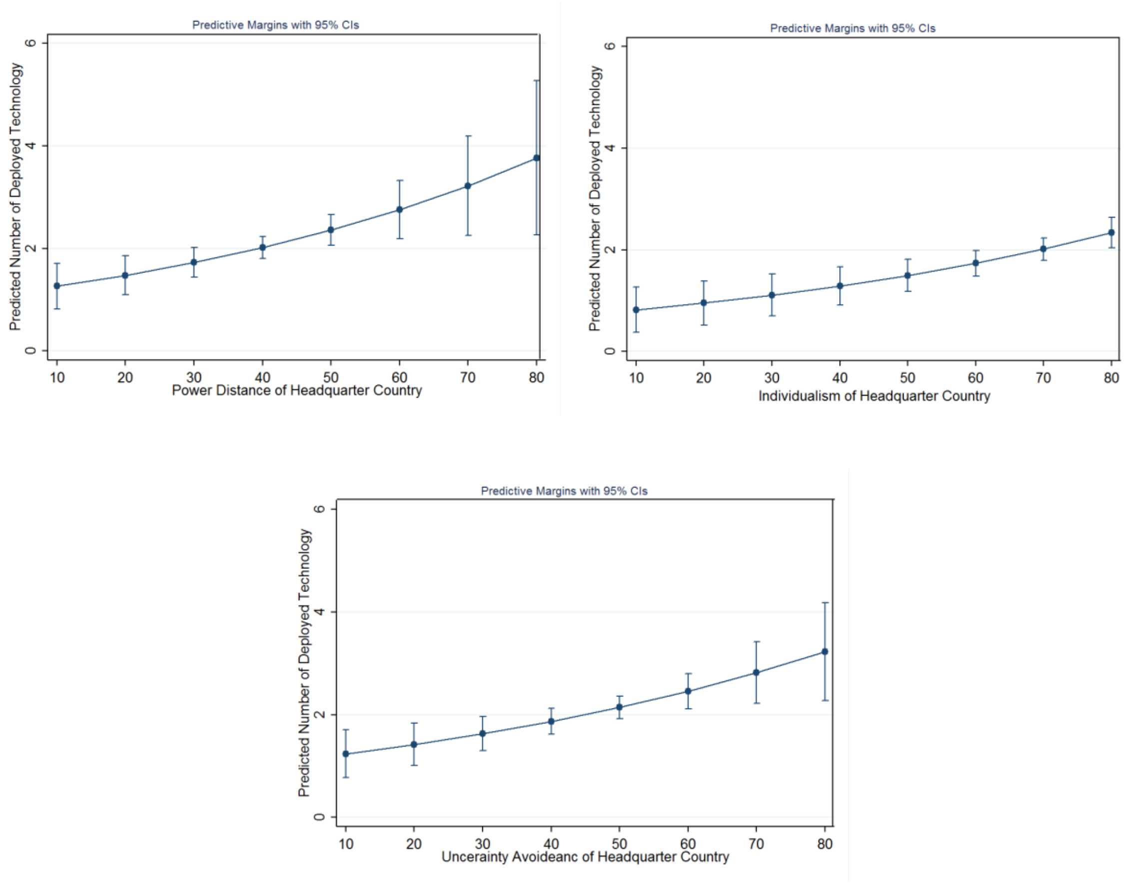

Figure 5-3 *Marginal plots to predict the effect of headquarters country's cultural dimension scores on deployed technology generation by oil and gas business units*

5.4 Cultural Effects of Location of Business Unit

The main aim of the current study was to understand the positive influence on innovation output of multinational oil and gas companies establishing overseas research centres. As such, it was important to determine an appropriate location for establishing a research centre by understanding the possible influence of the local country's cultural values on innovation output. Thus, this study employed a regression model on the survey data to extract the possible effect of the local country's cultural dimension score on the innovation output of oil and gas business units.

The Poisson regression results and marginal graphs of the abovementioned modelling are presented in Table 5-4 and Figure 5-4, respectively. As shown in Table 5-4, all cultural dimension scores of the local country could significantly predict patent generation by the oil and gas business units ($P < 0.05$). In addition, the results in this table suggest that the masculinity of the local country with a *Coef.* value of 0.038 had the strongest influence on the predicting the business units' patent generation. Interestingly, the effect of the local country's masculinity on predicting patent generation was in contrast to the effect of the headquarters country's masculinity (compare Table 5-2 to Table 5-4).

This study performed a detailed evaluation of the influence of the local country's cultural dimensions on the patent generation of the oil and gas overseas research centres by plotting the marginal graphs in Figure 5-4. These marginal graphs are usually used to assess the relationship between two variables, and examine their distributions.

Table 5-4 *Poisson regression results to model the effect of local country's cultural dimensions on the patent generation of oil and gas business units*

```
Poisson regression                              Number of obs     =        166
                                                LR chi2(4)        =     117.53
                                                Prob > chi2       =     0.0000
Log likelihood = -821.94422                     Pseudo R2         =     0.0667
```

patents	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PDI_Local	.0223068	.0042788	5.21	0.000	.0139205	.0306932
IND_Local	.0104566	.0034397	3.04	0.002	.0037148	.0171983
MAS_Local	.0379501	.0063692	5.96	0.000	.0254666	.0504336
UCA_Local	.0230368	.0031822	7.24	0.000	.0167998	.0292737
_cons	-4.093949	.6972097	-5.87	0.000	-5.460455	-2.727443

Figure 5-4 presents the marginal plots for the predicted number of patents generated by the oil and gas business units as a function of the local country's cultural dimension scores. As indicated in this figure, all Hofstede's cultural demotions could have a positive influence on predicting patent generation. However, the masculinity score had the strongest influence, while individualism had a very moderate effect. For example, if the overseas business unit of an oil and gas was located in Austria (with a masculinity score of 79), there was an expectation of producing four times more patents than a business unit located in Iran (with a masculinity score of 43). In contrast, for the individualism score of the local country, no considerable difference in patent generation was expected by locating the overseas business units in different countries. Figure 5-4 illustrates that power distance and uncertainty avoidance scores could show a very similar, yet moderate, influence on the expected number of patents generated. Therefore, the results in Figure 5-4 and Table 5-4 validate Hypotheses 2b, 2c and 2d but reject Hypothesis 2a.

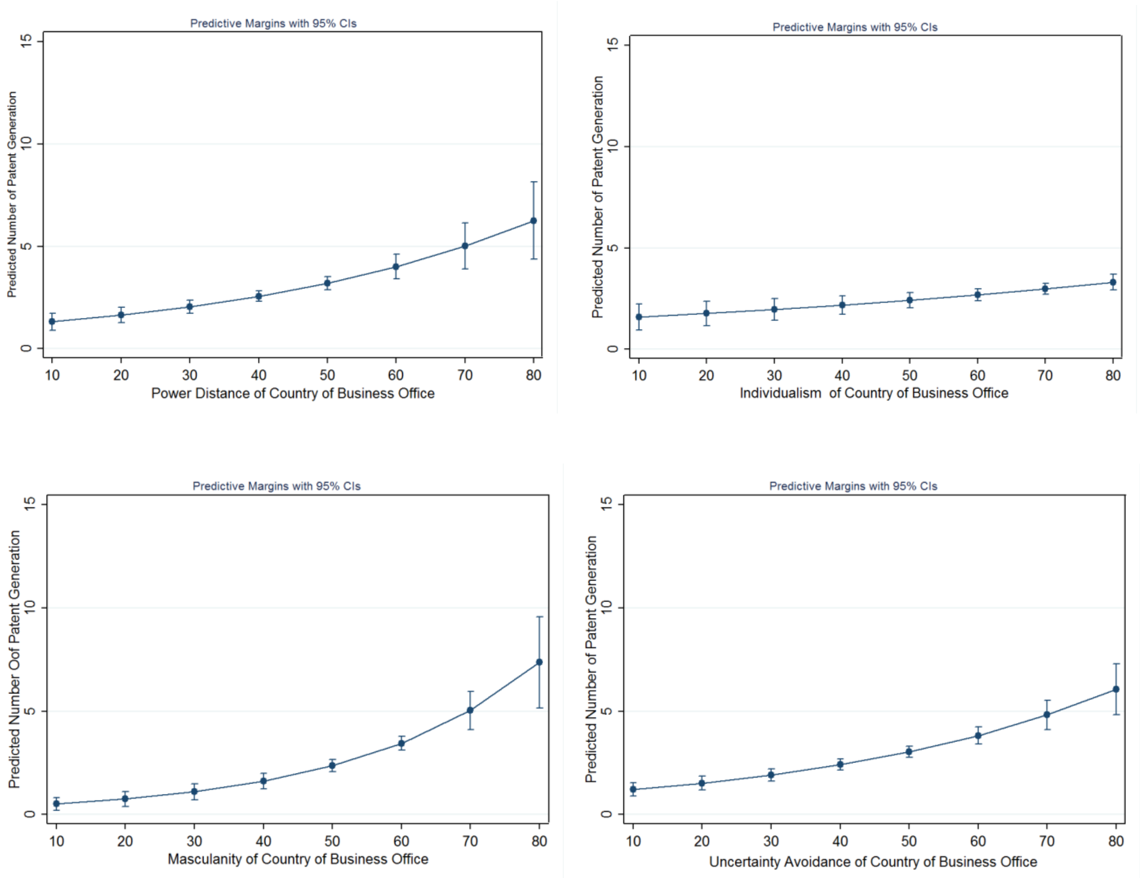

Figure 5-4 *Marginal plots to predict the effect of local country's cultural dimension scores on number of patents generated by oil and gas business units*

Similar to the previous section, the Poisson regression model was used on the surveyed data to study the possible influence of the local country's cultural dimension scores on the initiation of deployed technology by the overseas business units of a multinational oil and gas company. The Poisson regression results and corresponding marginal plots for this modelling are presented in Table 5-5 and Figure 5-5, respectively. Table 5-5 indicates that, among the four cultural dimensions, the individualism score had a large significant value ($P > 0.05$) and had no significant influence on predicting deployed technology initiation by overseas business units. However, the other three dimensions (power distance, masculinity and uncertainty avoidance) could have a significant influence on the business unit's innovativeness.

Table 5-5 *Poisson regression results to model the effect of local country's cultural dimensions on the deployed technology of oil and gas business units*

```
Poisson regression                               Number of obs     =        166
                                                 LR chi2(4)        =      39.23
                                                 Prob > chi2       =     0.0000
Log likelihood = -520.34221                      Pseudo R2         =     0.0363
```

technology	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PDI_Local	.0091889	.0046412	1.98	0.048	.0000923	.0182854
IND_Local	.0058598	.0039147	1.50	0.134	-.0018129	.0135325
MAS_Local	.0237489	.0058053	4.09	0.000	.0123708	.035127
UCA_Local	.0179898	.0040954	4.39	0.000	.0099628	.0260167
_cons	-2.366215	.6809267	-3.47	0.001	-3.700807	-1.031623

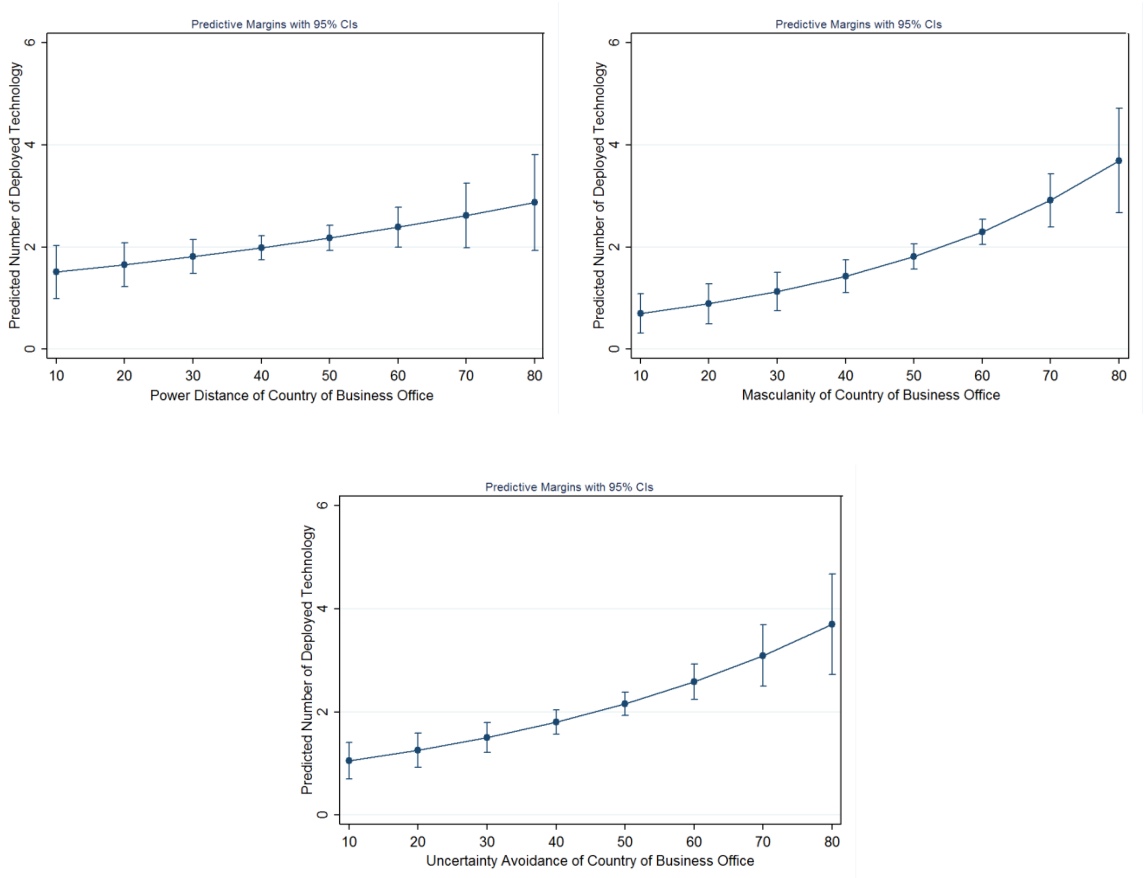

Figure 5-5 *Marginal plots to predict the effect of local country's cultural dimension scores on deployed technology by oil and gas business units*

5.5 Effects of Individual Dimensions of Cultural Distance

The previous results indicated the effect of each individual country's culture (headquarters and local countries) on the innovation output of oil and gas business offices. However, when considering overseas business offices (or research centres) and their connections with the headquarters office, the cultural distance between the two countries could have more influence on innovation output. Similar to the previous section, Poisson regression analysis was performed on the data, and the cases that had different countries as their headquarters and local countries were considered in the model to be able to measure the cultural distance.

Table 5-6 summarises the Poisson regression model to predict the influence of cultural distance on patent generation by overseas business units. As shown, all four cultural dimensions had a significant value ($P < 0.05$). The results in Table 5-6 also indicate that, while the distances for power distance and uncertainty avoidance had a negative influence on the predicted number of patents generated (*Coef.* < 0.0), the distances for individualism and masculinity had a positive influence. Thus, the researchers expected less patent generation as the differences in power distance or uncertainty avoidance between the headquarters and local countries increased. In contrast, as the differences in individualism and masculinity dimensions increased, more patent generation was expected. To evaluate such expectations, the marginal plots were extracted from the Poisson regression model, as shown in Figure 5-6. As expected, both power distance and uncertainty avoidance had a negative influence on the expected number of patents generated, while individualism and masculinity had positive influences. Figure 5-6 indicates that, while a small distance (or no distance) in power distance between the headquarters and local countries can increase the chance of patent generation by up to three times, increasing this distance will reduce the expected number of patent generations and approach zero as the distance between power distance increases. However, increasing the masculinity or individualism distances could increase the expected number of patents generated.

Figure 5-6 indicates that, among all cultural distance dimensions, individualism had the greatest influence on the predicted number of patents generated. In other words, if the individualism distance between the headquarters and local countries increased by 10 score, the predicted number of patents generated by the overseas business unit would significantly increase by five times (Figure 5-6).

***Table 5-6** Poisson regression results to model the effect of cultural distance between headquarters and local countries on patent generation by oil and gas business units*

Poisson regression	Number of obs	=	49
	LR chi2(4)	=	25.35
	Prob > chi2	=	0.0000
Log likelihood = -142.67239	Pseudo R2	=	0.0816

patents	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PDI_Distance	-.1366819	.0484766	-2.82	0.005	-.2316943	-.0416696
IND_Distance	.138974	.0476053	2.92	0.004	.0456693	.2322786
MAS_Distance	.1014704	.0358699	2.83	0.005	.0311667	.171774
UCA_Distance	-.3201821	.1460421	-2.19	0.028	-.6064193	-.033945
_cons	.5521956	.1930368	2.86	0.004	.1738504	.9305408

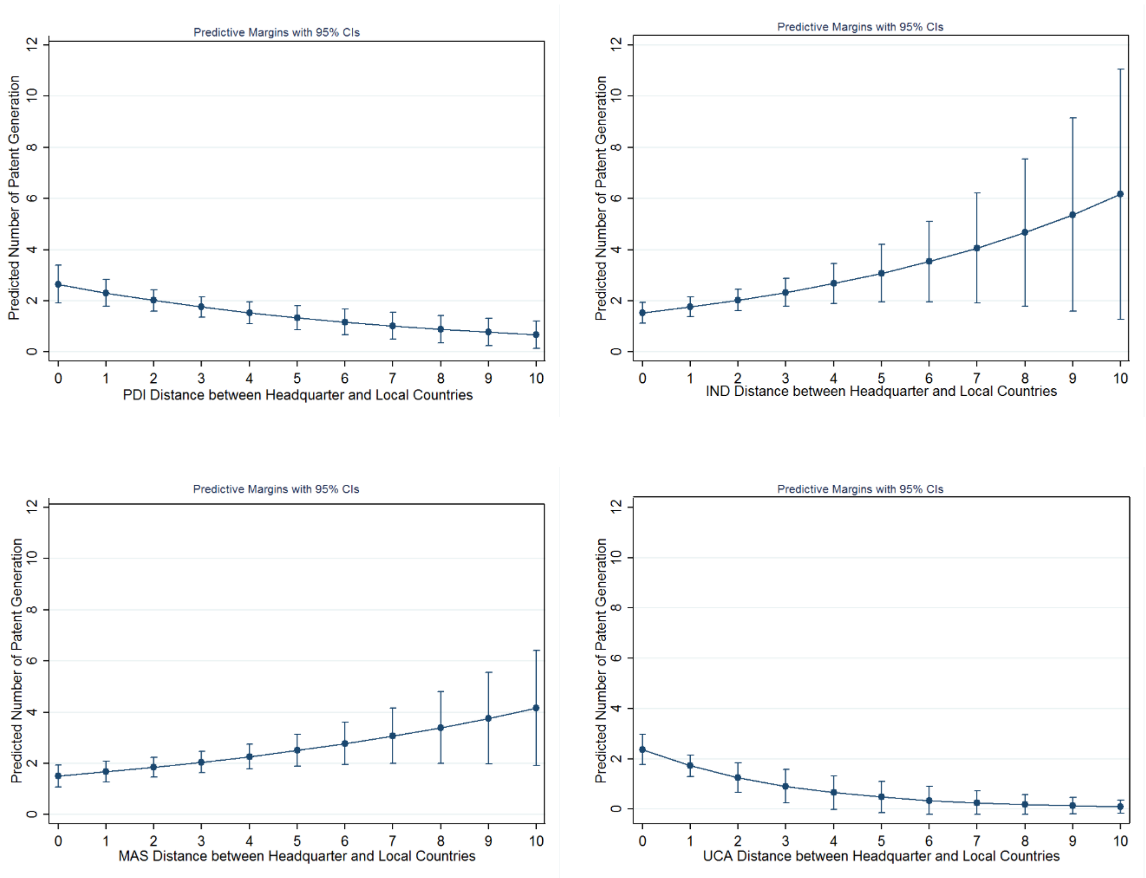

***Figure 5-6** Marginal plots to predict the effect of cultural distance between headquarters and local countries' cultural dimension scores on patent generation by oil and gas business units*

Similar Poisson regression modelling was performed on survey data to predict the influence of the cultural distance between the headquarters and local countries on deployed technology. The results of this modelling are presented in Table 5-7. The results indicated that, for all cultural dimension distances, the masculinity distance was the only cultural dimension that could significantly influence the expected number of deployed technologies ($P < 0.05$). No other cultural dimensions had significant values ($P > 0.05$) or a relationship with the business unit's innovativeness. Therefore, the marginal graphs were plotted for uncertainty avoidance distance in Figure 5-7.

Table 5-7 *Poisson regression results to model the effect of cultural distance between headquarters and local countries on deployed technology initiation by oil and gas business units*

Poisson regression	Number of obs = 49
	LR chi2(4) = 12.77
	Prob > chi2 = 0.0125
Log likelihood = -116.15929	Pseudo R2 = 0.0521

technology	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PDI_Distance	-.0252724	.0446296	-0.57	0.571	-.1127448	.0622001
IND_Distance	-.0298793	.0578531	-0.52	0.606	-.1432692	.0835107
MAS_Distance	-.0153734	.0378748	-0.41	0.685	-.0896067	.0588599
UCA_Distance	-.363586	.1529546	-2.38	0.017	-.6633715	-.0638005
_cons	.9649962	.1689614	5.71	0.000	.633838	1.296154

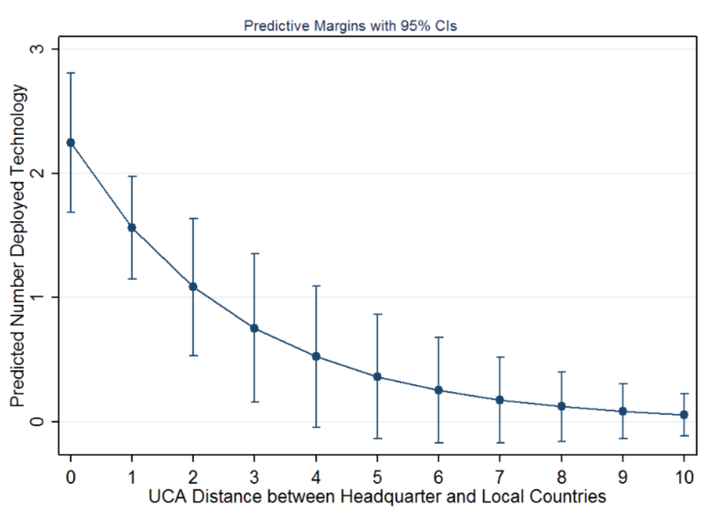

Figure 5-7 *Marginal plot to predict the effect of uncertainty avoidance distance between headquarters and local countries on deployed technology initiation by oil and gas business units*

5.6 Effects of Combined Dimensions of Cultural Distance

Culture is a composite variable of all four Hofstede cultural dimensions; thus, evaluating the overall cultural distance between the headquarters and local countries could be a better way to evaluate the influence of cultural distance on innovation output. To evaluate Hypothesis 4a, Poisson regression modelling was performed on the survey data. The results are presented in Table 5-8. This table suggests that the cultural distance between the headquarters and local countries cannot predict the patent generation by overseas business units ($P > 0.05$).

Table 5-8 *Poisson regression results to model the effect of overall cultural distance between headquarters and local countries on patent generation by oil and gas business units*

Poisson regression				Number of obs	=	49
				LR chi2(1)	=	0.43
				Prob > chi2	=	0.5137
Log likelihood = -155.13389				Pseudo R2	=	0.0014

patents	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Cultural_Distance	-.0433953	.0667206	-0.65	0.515	-.1741653	.0873746
_cons	.7547393	.1598189	4.72	0.000	.4415	1.067979

In another attempt to evaluate Hypothesis 4b, Poisson regression modelling was performed to assess the influence of overall cultural distance on deployed technology initiation by overseas business units in the oil and gas industry. The results of this modelling are presented in Table 5-9. The results in this table suggest that the overall cultural distance between headquarters and local countries can significantly predict the deployed technology invitation by overseas business units ($P < 0.05$). This table indicates a powerful and negative influence of cultural distance on deployed technology (*Coef.* = -0.17). To graphically display this influence, the marginal plots of this modelling are presented in Figure 5-8.

Table 5-9 *Poisson regression results to model the effect of overall cultural distance between headquarters and local countries on deployed technology initiation by oil and gas business units*

Poisson regression				Number of obs	=	49
				LR chi2(1)	=	6.03
				Prob > chi2	=	0.0140
Log likelihood = -119.52596				Pseudo R2	=	0.0246

technology	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Cultural_Distance	-.1737319	.0724877	-2.40	0.017	-.3158053	-.0316586
_cons	.9111526	.1541727	5.91	0.000	.6089796	1.213326

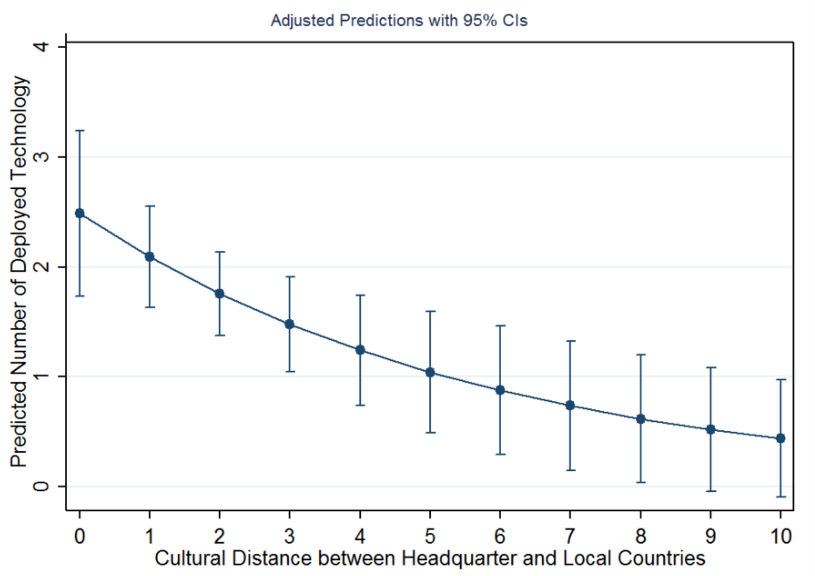

Figure 5-8 *Marginal plot to predict the effect of overall cultural distance between headquarters and local countries on deployed technology initiation by oil and gas business units*

Figure 5-8 indicates that, while a small (or no) cultural distance between the headquarters and local countries can increase the chance of deployed technology initiation by up to three times, increasing this distance will reduce the expected number of deployed technologies and approach zero as the cultural distance increases. For instance, considering the headquarters of an oil and gas company in the US, establishing a business unit in Australia (with a negligible cultural distance to the US of 0.02) could expect up to three times more deployed technology than establishing a business unit in the United Arab Emirates (with a large cultural distance to the US of 3.93).

5.7 Innovation Performance of Hyper-innovative Companies

As aforementioned, of the 199 cases that responded to the survey, 18 cases were separated from the previous analysis as hyper-innovative companies with a large number of patents and/or deployed technologies. A review of these 18 cases indicated that all related to large multination companies (with more than 10,000 employees) located in technology-intensive countries (mostly the US). To evaluate how these cases related to the cultural dimension scores of their host country, Figure 5-9 summarises the relationship between the number of innovations and the Hofstede’s score for different cultural dimensions. It should be noted that, due to the limited number of data (number of cases), no statistical analyses were performed.

Figure 5-9 shows that more that 90% of patents and deployed technologies were generated by companies located in countries with low power distance scores, high individualism scores and low uncertainty avoidance scores. As expected, these scores in Hofstede's cultural values were related to countries that are technology-intensive in the oil and gas industry (such as the US and Norway).

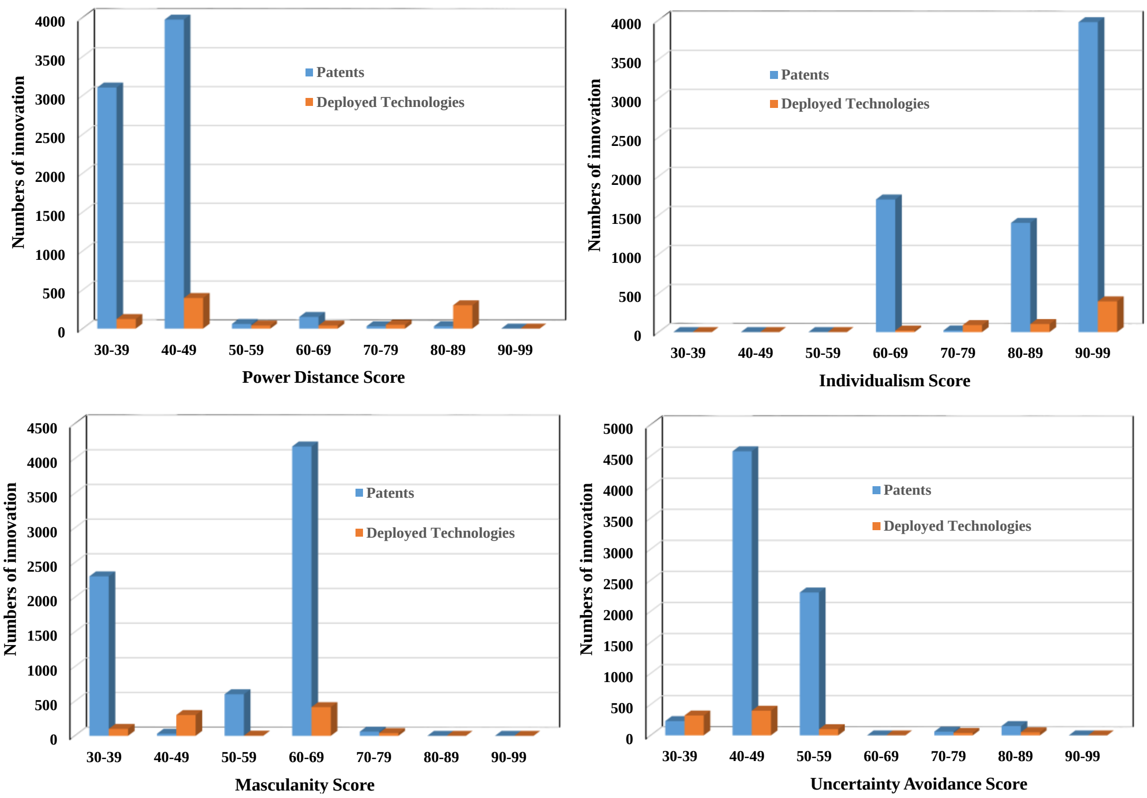

Figure 5-9 *Distribution of innovation output of hyper-innovative companies as the Hofstede's cultural score for R&D centre location*

CHAPTER SIX

6 Discussion

The results of this study indicated mixed influences of different cultural dimensions on the innovation output of oil and gas MNCs. To attain a better view of these influences, each of Hofstede's cultural dimensions were studied separately, and their influence on both patent generation and deployed technology were analysed. In addition, the results were compared with the available literature on each cultural dimension to evaluate the similarities and differences between the current findings and existing literature.

6.1 Power Distance

Table 6-1 presents a summary of the influence of power distance on innovation output in the current study. The results in this table indicate the strong and positive influence of the power distance scores of both the headquarters and local countries on the innovation output of oil and gas business units. This is in contrast to previous findings from Shane (1992) and Rinne, Steel and Fairweather (2012). As indicated in Figure 5-2, this positive influence was more obvious for the power distance of the headquarters countries. In other words, *when the headquarters of a multinational oil and gas company are located in a country with a higher score on the power distance index, more innovation (both patent generation and deployed technology) is expected by the overseas business units of that company*. This statement indicates that all Hypotheses 1a, 1b, 2a and 2e were not valid and rejected by the findings of this study.

When examining the power distance between two countries (the headquarters and local countries), the results were different. As Figure 5-6 indicates, the power distance between the headquarters and local countries had a negative influence on the patent generation by overseas business units; thus, Hypothesis 3a was accepted by the results of this study. However, the results were unable to evaluate Hypothesis 3e on the influence of cultural distance between the headquarters and local countries on the initiation of deployed technology.

To analyse the results in Table 6-1 and understand the difference between these results and previous findings—especially the findings by Shane (1992) and Rinne, Steel and Fairweather (2012)—it is necessary to revisit Hofstede's definition of power distance. The unequal distribution of power in a society is a necessary perception of power distance. Innovation may create a threat to this perception because lower class members of a society can move to a higher class if they work more successfully; thus, innovation is more difficult in nations with a high score in power distance. In addition, employees of a workplace in a high power distance nation expect to be told to what to do and what not to do, which is in opposition to an innovative environment. Thus, not much innovation is expected from such workplaces. However, the results of the current work indicate contrasting results, whereby the business units located in high power distance countries were indicated as being able to innovate more than the units located in low power distance countries.

These differences in the findings of this study regarding power distance, in comparison to previous work (Rinne, Steel & Fairweather 2012; Shane 1992, 1993), could have arisen from the nature of the current work's case study and difference to previous studies. Previous scholars have mostly examined innovation within a country (national-level study) and compared their results with other countries to determine the effect of the country's cultural dimensions on the country's innovation output. However, the current study examined multinational companies and measured the effect of the country's culture on MNCs' innovation output. The researchers believe that, in this case (studies of oil and gas MNCs), innovation (and other activities) are mostly directed by MNCs' policies and guidelines. In other words, the MNCs' working environment is characterised by centralised decision structures, authority and the use of formal rules. Based on Hofstede's (2001) definition, these are characteristic of countries with a high score in power distance. Therefore, locating a headquarters office or business unit in countries with a higher score in power distance—where employees tend to follow their company decisions and instructions—could result in a higher rate of patent generation and deployed technology initiation. However, the researchers believe that this type of innovation is mostly instructed and guided innovation, rather than innovation deriving from the talent and hard work of individuals.

Another important difference between the current work and the previous work by Rinne, Steel and Fairweather (2012) and Shane (1992, 1993, 1995) is the size and extent to which the studies were performed. While the current work concentrated on oil and gas research centres and companies, the previous work by Shane (1992, 1993, 1995) and Rinne, Steel and Fairweather (2012) studied national-level innovation outcomes. The current study was a corporation-based study, while the previous works were nation-based studies. Therefore, limiting the study to a specific sampling area (oil and gas) and using nation-wide measure values (cultural dimension scores) could introduce some uncertainty to the results.

An additional area of difference between the current study and previous studies that requires further attention and consideration is related to the nature of work and employment in the oil and gas industry. Considering that employees in multinational oil and gas companies usually come from different backgrounds and cultures, their individual background and culture could influence their work output. In other words, in an oil and gas MNC, considering the national culture does not necessarily refer to a single nation, and multiculturalism is evident in these cases (Mearns & Yule 2009). Therefore, having a strong positive influence of power distance score on innovation output in current case could be a positive influence of multinationalism on innovation.

Table 6-1 *Summary of influence of power distance on innovation output in oil and gas industry*

Hypothesis No	Innovation Measure	Cultural Dimension	Model Prediction
1a	Patent	Power distance of headquarters country	Highly rejected
1b	Deployed technology	Power distance of headquarters country	Highly rejected
2a	Patent	Power distance of local country	Highly rejected
2e	Deployed technology	Power distance of local country	Moderately rejected
3a	Patent	Power distance between local and headquarters countries	Accepted
3e	Deployed technology	Power distance between local and headquarters countries	—

Finally, the work in the current study is the result of collaboration between employees working in the headquarters and overseas offices. Thus, the difference in cultural scores on power distance *between* the two countries in which the headquarters and overseas business units are located should have more influence than the power distance scores of either the local or headquarters countries. This study's results indicate that, when the power distance between the headquarters and overseas offices increased, the predicted number of patents generated decreased. In other words, *power distance has a negative influence on innovation*. Thus, viewing the results from the perspective of cultural distance indicates similarities with the findings of Shane (1993) and Rinne, Steel and Fairweather (2012).

6.2 Individualism

Table 6-2 presents a summary of this study's findings on the influence of the individualism scores of the headquarters and local countries, as well as the individualism distance between the two countries, for both patent generation and deployed technology initiation by overseas oil and gas business units. These results are somewhat surprising. First, the results indicate the positive influence of cultural individualism of the headquarters and local countries on patent generation as a measure of innovation output for oil and gas MNCs. Second, when deployed technology is considered as a measure of innovation, the individualism of the headquarters country indicated a moderate influence on this factor; however, no relationship was found between the individualism score of the local country and deployed technology initiation. Third, when analysing the individualism distance between the headquarters and local countries, the results strongly supported previous findings (Shane 1992; Rinne, Steel and Fairweather 2012; Taylor and Wilson 2012), with a strong and positive relationship between individualism distance and patent generation. However, the individualism distance did not indicate any influence on deployed technology initiation. Therefore, the results of this study supported Hypothesis 1c, 1d and 2b, rejected Hypotheses 3b, and could not evaluate Hypotheses 2f and 3f.

Table 6-2 Summary of influence of individualism on innovation output in oil and gas industry

Hypothesis No	Innovation Measure	Cultural Dimension	Model Prediction
1c	Patent	Individualism of headquarters country	Moderately accepted
1d	Deployed technology	Individualism of headquarters country	Weakly accepted
2b	Patent	Individualism of local country	Moderately accepted
2f	Deployed technology	Individualism of local country	—
3b	Patent	Individualism distance between local and headquarters countries	Highly rejected
3f	Deployed technology	Individualism distance between local and headquarters countries	—

This mixed influence of individualism on the two different measures of innovation was probably caused by the nature of the innovation measurement systems (patents and deployed technology). While patent generation is an activity that can be performed both individually and collectively as a team, the initiation of a deployed technology—especially for complicated and large-scale technology related to oil and gas—could be the result of team and company work, rather than individual work. Autonomy, independence and freedom are associated with individualism (Rinne, Steel & Fairweather 2012) and are more personal factors, rather than group or team factors; thus, societies with a higher individualism score should have more innovation in terms of patent generation (an individual activity). However, when involving a teamwork activity (such as deployed technology), personal factors may have less influence, as indicated by this analysis.

6.3 Uncertainty Avoidance

This study's results regarding the influence of uncertainty avoidance on innovation are interesting and against previous work indicating a positive influence of uncertainty avoidance score of a nation on innovation output (Table 6-3). This study's analysis indicated that the uncertainty avoidance of headquarters and local countries has a positive influence on both measures of innovation, thereby accepting Hypotheses 1e, 1f, 2c and 2g.

On the other hand, when analysing the uncertainty avoidance distance between two countries, negative influences were found on both patents and deployed technology. In other words, *when the distance between the uncertainty avoidance scores of the headquarters and local countries increases, the possibility of patent generation and deployed technology initiation by oil and gas research centres decreases*. This supports Hypotheses 3c and 3g.

According to Hofstede (2001), organisations in countries with a high score of uncertainty avoidance generally have highly formalised management systems and innovate mostly by rules (Everdingen & Waarts 2003). As aforementioned, the nature of oil and gas MNCs supports similar rules to high uncertainty avoidance countries. Therefore, the researchers expected a better match between company rules and nation cultural attitude when the headquarters and/or business units were located in countries with high uncertainty avoidance score. This match between people and company rules and policies could result in a higher rate of innovation, which is a type of guided innovation.

Table 6-3 *Summary of influence of uncertainty avoidance on innovation output in oil and gas industry*

Hypothesis No	Innovation Measure	Cultural Dimension	Model Prediction
1e	Patent	Uncertainty avoidance of headquarters country	Moderately accepted
1f	Deployed technology	Uncertainty avoidance of headquarters country	Highly accepted
2c	Patent	Uncertainty avoidance of local country	Highly accepted
2g	Deployed technology	Uncertainty avoidance of local country	Highly accepted
3c	Patent	Uncertainty avoidance between local and headquarters countries	Accepted
3g	Deployed technology	Uncertainty avoidance between local and headquarters countries	Highly accepted

6.4 Masculinity

Table 6-4 summarises the results of the current work on the influence of masculinity and masculinity distance on the innovation output of oil and gas companies. These results indicated that, while the current analysis could not evaluate the influence of the masculinity scores of the headquarters country on either form of innovation output (Hypotheses 1g and 1h), the masculinity of local countries had a strong and positive influence on both innovation measures (strongly accepting Hypotheses 2d and 2h). However, when the masculinity distance between the headquarters and local countries was tested, a strong influence was found for patent generation (accepting Hypothesis 3d), yet no influence was found for deployed technology.

Table 6-4 *Summary of influence of masculinity on innovation output in oil and gas industry*

Hypothesis No	**Innovation Measure**	**Cultural Dimension**	**Model Prediction**
1g	Patent	Masculinity of headquarters country	—
1h	Deployed technology	Masculinity of headquarters country	—
2d	Patent	Masculinity of local country	Highly accepted
2h	Deployed technology	Masculinity of local country	Accepted
3d	Patent	Masculinity between local and headquarters countries	Highly accepted
3h	Deployed technology	Masculinity between local and headquarters countries	—

6.5 Cultural Distance

As an assumption, during Poisson regression modelling of every individual cultural values, all other cultural values kept constant. For example, when regression modelling was performed to evaluate the influence of power distance on patent generation, it was supposed that uncertainty avoidance, individualism and masculinity were constant values. Therefore, the simultaneous effect of other cultural values was neglected while measuring each value, which could introduce some uncertainty to the results. Thus, overall cultural distance was probably a more accurate tool, as it considered all aspects of a culture. Therefore, while studying the effect of each individual dimension of culture on innovation output could be important for understanding the relationship between nations' culture and innovation output, because culture is a collection of different dimensions, it must be considered as a package, rather than as individual dimensions.

Previous scholars have also found different results when considering all cultural values simultaneously. For example, Efrat (2014) found an interaction between the different dimensions of culture when modelling innovations. For instance, she found that, while uncertainty avoidance alone indicated a negative influence on innovation output, the influence become positive when individualism and masculinity were combined with uncertainty avoidance. Table 6-5 summarises the current study's findings on the influence of overall cultural distance between the headquarters and local countries on patent generation and deployed technology initiation. The results indicated that, while the current analysis could not evaluate the influence of cultural distance on patent generation, the influence on deployed technology initiation was negative and strong (accepting Hypothesis 4b).

Table 6-5 *Summary of influence of overall cultural distance on innovation output in oil and gas industry*

Hypothesis No	**Innovation Measure**	**Cultural Dimension**	**Model Prediction**
4a	Patent	Cultural distance between local and headquarters countries	—
4b	Deployed technology	Cultural distance between local and headquarters countries	Highly accepted

CHAPTER SEVEN

7 Conclusions and Recommendations

7.1 Conclusions

This study investigated the influence of culture on innovation outputs in the oil and gas industry. Four dimensions of Hofstede’s cultural dimensions theory were chosen as the criteria to assess the culture of each country. These dimensions were power distance, individualism versus collectivism, masculinity versus femininity and uncertainty avoidance. To measure the innovation outputs of the business units (R&D centres) of multinational oil and gas companies, two variables were measured: number of patents and number of deployed technologies. In this regard, an online survey was performed in collaboration with the SPE to answer a wide range of research questions, including the number of patents and deployed technologies initiated by the business units/R&D centres.

To analyse the survey data, Poisson regression analyses were performed as the most appropriate tool to determine the influence on innovation output of each individual cultural dimension of both the headquarters countries and overseas research centre countries. The results were compared with the available literature. The most important conclusions drawn were as follows:

1. The power distance scores of both the headquarters and local (where the business units were located) countries had a strong and positive influence on the number of patents and number of deployed technologies. When the countries’ power distance scores increased, there was a greater chance of innovation by the business units located in those countries. However, when analysing the cultural distance between the headquarters and local countries, the results were different. As the distance in the power distance scores between the two countries increased, the possibility of the overseas business units issuing patents decreased.

2. While the individualism of both the headquarters and local countries indicated a positive influence on the patent generation of overseas oil and gas business centres, no considerable influence was detected for deployed technology. In contrast, the

results indicated a strong and positive relationship between the individualism distance between the two countries and patent generation.

3. The masculinity score of the headquarters country did not indicate any influence on the innovation output of the oil and gas research centres. However, the masculinity scores of the local countries indicated a strong and positive influence on innovation outputs. In contrast, a strong influence of masculinity distance was found on patent generation, yet no influence on deployed technology.

4. The uncertainty avoidance scores of the headquarters and local countries indicated a positive influence on innovation output. However, the uncertainty avoidance distance between the two countries revealed a negative influence on innovation.

7.2 Contribution

This study has investigated the influence of local and international culture on the innovation output of the oil and gas industry. The strength of the analysis in this study is that it did not confine itself to a limited region or country, but collected data from all around the world. The results of this study can be used by both academia and industry to understand how internationalisation affects innovation in a cultural context.

As a theoretical contribution, this work provides a valuable foundation for further investigations on how innovation is managed in the upstream oil and gas industry. One of the most important outcomes from a theoretical perspective is the influence of each single Hofstede cultural dimension on innovation outcomes. The results enrich the current understanding on this context. This study identified different effects from different dimensions of culture—some dimensions (such as power distance and uncertainty avoidance) had strong influences, while others (such as individualism) had moderate to weak influences.

Considering the industrial contribution of the current work, the results were able to identify the cultural values of a country that potentially result in a better innovative outlook. As shown throughout this work, different cultural dimensions may have different influences on both forms of innovations (patent generation or deployed technology). Therefore, the results of this work could assist upstream oil and gas managers to locate the best region or country for establishing new R&D centres based on the expectation of innovativeness in patent generation or the development of new technologies.

7.3 Research Limitations and Recommendations for Further Research

While the current work generated comprehensive and interesting knowledge regarding the influence of culture on innovation output, there remain some important limitations that require further research and consideration, as follows:

1. The main limitation of this research is that the pool of respondents did not provide a comprehensive picture of the entire industry's R&D activities, and the statistics captured in this work did not reflect the totality of the industry's output with regard to innovation and new technologies. Nonetheless, the survey did provide a potentially valuable snapshot of the industry's R&D-related activities around the world.

2. To measure the cultural dimension scores of each interested country, this study used Hofstede's measured values, which are the overall score value for the whole country (or, more specifically, for employees of IBM in different countries). However, some industries (including the petroleum industry) are known to have employees from all around the world, with different cultural backgrounds and different approaches to innovation. This makes assumptions regarding sample selection difficult, as employees of research centres or headquarters offices may have cultures that differ from the host country. However, Hofstede's cultural dimension scores in each country are a sample of overall measurements and can include some overseas respondents living or working in that country; thus, the results may be less complicated.

3. A quick review of the survey findings in the current work suggests that, while business units located in their headquarters countries generate more patents, remote units are responsible for more technology development. The reason for this finding remains unclear and requires further research. The reason for this finding may arise from the greater availability of lawyers in the headquarters countries. Also, the difficulties associated with patent innovations in international environments may be the reason. However, more research are needed to clarify these statements.

4. The applied modelling approach in current work is suffering from lack of a control variable. The available data set includes the size of the firm (number of employment) for all business units, which could be considered as an interesting control variable in the model. Therefore, a new set of modelling study is recommended by including firm size as a control variable.

5. The moderation influence of any cultural dimension on effect of other cultural distance dimensions on innovation output of international business units, is another interesting study for further investigation. For instance, how masculinity score of a country where the international business unit is located could moderate the powder distance differential between the countries of headquarter and business unit locations?

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