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EXTRACTIVE INDUSTRIES AS A PLATFORM FOR THE CREATION OF KNOWLEDGE INTENSIVE INDUSTRIES: TRINIDAD AND TOBAGO'S OIL AND GAS SERVICE PROVIDERS

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The South American Network on Applied Economics (Red Sudamericana de Economía Aplicada, Red Sur), is a policy-oriented research network integrated by public and private universities and centers of knowledge production in the region. It conducts research in the areas of economic development, natural resources, inclusive growth, employment, integration, trade and value chains, productivity and innovation.

Red Sur is interested in promoting regional socio-economic analysis for policy discussion to respond to the challenges of development. It promotes, coordinates and develops joint studies from an independent and rigorous perspective on the basis of common methodologies with a regional vision.

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The reliance on oil and gas has long been Trinidad and Tobago's strength and weakness. The country is rich in oil and gas resources and considered the most industrialized economy in the English-speaking Caribbean. Its first-class oil and gas and downstream petrochemical industry is over 100 years old, with a growing number of oil and gas Knowledge Intensive Business Services (KIBS) firms operating regionally and internationally. The oil and gas services sector where KIBS firms operate employs about one third of all oil and gas sector workers, and globally the share of knowledge intensive services to total output has been steadily increasing over time.

Yet, the challenges and opportunities for the future are many, not to name the drastic fall in international oil and gas prices along with falling oil and gas production locally. While the government invested in education and training and the country has a highly educated workforce, the country has been less successful at diversification and entrepreneurship. In transitioning from an extractive to a knowledge based economy Trinidad and Tobago's public policies now need to focus on science, technology and innovation and on creating and diffusing knowledge.

While the T&T government has stated its intention to diversify the economy and increase innovation there has been little success. Trinidad and Tobago's oil and gas KIBS firms may play a major role here and for the analysis of the future of extractive industries in Latin America and the Caribbean. KIBS firms are likely to be one of the main engines for future growth.

The objective of this study is to empirically examine the role of Trinidad and Tobago oil and gas KIBS firms in diversifying the economy away from an extractive to a knowledge intensive sector. The paper also examines the role of oil and gas KIBS firms in building employment capabilities, human capital development, environmental protection and sustainability given their importance in knowledge-based economies. The paper uses primary and secondary data sources and firm specific case studies. The case of TOFCO for instance, illustrates diversification into new sub-sectors within the oil and gas services sector, as well as new sectors outside of oil and gas services. The paper identifies opportunities for cooperation, knowledge sharing and experiences from Trinidad and Tobago that can be replicated in the region. The paper concludes by making policy recommendations, identifying opportunities and obstacles for their implementation and possible institutional implications to further develop the sector by using examples of successful policies and strategies in other countries.

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1. Introduction

Extractive industries should not be viewed as isolated enclaves engaged solely in primary activity, but can be real drivers of economic development with substantial potential for creating knowledge intensive industries. Since natural resources are finite, resource rich developing countries should take advantage of the opportunities created by extractive industries. Empirical evidence suggests that the reliance on natural resources can foster economic growth and development when underpinned by efforts to increase technological innovation and accumulate capabilities to innovate around natural resources (Aslesen and Isaksen, 2010; Engen, 2009; and Noreng, 2005). Moreover, traditionally vertically integrated value chains in the extractive sector have been redesigned and new production paths created through the large scale use of Information and Communications Technology (ICT) and outsourcing and subcontracting, which have led to the mushrooming of Knowledge Intensive Business Services (KIBS) firms. Globally the share of knowledge intensive services to total output has been steadily increasing over time (Stehrer *et al*., 2012) and KIBS firms are likely to be one of the main engines for future growth (Gotsch *et al*., 2011).

These KIBS firms serve the demands of exploration and production and mining companies may potentially encourage structural change and diversification into a knowledge intensive industry since they may act as facilitators, sources and carriers of knowledge and innovation within the extractive sector and other sectors, as well as the country's National Science Technology Innovation (STI) system. KIBS firms therefore provide new opportunities for natural resource based developing countries to transition and diversify from extractive to knowledge intensive industries. Latin America and the Caribbean is one of the most natural resource abundant regions internationally and remains underdeveloped. Moreover, there exists little empirical evidence on the role and impact of KIBS firms in knowledge transfer, innovation and diversification, human capital development and environmental protection in the region. This paper is a step forward in filling this gap by empirically studying KIBS firms in Trinidad and Tobago's oil and gas sector.

Trinidad and Tobago is rich in oil and gas resources with a well-developed downstream petrochemical industry and is the most industrialized economy in the English-speaking Caribbean (Atarna *et al*., 2007). The country has successfully developed a first-class oil and gas and downstream petrochemical industry which is over 100 years old and has a growing number of oil and gas KIBS firms which operate in various Caribbean and Latin American countries and even internationally in Canada, the US and Africa. The reliance on oil and gas has long been the country's strength and weakness. The United Nations Office of the High Representative classifies the country as a Small Island Developing State (SIDS) for the Least Developed Countries, Landlocked Developing Countries and the Small Island Developing States (UN-OHRLLS). It however has a relatively high GDP per capita of US$ 14,200 (constant 2005) and is also a high-income country according to the World Bank World Development Indicators (WDI). While the country has been able to diversify and add value within its oil and gas sector with a highly developed downstream petrochemical industry, it has not been able to develop viable clusters outside of the sector. Nevertheless,

the country's growth and development has been led by the oil and gas sector, which accounts for more than 45% of GDP, 48% of government revenue and 80% of exports (CBTT, 2015). However, given its capital intensive nature the sector makes up only 3% of the country's employment (CBTT, 2015). On the other hand, the oil and gas services sector where KIBS firms operate has been growing and its contribution to GDP has increased, although slightly from 4% to 5% from 2001 to 2012 (CBTT, 2013) and employs about one third of all oil and gas sector workers (The Energy Chamber of Trinidad and Tobago, 2009).

Recently, there has been a drastic fall in international oil and gas prices along with falling oil and gas production locally and Trinidad and Tobago's GDP growth rate has averaged negative 0.53% in the past 5 years (WDI, 2015). There is a general agreement among policy makers, academics and the wider public that economic diversification along with improvements in innovation and productivity are critical for achieving sustainable long run growth and development. Moreover, while the government has stated its intention to diversify the economy and increase innovation expressed in various national development plans such as "Vision 2020" and the "Medium Term Policy Framework 2011-2014", there has been little success. Trinidad and Tobago's oil and gas KIBS firms may play a major role here and therefore constitute a very interesting study for the analysis of the future of extractive industries in Latin America and the Caribbean.

The objective of this study is to empirically examine the role of Trinidad and Tobago oil and gas KIBS firms in diversifying the economy away from an extractive to a knowledge intensive sector. These firms may potentially act as facilitators, sources and carriers of explicit and tacit knowledge and organizational and technological innovation locally and internationally in the oil and gas sector, other sectors and more broadly in the country's national STI system. The paper also examines the role of oil and gas KIBS firms in building employment capabilities and human capital development and environmental protection and sustainability given their importance in knowledge-based economies. The paper uses primary and secondary data sources and firm specific case studies. It identifies opportunities for cooperation, knowledge sharing and successful experiences and lessons learnt from Trinidad and Tobago that can be replicated in the region. Lastly, the paper concludes by making policy recommendations, identifying opportunities and obstacles for their implementation and possible institutional implications to further develop the sector by using examples of successful policies and strategies in other countries.

The paper consists of 9 sections including the introduction. The rest of the paper is organized as follows. Section 2 provides a literature review on the knowledge based economy and knowledge sharing and innovation in KIBS firms. Section 3 gives details of the methodology and various data sources used by the study. Section 4 presents an overview and economic contribution of Trinidad and Tobago's oil and gas industry as well as its oil and gas KIBS firms. Section 5 details the empirical findings on knowledge sharing, innovation, productivity and diversification of Trinidad and Tobago's oil and gas KIBS firms. Section 6 provides information on employment capabilities and human resource development by the oil and gas sector and its KIBS firms. Section 7 gives information on the oil and gas sector and the role of KIBS firms in environmental sustainability. Section 8 presents the lessons learnt from Trinidad and Tobago's oil and gas sector and makes policy recommendations. Section 9 concludes the paper.

2. Literature

A knowledge-based economy is one in which knowledge is increasingly present in all aspects of economic activity and knowledge drives productivity, economic growth and sustainable development. In the literature, new growth theory attempts to directly incorporate knowledge and technology through investments, for example in ICT, research and development (R&D) and education and training, in understanding their role in driving productivity and growth. Also, equally important is knowledge distribution through ICT and formal and informal networks. Innovation arises from the interaction of producers and users of knowledge, which may be enhanced in a knowledge-based economy. The national STI system is the structure by which information flows among firms, government and academia in the development of science and technology in a country and therefore plays a crucial role in a knowledge-based economy. Further, in a knowledge-based economy there is an increased demand for highly skilled workers, which requires government policy and firms to target increased employment capabilities and human resource development. Lastly, given the rise of ICT and other technologies, a knowledge-based economy may be better able to monitor and dispose of harmful environmental emissions and other environmental impacts. A knowledge-based economy may therefore lead to better environmental protection and sustainability.

The current literature offers no established theoretical framework on KIBS firms and their role in a knowledge-based economy. Nevertheless, KIBS firms are considered to be among the most innovative within the services sector with a performance comparable to high-tech manufacturing activities (Nählinder, 2002). KIBS firms can be viewed as knowledge creating entities, which can help with knowledge transfer and consequently innovation, productivity and diversification. KIBS firms provide services and business operations, which are heavily reliant on professional knowledge and depend on knowledge related to specific technical fields. They provide intermediate products and services that are knowledge based and knowledge intensive support for the business operations of other companies. KIBS firms can provide scientific and technological knowledge including ICT, R&D and engineering as well as traditional professional services such as advertising, procurement, legal, accounting, management, consulting and marketing. These KIBS companies may therefore provide an avenue for the creation of a knowledge intensive economy.

Knowledge is divided into two types: explicit and tacit (Nonaka *et al*., 1995). Explicit knowledge is codified knowledge that is readily available through written or verbal means and easily transferred. On the other hand, tacit knowledge is non-codified knowledge, is often acquired through experience and is not readily available and easily transferrable. Neo-Schumpeterian and evolutionary economics view innovation as an evolutionary process based on knowledge. Knowledge creation and transfer from the interactions between different economic agents lead to innovation and KIBS firms may play a key role here. Nonaka (1994), Nonaka and Takeuchi (1995) and Nonaka *et al*. (2000) state that knowledge transformation processes can occur within firms and developed a knowledge creation function to illustrate the knowledge creation capabilities of these firms. They showed that the knowledge conversion process involves both explicit and

tacit knowledge. Since knowledge generation and transfer are considered a pre-requisite for successful innovation, innovative activity is related to the generation and transfer of explicit and tacit knowledge. Consequently innovation can be understood as a cycle involving interactions between explicit and tacit knowledge.

In the limited but emerging literature, KIBS firms act as facilitators, carriers and sources of knowledge for client firms (Fischer, 2001, and Hipp, 2000). KIBS companies combine highly specialized explicit and tacit knowledge in order to develop problem-specific solutions and transfer knowledge to their clients, therefore increasing the exchange of otherwise disconnected pockets of knowledge in the national STI system (Windrum and Tomlinson, 1999). Knowledge is generated, diffused and created through the interaction between KIBS firms and their clients. Also, the solutions to specific problems facing client firms can lead to the development of new knowledge (den Hertog, 2002). Further, KIBS firms play an intermediary role in transforming scientific and technical information into tacit knowledge by creating innovative solutions to meet customers' needs. Additionally, it is argued that KIBS firms not only transfer knowledge to clients, but also engage in collaborative learning and can transform clients into learning organizations (Aslesen and Isaksen, 2010).

KIBS firms also act as facilitators, carriers and sources of innovation as they seek to find innovative solutions to suit their clients' needs and play an important role in the innovation process of client firms (den Hertog, 2000; Tether, 2005; Camacho and Rodriguez, 2008; and Naranjo-Valencia *et al*., 2011) and are described in the literature as "bridges to innovation" (Czarnitzki and Spielkamp, 2000). They provide specific and localised solutions to meet the requirements of and solve technological and organizational problems of their customers. They may assist with client innovation by suggesting that they adopt solutions previously developed by other firms or in other sectors. Hence, KIBS companies pool together various types of specialized knowledge to develop problem-specific solutions for their clients, thereby increasing innovation (Miles, 2008). KIBS firms are facilitators of innovations if they support a client in its innovation process, but the innovation does not originate from KIBS firms, nor is it transferred (from other firms) by this KIBS firm to the client firm. They are carriers of innovation if they play a role in transferring existing innovations from one firm or industry to the client firm or industry, even though the innovation does not originate from the KIBS firms. KIBS firms are a source of innovation if they play a major role in initiating and developing innovations in client firms, usually in close interaction with the client firm.

KIBS firms play a critical role in contributing to a country's national STI system by providing technological knowledge diffusion and innovation within the extractive sector and throughout the economy. KIBS firms cooperate with their clients, disseminate and absorb knowledge from numerous sources, process it and pass it on in the most appropriate way to suit their clients' needs. They act as an interface between their clients and knowledge generators such as universities and public and private research institutions and the knowledge base of the entire economy, and may act as a catalyst for countrywide knowledge diffusion and innovation (Castellacci, 2008, and Castaldi, 2009). Hertog and Bilderbeek (1998) view KIBS firms as a type of second knowledge infrastructure which complement and fuse with universities, think tanks and public research institutions that

make up the first or traditional knowledge infrastructure. KIBS firms may therefore act as linkage institutions in the national STI system.

The impact of KIBS companies on knowledge provision and transfer and innovation will depend on the type and intensity of the relationship between the firms that provide the service, users of the service and the national STI system (Muller and Zenker, 2001; and Mas-Verdu, 2007). Hertog and Bilderbeek (1998) conducted an empirical study to investigate the role played by KIBS in the national STI system in the Netherlands. The results show the relevant role of KIBS firms in the Dutch innovation system in aspects like R&D cooperation and use as information sources, at the same level as the public knowledge infrastructure. Tether (2005) in a study of KIBS firms and the national STI system in Britain found that neither KIBS firms nor the public research infrastructure have great importance in terms of participation in formal networks for innovation and in their use as information sources for innovation. However, KIBS companies play a slightly more active role in the national STI system than the public infrastructure for formal and informal networks.

There is limited but growing empirical evidence which suggests that natural resources can foster economic growth and development when accompanied by an increase in technological innovation and accumulation of capabilities to innovate around natural resources, and KIBS firms may play a key role here (Engen, 2009, and Noreng, 2005). In the extractive sector, the development and widespread use of ICT has allowed for traditionally vertically integrated global value chains to be reconfigured and new production paths established based on outsourcing and subcontracting. The demand-pull, together with changes in the production function, has induced the rise of KIBS firms that serve the special demands of large natural resource based companies. In developed, natural resource endowed countries, such as Finland, Norway, Canada and Australia, these KIBS firms satisfy a growing demand for knowledge, new technology and innovation in the extractive sector and serve as "providers of solutions" for technological and organizational problems. They play a critical role in knowledge transfer, innovation and technology diffusion across the extractive sector, other sectors and the national STI system and diversification towards related higher value added goods and services and ensure that forward, backward and horizontal linkages are created with the rest of the economy.

Market failures may hinder the development of KIBS firms in the extractive sector, especially in developing countries, given the complexity and tacitness of knowledge. Innovation requires intense interaction and cooperation between the users (the natural resource firms) and the knowledge providers (the KIBS firms). In this interaction, asymmetric information problems may emerge affecting the matchmaking process and then hindering investment decisions (moral hazard and hold-up). The situation becomes more complex if spillovers are present and the intangible nature of the transaction makes contracting very difficult. Finland, Norway, Canada and Australia have established specific programs to tackle these market failures while such programs are limited in natural resource based developing countries like Latin America and the Caribbean.

3. Methodology and data sources

To explore the role of oil and gas KIBS firms in diversifying the economy away from an extractive to a knowledge intensive sector, the study uses a simple conceptual framework. It analizes the national STI system and several aspects of oil and gas KIBS firms: information sources for innovation, innovation collaboration, innovation activity, product and process innovation; diversification; employment capabilities and human resource development; environment and sustainability. KIBS firms are analyzed as facilitators, sources and carriers of explicit and tacit knowledge and product and process innovation locally and internationally in the oil and gas sector, other sectors and the national STI system. Sources of information used for innovation, innovation activities and innovation collaboration are divided into four categories: internal sources (from within the firm or enterprise group); market sources (customers, suppliers of equipment, materials, components and software, consultants, commercial labs and private R&D institutes, competitors and other market sources); public sector sources (universities/other higher education institutions and government/public research institutes); and other external sources (scientific journal and trade/technical publications, conferences, trade fairs and exhibitions, and professional and industry associations).

The study uses primary and secondary data sources, and case studies. The secondary data used comes from several sources. Firstly, the Energy Chamber of Trinidad and Tobago conducts a quarterly Energy Services Sector Survey of oil and gas service firms in Trinidad and Tobago, which maps their performance and optimism and provides data on business confidence, plans for investment and expansion, employment and training. The Energy Chamber also has a comprehensive listing of firms operating in the oil and gas services sector and their respective market segments in Trinidad and Tobago. General firm information on the year the firm was established, the type of ownership, whether it is export or non-export oriented, the partnerships it has developed, the technology used, and products offered are taken from the websites of various oil and gas service firms. The paper uses data on the number of on-shore and offshore rigs in use from the Ministry of Energy and Energy Affairs' Monthly Consolidated Bulletins as well as information from Trinidad and Tobago's Heritage and Stabilization Fund Reports. General macroeconomic such as GDP, government revenue, exports, employment, oil and gas production and value added are taken form the Central Bank of Trinidad and Tobago. The paper also uses secondary data from various government reports and policy documents. Primary data are collected through a questionnaire with key industry stakeholders. The questionnaire is displayed in the appendix. Lastly, to deepen the analysis the paper also uses various case studies.

4. Trinidad and Tobago's oil and gas industry

4.1. Overview

Trinidad and Tobago's oil and gas industry is over 100 years old and is one of the oldest in the world. The country is the largest oil and gas producer in the Caribbean. It has undertaken extensive exploration activity on-shore and offshore and has a cumulative oil production totaling over 3 billion barrels and has estimated proven oil reserves of 728 million barrels.[1] While Trinidad and Tobago's hydrocarbon sector started off as being oil dominated, by the late 1970s and early 1980s the industry profile was changing from a focus on oil to gas, which then led to the development of the petrochemical sector. During the late 1960s to early 1970s, significant oil discoveries were made off the southeast coast of Trinidad. Oil production then peaked, stimulating further exploration activity, which led to significant natural gas discoveries. Furthermore, the creation of Atlantic LNG in the 1990s for the production and export of LNG further increased the importance of Trinidad and Tobago's gas sector.

The country has a well-developed upstream, midstream and downstream oil and gas sector with KIBS firms operating throughout the value chain. The upstream sector consists of large exploration and production companies, such as bp Trinidad and Tobago, BHP Billiton and the Petroleum Company of Trinidad and Tobago (Petrotrin), together with smaller companies like Venture Trinidad. Petrotrin, which is state owned, is the only company for refining. The midstream sector also has a single player which is state owned, the National Gas Company of Trinidad and Tobago (NGC). National Petroleum (NP) and the United Independent Petroleum Marketing Company Limited (Unipet) operate in the downstream sector and market and distribute petroleum products. Additionally, the downstream petrochemical sector consists of 11 ammonia plants, 7 methanol plants, 1 urea plant, 1 Natural Gas Liquids Processing Facility, 4 Liquefied Natural Gas (LNG) Trains and 1 Ammonia Urea Ammonium Nitrate Melamine Complex. Moreover, the government has plans to further diversify the downstream sector and the Ministry of Energy and Energy Affairs has been in talks with investors for the manufacture of calcium chloride and dimethyl ether.

The country's natural gas processing facility is one of the largest in the Western Hemisphere –the Phoenix Park Gas Processors Limited (PPGPL)– with a processing capacity of almost 2 billion cubic feet per day and an output capacity of 70,000 barrels per day of natural gas liquids (NGL). After processing, the gas is transferred to the various power generation sites for electricity generation and to the various petrochemical plants for use as a feedstock. The electricity sector is fueled entirely by natural gas. Output from the downstream sector is targeted mainly for export. Foreign private capital played an important role in the development of the petrochemical sector as part of a deliberate government strategy, because of the large capital required and access to international markets.[2] The government also entered into a number of joint venture arrangements with varying levels of participation.

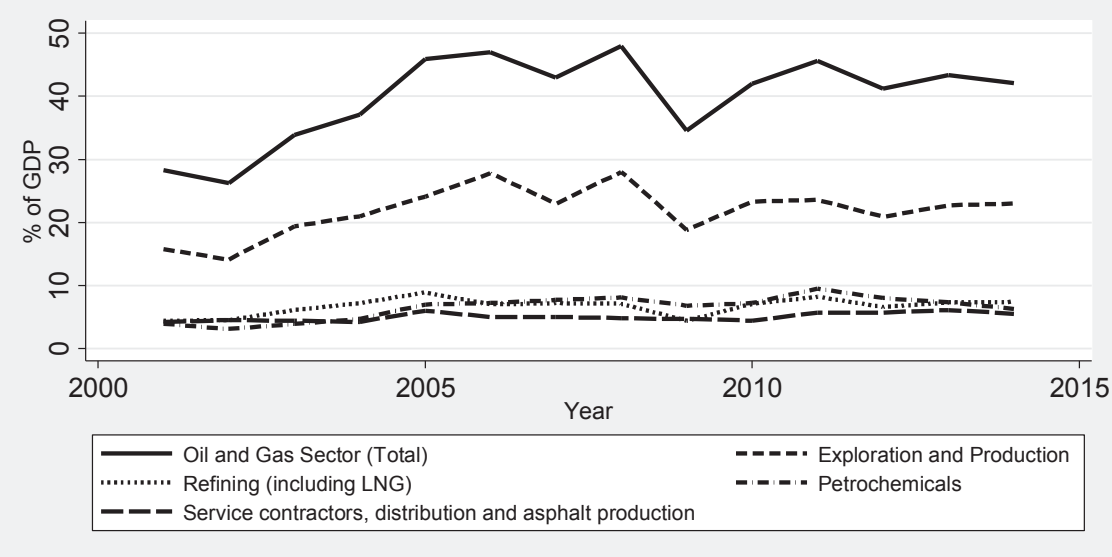
1. http://www.energy.gov.tt/our-business/oil-and-gas-industry/
2. http://www.energy.gov.tt/our-business/lng-petrochemicals/petrochemicals/

Currently, international oil and gas prices are low, most of the country's oil fields are mature and depleted, and local production is on a decline. A number of bid rounds are being carried out in an attempt to increase deep-water exploration. The situation presents numerous opportunities for innovation and diversification in Trinidad and Tobago's oil and gas sector particularly around geological evaluations, seismic survey and enhanced oil recovery operations and for increasing energy services exports.

4.2. Economic contribution

Trinidad and Tobago's oil and gas sector has contributed significantly to the country's GDP growth. Figure 1 shows that the share of GDP from the oil and gas sector increased from 28.3% in 2001 to 42.2% in 2014. The exploration and production sub-sector accounted for the largest contribution to GDP, while refining, petrochemicals and service contractors, distribution and asphalt production, which include oil and gas KIBS firms, played a relatively small role. Nevertheless, there has been some growth in the service contractors, distribution and asphalt production sector from 4% to 5.5% for 2001-2014. More recently, in the period 2011-2014 the oil and gas sector experienced a four year decline in real output. This was mainly because of falling international oil and gas prices along with production stoppages at two large natural gas producers, and a decline in real output in the refining sub-sector because of maintenance work and lower refinery throughput at Petrotrin (CBTT, 2014, Annual Economic Outlook). This consequently resulted in weaker overall GDP growth of negative 1%, despite steady positive growth in the non-energy sector, highlighting the major influence the oil and gas sector has on the overall economy (CBTT, 2014, Annual Economic Outlook).

Figure #1: Economic contribution of the oil and gas sector, share of GDP (%)



Source: Central Bank of Trinidad and Tobago.

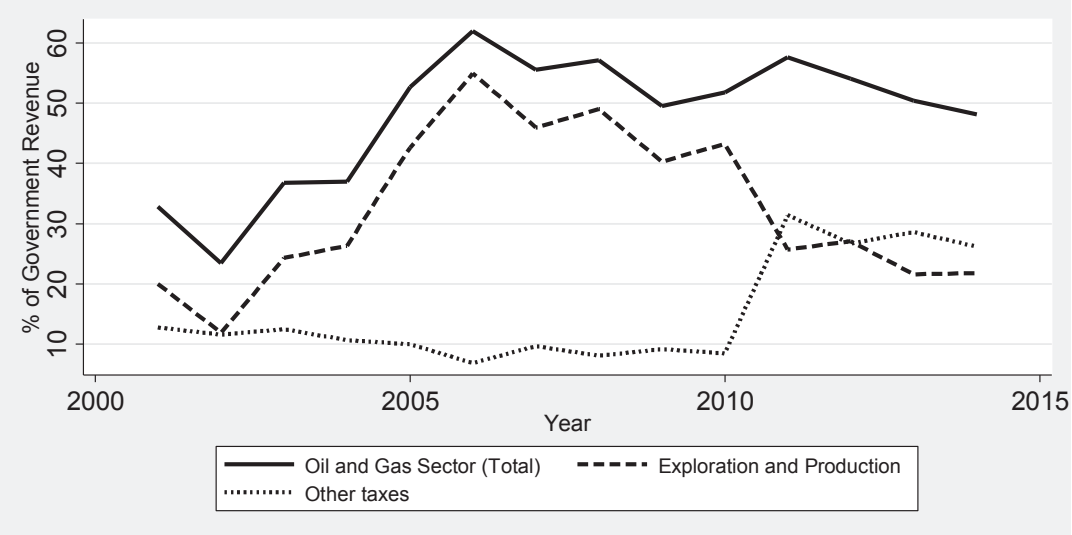
During the four-year decline, however, the service contractors, distribution and asphalt production sector experienced its highest contribution to GDP, of 6.1% since 2001. This may have resulted from the increased maintenance work of the refining sub-sector. During periods of falling oil and gas prices, exploration and production activity may decrease, and firms may take the opportunity for planned maintenance and shutdown, which may translate into increased activity in the oil and gas services sector for rig and plant maintenance and inspection services thereby benefiting KIBS firms which offer these services.

One of the most significant and direct links of Trinidad and Tobago's oil and gas sector to the entire economy is through government revenue, since oil and gas revenues are the largest annual contributors, through taxes and profits from state owned enterprises and joint ventures, and royalties and payments under contractual arrangements, like concessions and production sharing agreements. Figure 2 shows the share of government revenue from the entire oil and gas sector, as well as broken down into exploration and production taxes (refining and gas processing, petrochemicals and service contractors) and other taxes (withholding tax, royalties oil impost, unemployment levy, excise duties and receipts from signature bonuses for the award of production sharing contracts). Since 2001 the share of government revenue from the oil and gas sector has increased from 32.8% to 48.1%, reaching as high as 61.95% in 2006, when oil prices were very high. Exploration and production taxes have been increasing since 2001 until 2010, after which they began to decrease and were offset by an increase in other taxes. Since 2011, international oil and gas prices and local production have been falling and government revenue has been on a continuous decline.

Government revenue from the oil and gas sector in Trinidad and Tobago is used to fund human capital investments in education, health and security, to make work programs, for infrastructural development and to support the development of other sectors. Trinidad and Tobago has also created a sovereign wealth fund –the Heritage and Stabilization Fund– in 2007 to help insulate the economy from oil and gas price fluctuations. An Act of Parliament, the Heritage and Stabilization Fund Act, 2007, established the Fund. The Act states that the purpose of the Fund is to save and invest surplus oil and gas revenues to: 1) cushion the impact or sustain government expenditure during periods of revenue decline because of falling international oil and gas prices; 2) generate an alternate stream of income to support government expenditure because of a fall in revenue caused by the depletion of non-renewable oil and gas resources; and 3) provide a heritage for future generations of Trinidad and Tobago from savings and investment income derived from excess oil and gas revenues. Deposits into the Fund are made when oil and gas revenues exceed expectations. Table 1 shows the valuation of the Fund and contributions since it was set up in 2007. The data are taken from the Heritage and Stabilization Fund Quarterly Reports from the Ministry of Energy and Energy Affairs. As seen in the table, while the valuation of the Fund has been steadily increasing, contributions are highly variable since it is dependent on government revenue, which is influenced by the international oil and gas price and local production.

The recent fall in oil and gas prices along with declining production has had a negative and destabilizing effect on Trinidad and Tobago's fiscal budget. The government had to revise its national budget figures and plan to reduce expenditure by 7% across all ministries and state owned enterprises. The government also used funds from the Heritage and Stabilization fund to make up the shortfall in revenue.

Figure #2: Economic contribution of the oil and gas sector, share of government revenue (%)



Source: Central Bank of Trinidad and Tobago.

Table #1: Heritage and Stabilization Fund valuation and contributions

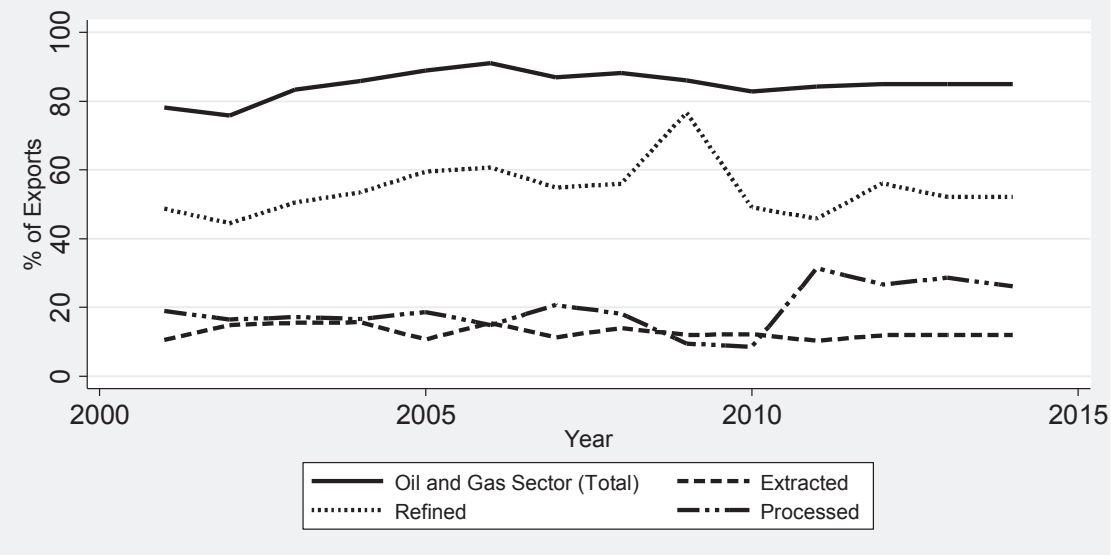
Year	Valuation US million	Contributions US million
2007	1.766	322
2008	2.888	1.054
2009	2.965	-
2010	3.622	477
2011	4.084	451
2012	4.712	208
2013	5.154	42
2014	5.533	-

Source: Ministry of Energy and Energy Affairs.

Trinidad and Tobago's oil and gas industry contributes tremendously to exports. Figure 3 shows that the share of the oil and gas sector to the country's total merchandise exports has been increasing from 2001 to 2014, from 78.2% to 85%, with a high of 91.1% in 2006, given the high oil and gas prices at the time. Additionally, Table 4 shows that within this period exports have remained constant since the fall in international oil and gas prices and local production from 2011. The table also shows oil and gas exports broken down by extracted exports (crude oil); refined exports (petroleum, liquefied natural gas and natural gas liquids); and processed exports (all other oil and gas related exports such as petrochemicals). Refined exports make up the largest contribution of oil and gas merchandise exports, followed by processed exports and then petrochemical exports. Figure 3 also shows that the contribution of all three sub-sectors has been increasing since 2001; although from 2011 extracted exports have remained constant, and refined and processed exports have fallen. Data on energy services exports is not available. The Energy Chamber of Trinidad and

Tobago, however, approximates that there are 20-30 local companies which export energy services regionally and internationally (Trinidad and Tobago Energy Chamber, 2009).

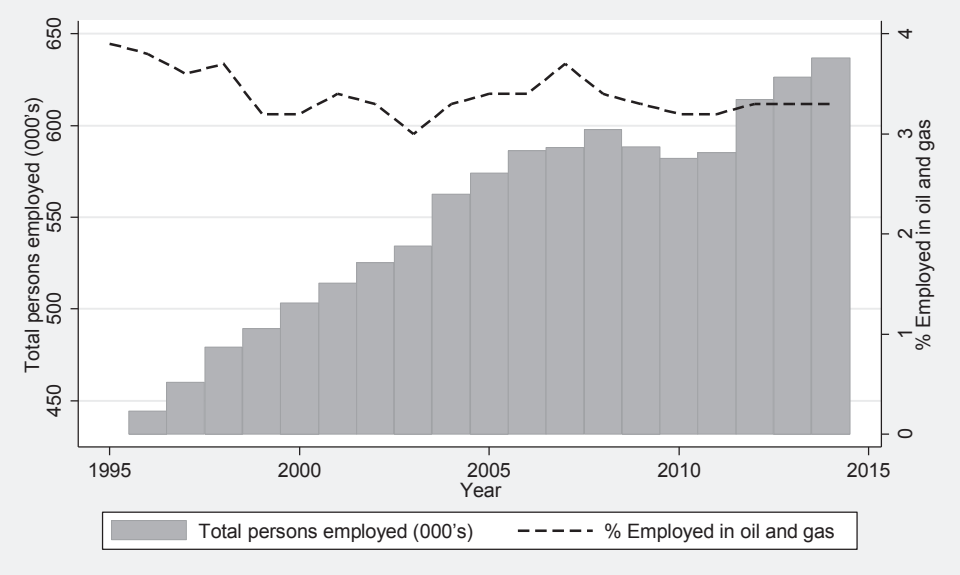
Figure #3: Economic contribution of the oil and gas sector, share of merchandise export receipt (%)



Source: Central Bank of Trinidad and Tobago.

Trinidad and Tobago's oil and gas sector contributes little to direct employment since the sector is generally capital intensive with limited opportunities for permanent employment. Figure 4 shows that the average employment in the oil and gas sector is about 3.5% of total persons employed. Since 2011 employment in the sector has remained constant at 3.3%. The capital-intensive nature of the oil and gas sector is unlikely to change in the future. Hence, the country's main economic sector is not its main employer. Nevertheless, while the oil and gas sector only accounts for around 3.5% of total employment, the oil and gas services sector is said to be a major employer within the oil and gas sector and the Energy Chamber of Trinidad and Tobago estimates that it employs about one third of all oil and gas sector workers (The Energy Chamber of Trinidad and Tobago, 2009). Also, the majority of workers in the oil and gas services sector are highly skilled nationals of Trinidad and Tobago, working in both local and foreign companies (The Energy Chamber of Trinidad and Tobago, 2009). Data on employment in the oil and gas services sector is not available.

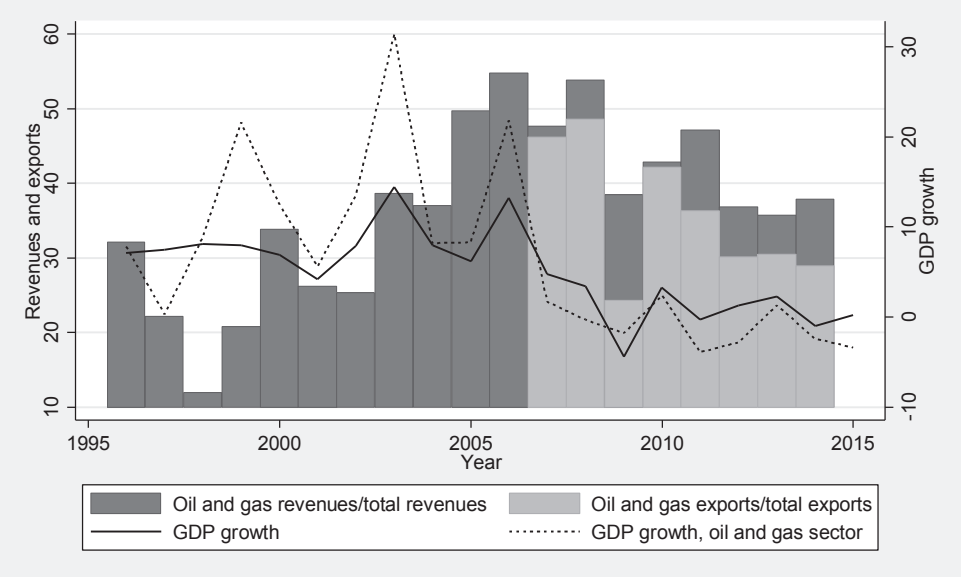
Figure #4: Employment



Source: Central Bank of Trinidad and Tobago.

As seen above, the oil and gas industry in Trinidad and Tobago makes important contributions to GDP, government revenue and exports. Figure 5 shows the relationship among these variables. The solid line represents real GDP growth and the dotted line shows real GDP growth by the oil and gas sector, while the dark bars show oil and gas government revenue as a percent of total government revenue and the light bars show oil and gas exports as a percent of total exports. The country's overall GDP growth is heavily influenced by growth in the oil and gas sector. As seen in Figure 5, the country's real GDP growth closely follows GDP growth in the oil and gas sector. Moreover, since 2006 real GDP growth and GDP growth in the oil and gas sector has been declining. The figure also illustrates that when growth in the oil and gas sector is high, the share of government revenue and exports from oil and gas increases, while a low growth rate is associated with low revenue and exports and since 2006 both have been declining. The figure therefore suggests that the oil and gas sector plays an important role in the national economy and what happens in the oil and gas sector may affect other aspects of the economy.

Figure #5: GDP growth, government revenue and exports



Source: Central Bank of Trinidad and Tobago.

4.3. Trinidad and Tobago oil and gas KIBS firms

Trinidad and Tobago's oil and gas KIBS firms offer technical services to the oil and gas sector, locally, regionally and internationally, along the entire oil and gas value chain. Exploration and production companies do not typically complete all the tasks in the oil and gas value chain themselves since they are difficult and costly and involve the use of highly specialized knowledge, skills, equipment and technology. On other hand, oil and gas KIBS firms offer technical and professional services and provide specialized equipment to exploration and production companies, but do not typically engage in the production of oil and gas. These services aim to improve operational efficiency and minimize the risk of oil and gas exploration of production companies, thereby saving them time and money. Trinidad and Tobago oil and gas KIBS firms may therefore act as facilitators, carriers and sources of knowledge and innovation along the entire oil and gas value chain and engage in local, regional and international knowledge spillovers.

While Trinidad and Tobago's oil and gas industry is over 100 years old and always required energy services, in 1989 the government first introduced the lease operatorship and farm out program. The aim was for oil and gas services to be contracted out to local firms thereby reducing the operating cost of exploration and production companies and making uneconomic wells and blocks economic once more. This led to a mushrooming of local oil and gas KIBS firms.

Trinidad and Tobago, in further developing its oil and gas services sector in 2004, implemented the "Local Content Strategy for the Energy Sector", where local content includes ownership, control, decision making and preferential access to finance by citizens

of the country. The local content strategy focused on: 1) local capability development (international exploration and production companies are required to contract local service providers so that they are given the opportunity to work, learn and acquire knowledge); 2) education and training (support to universities, establishment of specialized learning and training centres and the design of appropriate academic curricula); and 3) diversification and new business creation (to develop the capacity to supply local industry needs and create new export opportunities). Moreover, according to the local content policy, oil and gas exploration and production companies should give preference to local KIBS firms that are qualified and meet quality, cost and schedule requirements and should monitor local content and the cost of local materials, labor and services. Production sharing contracts should also include requirements for local content to match the capability of local KIBS firms and to ensure that seismic activity is undertaken locally and that there is transfer of technology and expertise.

While Trinidad and Tobago's local content policy has played a useful role in the development of domestic KIBS firms, there are several shortcomings of the policy, which if addressed may allow for further development of these local firms. There is currently no institution responsible for the coordination and implementation of the local content policy and to ensure compliance. The setting up of a Permanent Local Content Committee was proposed but never implemented. Additionally, the government planned to establish a database on the status of projects and opportunities to help oil and gas exploration and production companies find local KIBS firms but this has not taken place. The local content policy also lacks the legislative provisions to ensure compliance and dedicated resources to monitor implementation and measure targets (Tomas *et al*., 2012).

In 2004 the government also proposed the establishment of the Centre for Energy Enterprise Development (CEED) to increase local participation in value added oil and gas projects, increase the depth and scope of the local industry, develop business skills and competencies in small and medium enterprises (SMEs), boost innovation and new thinking, help entrepreneurs enter niche markets and the creation and support of clusters with other industries that have natural synergies with the oil and gas sector to increase diversification. However, a Centre for Enterprise Development (CED) was eventually launched, which is not limited to the oil and gas sector only, but instead focuses on building capacity and capability for enterprise creation from idea to market in all sectors. As such it provides accommodation and technical and business advisory support services to persons or firms with innovative ideas wishing to take these through from incubation to commercialization. This may hinder oil and gas KIBS firms from achieving their full potential given the lack of support tailored to meet the needs of the industry.

Trinidad and Tobago oil and gas services sector consists of approximately 300-400 KIBS firms (The Energy Chamber of Trinidad and Tobago, 2009). These firms are well established, are mainly SMEs and are privately owned family run companies, although some are subsidiaries of major conglomerates. There are also large multinational corporations operating in Trinidad and Tobago including Baker Hughes, Schlumberger, Halliburton and Weatherford. Local oil and gas KIBS firms initially competed against these international firms without any trade barriers, however in 2004 government support came about with the development of the local content policy. The initial exposure to competition followed by government

support may have positively contributed to the competitiveness of local KIBS firms and their development of export capabilities (The Energy Chamber of Trinidad and Tobago, 2009).

While most of the local oil and gas KIBS firms primarily serve the local market, there is a core group of local firms that export energy services. There are also local oil and gas KIBS firms that have set up business operations outside of Trinidad and Tobago. The Energy Chamber approximates that there are approximately 20-30 local KIBS firms, which have achieved fairly good economies of scale and have been successful at exporting energy services (The Energy Chamber of Trinidad and Tobago, 2009). These companies export their services and operate in the Caribbean and Latin America, including Barbados, Jamaica, Suriname, Guyana, Cuba, Aruba, Venezuela, Columbia, Belize and Brazil, as well as outside the region in Canada, the US, Ghana, Indonesia, Bahrain, Dubai, Vietnam and Uganda. The export market presents significant opportunity for oil and gas KIBS firms since the international market for energy services is huge and growing and its estimated worth is approximately US$ 100 billion (Standard and Poor's, 2013).

Tucker Energy Services is perhaps the most successful oil and gas KIBS firm to conduct business outside of Trinidad and Tobago. The company operates globally, outside of Trinidad and Tobago, in Venezuela, Belize, Brazil, Colombia, Suriname, Canada and the US, and is headquartered in Houston, Texas. As part of its innovation strategy, the firm sought out and exploited niche geographic markets where its competitors did not excel or did not wish to operate. Massy Energy and Industrial Gases is another local company, which exports throughout the Caribbean and some parts of Latin America and has also set up sub-divisions outside of Trinidad and Tobago. These include Massy Gas Products Jamaica, Massy Gas Products Guyana, Massy Energy Colombia SAS and Massy-Kersten in Suriname.

The Energy Chamber of Trinidad and Tobago states that one of its members earned US$ 253 thousand by providing training services to East Africa, while another earned US$ 7 million for the export of pipe recovery, production logging and stimulation services. There is therefore significant potential to increase exports of energy services by domestic KIBS firms, particularly since Trinidad and Tobago has developed a global reputation in the oil and gas services sector, especially in services around drilling exploration and development wells (The Energy Chamber of Trinidad and Tobago, 2009). Other oil and gas services the country has expertise in but has yet to penetrate global markets are construction, port development, rig positioning, logistics, inspection, pipeline and subsea services (The Energy Chamber of Trinidad and Tobago, 2009).

The Energy Chamber of Trinidad and Tobago has been actively promoting the export of oil and gas services and has undertaken Energy Services Trade Missions to Guyana and Suriname (October-November 2007), Cuba (November 2008), West Africa (June 2009) and Ghana (March 2015). Local KIBS firms subsequently began operations in these foreign markets. This also resulted in the Energy Chamber assisting a Surinamese company to enter the Trinidad and Tobago market to provide heavy equipment maintenance services. In terms of government support for energy services exports, the government established the National Export Facilitation Organization of Trinidad and Tobago (exportTT Ltd.). Its mandate is, however, not focused specifically on energy services, but on increasing exports across all sectors. This may prevent the oil and gas services sector from developing its true export potential.

Growth in the oil and gas services sector is dependent upon having a constant stream of projects such as exploration, drilling, maintenance and construction of plants. Whenever there is a slowdown in energy projects, growth in the services sector is limited or may even decrease. The recent fall in oil and gas prices and reduced local production, have led to a fall in the demand for oil and gas services. Knowledge of when oil and gas exploration and production companies plan new drilling campaigns and knowledge on future drilling trends of the industry, as well as coordinated plant shut down and maintenance, are therefore very important for oil and gas KIBS firms to plan future operations and allocate resources accordingly.

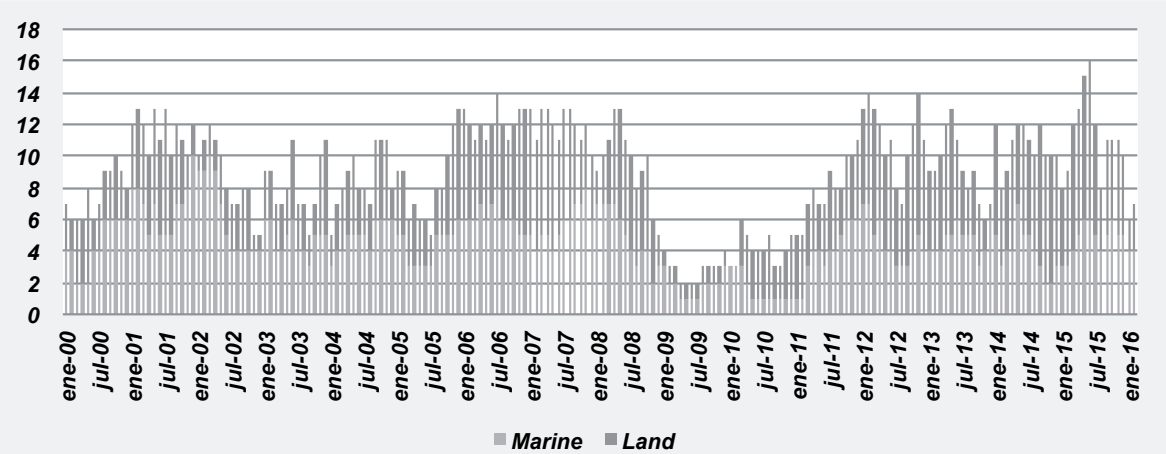
Coordinated plant shut down and maintenance drives the demand for oil and gas services in the downstream oil and gas sector and can act as a proxy for activity in this area. However, this data is not available. On the other hand, a good proxy for the demand for upstream oil and gas services is the country's rig rate, which is the number of drilling rigs currently exploring for oil or gas and this data is available from the Ministry of Energy and Energy Affairs in its Consolidated Monthly Bulletins. It must be noted that off-shore rigs require a much higher level of services than on-shore rigs and is the main source of income for international oil and gas KIBS firms and the larger local oil and gas KIBS firms. Offshore drilling rigs require significant skills and expertise, capital-intensive equipment, supply boats and an efficient on-shore base. An off-shore exploration well will typically cost approximately US$ 80-100 million to drill, so each well represents a significant market for oil and gas KIBS firms which supply the required services (The Energy Chamber of Trinidad and Tobago, 2009). Also, the Energy Chamber estimates that an offshore rig operating in Trinidad and Tobago has daily operating rates of approximately US$ 200-400 thousand (The Energy Chamber of Trinidad and Tobago, 2009).

Given the high costs involved, oil and gas exploration and production companies place great emphasis on ensuring efficient use of off-shore rigs and the elimination of down-time and logistics around the supply of goods and staff. Successful oil and gas KIBS firms must therefore be highly efficient in supplying these services. On the other hand, on-shore drilling typically requires fewer services by oil and gas KIBS firms. Although, on-shore seismic data acquisition can be much more time consuming and labor intensive than offshore seismic data acquisition. Also, for remote onshore sites there may be problems with moving a rig to the drilling location that may require new infrastructure.

As seen in Figure 6, the on-shore rig rate for Trinidad and Tobago is much higher than the offshore rig rate, meaning that a larger number of on-shore rigs than offshore rigs are in operation at any given time. Also, seen in Figure 6 is that the rig rate in Trinidad and Tobago is highly variable over time, indicating that the demand for oil and gas exploration and development services is highly variable. International oil and gas KIBS firms operating in Trinidad and Tobago cope with this variability by moving workers and resources to other countries where there is an increased demand for oil and gas services. These companies are truly global and operate in over 80 countries. On the other hand, local oil and gas KIBS firms face severe challenges and must find a way to survive. Most of these firms undergo re-structuring and cut backs in operations and staff when the local rig rate is low. In Trinidad and Tobago's oil and gas sector downturn of the late 1980s many local oil and gas KIBS firms closed down and others had to significantly reduce their

activity. Local firms that survived experienced significant growth thereafter. These firms invested in quality assurance and health and safety systems to be able to secure work with multinationals operating offshore and became successful exporters doing business abroad with the same multinationals they do business with in Trinidad and Tobago.

Figure #6: Offshore and On-shore Rig Use



Source: Ministry of Energy and Energy Affairs.

Apart from variability in the demand for energy services, Trinidad and Tobago's oil and gas KIBS firms face several other obstacles. The Energy Service Sector Survey conducted quarterly by the Energy Chamber of Trinidad and Tobago collects data on obstacles facing oil and gas KIBS firms. The survey asks these firms to indicate what factors are likely to limit their ability to increase their level of business in the next 12 months. Local oil and gas KIBS firms have identified the level of international competition and a bias towards multinational corporations, ineffective local content policy, access to finance and the level of demand and the availability of technical and professional staff as key obstacles they face in growing and developing the industry. According to the Energy Chamber of Trinidad and Tobago, funding is a problem for local oil and gas KIBS firms as local banks do not understand the sector and are unable to assess risk and develop appropriate financial instruments. Further, in general funding is more difficult for service firms given the large amount of intangible assets, which are difficult to cost. Also, local oil and gas KIBS firms provide engineering and construction services to large multinational firms. These local sub-contractors are sometimes not fully paid for work they have completed when there are problems with projects due to the fault of the multinational corporation because of costs overruns and time delays. Costs prevent these local KIBS firms from pursuing legal action in the international courts. According to the Energy Chamber of Trinidad and Tobago there has been a number of occasions when this type of situation has occurred and although the Chamber has initiated discussions on the issue there has been no agreed industry or government plan to overcome the problem.

5. Innovation, productivity and diversification

5.1. Oil and gas KIBS firms and the national STI system

A country's national STI system is a collection of public and private institutions and mechanisms, including oil and gas KIBS firms, that interact to stimulate and support knowledge sharing and innovation within the national economy, where the partnership between government, universities, the private sector and other institutions is fundamental for success. The government of Trinidad and Tobago is of the view that it is necessary and important to develop its national STI system. The Vision 2020 sub-committee on Science, Technology and Innovation of Trinidad and Tobago in 2005 produced a report on the country's national STI system (NIHERST, 2006). According to the report, Trinidad and Tobago since its independence has been steadily building its institutional capacity for the supply of knowledge and a number of STI based institutions have been created and supported by the government.[3] These institutions can be viewed as the public knowledge base of the economy and include tertiary level education and institutes, vocational training institutions and government agencies responsible for R&D, innovation, SME development and environmental protection and preservation.

On the other hand, the report found that there is not enough initiative in stimulating the demand for knowledge in Trinidad and Tobago. Incentives and policies linked to technology development and transfer and building the absorptive capacity of firms and competitiveness must therefore be set up to stimulate knowledge demand. Additionally, the report stated that work needs to be done in creating the necessary linkages and interactions between actors to allow for knowledge sharing and knowledge spillovers. In terms of oil and gas services, the report identified 9 specific R&D priorities for the oil and gas sector, but does not specifically identify energy services as a priority except broadly under upstream offshore services, upstream fabrication and design engineering.[4]

Following this, in 2011 the government created the Medium-Term Policy Framework and identified a knowledge intensive sector as key in Trinidad and Tobago's diversification thrust. As a result of this, the National Institute for Higher Education, Research, Science and Technology (NIHERST) was tasked with developing a National Policy on Science, Technology and Innovation in accordance with government's development strategy. Also, the Council for Competitiveness and Innovation (CCI) was established by the government

3. These institutions include the University of the West Indies (UWI), the University of Trinidad and Tobago (UTT), College of Science, Technology and Applied Arts of Trinidad and Tobago (COSTAATT), the Caribbean Industrial Research Institute (CARIRI), Trinidad and Tobago Bureau of Standards (TTBS), the Caribbean Agricultural Research and Development Institute (CARDI), the Institute of Marine Affairs (IMA), the National Institute for Higher Education, Research, Science and Technology (NIHERST), the Tourism Development company Limited (TIDCO), the Small Business Development Company (SBDC) and the Environmental Management Authority (EMA).

4.The 9 oil and gas R&D priorities are: 1) Value-added oil and gas-based activities such as expanded refining activities and more complex petrochemical synthesizing processes (ethylene, gas-to-liquids and methanol-to-olefins); 2) New approaches to downstream value-added activities; 3) Replacing obsolete plant and equipment to maintain international competitiveness; 4) Global technological change and its impact on exploration and production, refining, and gas-based industrial development; 5) Deepening the reach of industries into new, more complex and different areas, such as upstream offshore services, upstream fabrication, and design engineering, both upstream and downstream; 6) Increasing the overall benefits that accrue to the nation through enhancing the role of domestic capital in the sector, labour, the application of appropriate technology and local institutional capacity; 7) Sustaining a competitive world-class energy sector with deeper, broader, and more complex and environmentally responsible industries; 8) Increasing the share of benefits accruing to the country from the value chain through strengthening of the direct and indirect linkages between the energy sector and the rest of the economy; and 9) Electricity as an industrial input and the potential spin-off of industrial and commercial activities, including e-commerce and ICT.

in early 2011 as an advisory board to the Ministry of Planning and Sustainable Development and is responsible for improving the country's global competitiveness ranking and increasing innovation as key drivers of a diversified knowledge-based economy. The Council is expected to develop and implement a comprehensive competitive innovation policy that will transform the economy and improve its global competitiveness and innovation rank over a ten-year period. There is currently no institution set up for stimulating knowledge creation and spillovers and innovation in the oil and gas sector.

5.2. Oil and gas KIBS firms as facilitators, carriers and sources of knowledge and innovation

This section provides empirical evidence on Trinidad and Tobago's oil and gas KIBS firms as facilitators, carriers and sources of knowledge and innovation in developing a knowledge intensive cluster of goods and service suppliers in Trinidad and Tobago and other countries regionally and internationally in which they operate. In doing so, oil and gas KIBS firms may act as facilitators, sources and carriers of knowledge within Trinidad and Tobago's national STI system. It presents results from the primary data collected from oil and gas KIBS firms in their role as facilitators, carriers and sources of knowledge and innovation. The section also presents the case studies of Sadhna Petroleum Services Company, which has operations regionally, and Tucker Energy Services, which has operations internationally, in order to obtain a deeper analysis of oil and gas KIBS firms in their role as facilitators, carriers and sources of knowledge and innovation regionally and internationally.

The sample of firms for the study was identified from a list of 200 oil and gas KIBS firms, which are registered with the Energy Chamber of Trinidad and Tobago and therefore formed our statistical frame. A sample of 56 oil and gas KIBS firms responded to our questionnaire on innovation, productivity and diversification, 17 firms declined participation and no response was obtained from the remaining 127 companies. Using the data collected we analyze the role of oil and gas KIBS firms from two points of view: 1) as facilitators, sources and carriers of knowledge and consequently bridges for innovation by analyzing their use of information sources and their co-operation on innovation with other firms and organizations and; 2) as innovators, that is, as agents of product and process innovation.

The survey asked a question on the 'sources of information used for innovation', which gives an indication of the extent to which KIBS firms are facilitators, carriers and sources of explicit and tacit knowledge based on their interactions between different economic agents that may then lead to innovation. The question asked the KIBS firms surveyed about 11 sources of information used for innovation, including sources internal to the firm, market sources, public sector sources and other external sources. More specifically, the question was "does your firm use any of the following information sources for innovation activities: 1) within the firm enterprise or enterprise group; 2) suppliers of equipment, materials, components, or software; 3) clients or

customers; 4) competitors or other enterprises in the sector; 5) other market sources; 6) consultants, commercial labs, or private R&D institutes; 7) universities or other higher education institutions; 8) government or public research institutes; 9) conferences, trade fairs, exhibitions; 10) scientific journals and trade or technical publications; and 11) professional and industry associations?"

A descriptive analysis of the results is shown in Table 2 for all firms surveyed and for the subset of firms that introduced at least one product and/or process innovation in the last 5 years. The data shows that market and other external information sources were most widely used by KIBS firms for innovation, followed by sources internal to the firm, while public sector sources which are dedicated to the production of knowledge were the least used sources of information for innovation for all firms surveyed as well as for the sub-set of innovators. Of all respondents, 82% of firms used information from conferences, trade fairs and exhibitions; 79% used information from professional and industry associations; 77% used clients or customers; 68% used suppliers of equipment, materials, components, software; 66% used market sources; 64% used scientific journal and trade or technical publications; 61% used competitors or other enterprises in the sector; 57% used within the firm enterprise or enterprise group; 48% used consultants, commercial labs, private R&D institutes; 34% used government or public research institutes; and 30% used universities or other higher education institutions.

In terms of innovative firms only, as seen in Table 2, conferences, trade fairs and exhibitions were the most widely used source of information (87% for product innovators and 89% for process innovators). Professional and industry associations were the second most widely used source of information for innovative firms (81% for product innovators and 87% for process innovators), followed by suppliers of equipment, materials, components and software (72% for product innovators and 79% for process innovators) and clients or customers (72% for product innovators and 76% for process innovators). 64% of product innovators and 66% of process innovators used scientific journal and trade or technical publications. 62% of product innovators and 61% of process innovators used information from competitors or other enterprises in the sector. 60% of product innovators and 63% of process innovators utilized internal sources of information from within the firm or enterprise group. 49% of product innovators and 53% of process innovators used information from consultants, commercial labs and private R&D institutes. In contrast, universities or other higher education institutes and government or public research institutes dedicated to the provision of knowledge were the least used sources of information for innovation. Universities were used by 32% of product and process innovators, and 34% of product innovators and 37% of process innovators used government or public research institutes.

The wide use of market and other external sources of information suggest that oil and gas KIBS firms in Trinidad and Tobago act mainly as carriers of knowledge for innovation from these sources. However, oil and gas KIBS firms are least likely to be carriers of information from universities and other public sector sources. Additionally, the extensive use of professional and industry associations as sources of information indicate that oil and gas KIBS firms act as facilitators of knowledge sharing for innovation. Lastly, there was some use of information from internal sources, suggesting that oil and gas KIBS firms are sources of knowledge for innovation.

Since all firms may not be successful in introducing a product or process innovation but may still engage in innovative activity, we look at innovative activity and information sources used. The data again shows that market and other external sources of information were the most frequently used sources of information followed by internal sources, while public sectors sources were least used. As shown in Table 3, all firms that have a dedicated innovation or R&D budget used internal, market and other external sources of knowledge, while 86% used public sources. All firms that have a dedicated full-time leader for innovation projects used market and other external sources of information, while 94% used internal sources and 72% used public sources. For firms with a formal innovation strategy, 90% used internal sources, 95% used market sources, 71% used public sources and 95% used other external sources. All firms with a formal structure or process for innovation used market and other external sources of information, 90% used internal sources and 70% used public sources. All firms with a department or a group of persons dedicated to innovative activity used market sources and other external sources, 80% used internal sources of information and 70% used public sources. For firms that successfully filed patents/trademark/industrial design/copyright registration in the last 3 years all firms used market and other external sources, 83% used internal sources and 67% used public sources.

Table #2: Sources of information used for innovation activities

Information source	All respondents	Innovators	
	(%)	Product (%)	Process (%)
Internal sources			
Within the firm enterprise or enterprise group	57	60	63
Market sources			
Clients or customers	77	83	82
Suppliers of equipment, materials, components, software	68	72	79
Consultants, commercial labs, private R&D institutes	48	49	53
Competitors or other enterprises in the sector	61	62	61
Other market sources	66	72	76
Public sector sources/public science base			
Universities or other higher education institutions	30	32	32
Government or public research institutes	34	34	37
Other external sources			
Scientific journal and trade or technical publications	64	64	66
Conferences, trade fairs and exhibitions	82	87	89
Professional and industry associations	79	81	87

Source: Authors' compilation based on survey data collected.

Table #3: Engagement in innovation activities and source of information for innovation

Innovation activity	Internal (%)	Market (%)	Public (%)	Other external (%)
Firm has a formal innovation strategy	90	95	71	95
Firm has a formal structure or process for making innovation happen	90	100	70	100
Firm has a department or a group of persons dedicated to innovative activity	80	100	70	100
Firm has a dedicated full-time leader for innovation projects	94	100	72	100
Firm have a dedicated innovation or R&D budget	100	100	86	100
Firm successfully file patents/trademark/ industrial design/copyright registration in last 3 years	83	100	67	100

Source: Authors' compilation based on survey data collected.

The question on engaging in innovation co-operation gives an indication on the extent to which oil and gas KIBS firms act as facilitators and carriers of innovation. The question asks "did your firm co-operate on any of your innovation activities with the following institutions: 1) other enterprises within your enterprise group; 2) suppliers of equipment, materials, components or software; 3) clients or customers; 4) competitors or other enterprises in your sector; 5) consultants, commercial labs, or private R&D institutes; 6) universities or other higher education institutions; and 7) government or public research institutes?" In the survey innovation co-operation is defined as active participation with other enterprises or non-commercial institutions on innovation activities where both partners do not need to commercially benefit but exclude pure contracting out of work with no active co-operation.

Table 4 gives the descriptive analysis of the total number of firms surveyed and for the sub-set of product and process innovators. From the table clients or customers (55%) were the most used partner for innovation collaboration from all respondents, followed by government or public research institutions (48%) and suppliers of equipment, materials, components or software (43%). The least used partners for co-operation on innovation for all respondents were competitors or other enterprises in the sector (13%), followed by universities or other higher education institutions (20%), other enterprises within the firm's enterprise group (21%) and consultants, commercial labs, or private R&D institutes (27%).

Among innovators a similar pattern holds for both product and process innovators. For product innovators the most widely used innovation partner was clients or customers (66%) followed by suppliers of equipment, materials, components or software (51%). On the other hand, the least used innovation partners were competitors or other enterprises in the sector (15%), universities or other higher education institutions (23%) and other enterprises within the firm's enterprise group (26%). For process innovators the most

used innovation partners were clients or customers (74%), followed by suppliers of equipment, materials, components or software (58%). While the least used innovation collaborators were competitors or other enterprises in the sector (16%) and universities or other higher education institutions (24%).

Table #4: Firms engaging in collaborative arrangements for innovation

Innovation partner	All respondents (%)	Successful innovators	
		Product (%)	Process (%)
Other enterprises within the firm's enterprise group	21	26	29
Suppliers of equipment, materials, components or software	43	51	58
Clients or customers	55	66	74
Competitors or other enterprises in the sector	13	15	16
Consultants, commercial labs, or private R&D institutes	27	32	37
Universities or other higher education institutions	20	23	24
Government or public research institutes	48	30	29

Source: Authors' compilation based on survey data collected.

Based on the data presented above, Trinidad and Tobago's public knowledge institutions, which are responsible for knowledge production and spillover, play a smaller role than private institutions in knowledge sharing and innovation co-operation in the oil and gas services sector. Instead, oil and gas KIBS firms operating in Trinidad and Tobago generally rely on clients, suppliers, consultants, commercial labs, private R&D institutes, professional and industry associations, journals, conferences and even competitors for knowledge sharing and innovation co-operation.

The question on introducing a product or process innovation in the past 5 years gives an indication as to the extent of which oil and gas KIBS firms are sources of innovation. From the data collected, 84% of firms were product innovators as they indicated that they introduced a new or significantly improved good or service in the last 5 years (shown in Table 5). The majority of these products were successful since only 1 firm indicated that the new or improved good or service failed. Furthermore, most of these product innovations are new to the market; 68% of product innovators stated that they provide products that have not been demanded before and 85% of product innovators indicated that the innovation increased the number of products offered as opposed to improving an existing product. However, the majority of the product innovations came from external knowledge sources rather than internally. 67% of the firms that introduced a product innovation imported the technology rather than created it internally, and 64% of product innovators used a licensed technology.

Based on our survey results, the product innovation seems in general to have positively impacted firm performance. 89% of the firms that successfully introduced a new or improved product saw an increase in sales, 91% of the firms found an increase in the

quality of the products offered, 77% of the firms had an increase in the number of new customers and 22% of the firms had an increase in exports. The product innovations also positively impacted productivity as 67% of firms that successfully introduced a product innovation stated that it reduced the average cost of production.

From Table 5 it can be seen that 68% of firms introduced a process innovation. The higher presence of product versus process innovation is characteristic of the services sector. In terms of individual process innovations: 38% of firms in the sample introduced new or significantly improved methods of manufacturing or producing goods and services; 46% of firms introduced new or significantly improved logistics, marketing, delivery or distribution method for inputs or goods and services; and 57% of firms introduced new or significantly improved supporting activities for processes, such as maintenance systems or operations for purchasing, accounting and computing. Based on the survey results these process innovations have generally not resulted in improved firm performance. 73% of process innovators stated that their innovation did not result in a reduction in labor cost per unit of output and 72% of process innovators were of the view that the innovation did not reduce input materials and energy per unit of output. These process innovations were perhaps more a matter of necessity as 81% of process innovators stated that their innovation met regulatory requirements. On the other hand, 61% of process innovators reported that their process innovation reduced environmental impacts and/or improved health and safety effects.

Table #5: Firm innovation

Innovation/Innovative activity	% of firms
Product innovation	
Introduced a new or significantly improved product in the past 5 years	84
Product innovation evaluation	
Product innovation not demanded before	68
Product innovation increased the number of products offered	85
Product innovation used imported technology	67
Product innovation used a licensed technology	64
Product innovation increased sales	89
Product innovation increased quality of products offered	91
Product innovation increased number of new customers	77
Product innovation increased exports	22
Product innovation reduced average cost of production	67
Process innovation	
Introduced a new or significantly improves process in the past 5 years	68
Introduced new or significantly improved method of manufacturing or producing goods and services	38
Introduced new or significantly improved logistics, marketing, delivery or distribution methods for inputs or goods and services	46
Introduced new or significantly improved supporting activities for processes, such as maintenance systems or operations for purchasing, accounting and computing	57
Process innovation evaluation	
Process innovation did not result in a reduction in labor cost per unit of output	73
Process innovation did not reduce input materials and energy per unit of output	72
Process innovation met regulatory requirements	81
Process innovation reduced environmental impacts and/or improved health and safety effects	61

Innovative activity	
Firm has a formal innovation strategy	38
Firm has a formal structure or process for making innovation happen	36
Firm has a department or a group of persons dedicated to innovative activity	36
Firm has a dedicated full-time leader for innovation projects	32
Firm have a dedicated innovation or R&D budget	13
Firm successfully file patents/trademark/industrial design/copyright registration in last 3 years	11

Source: Authors' compilation based on survey data collected.

A much lower percent of firms engage in innovative activity which brings about internal knowledge creation and innovation compared to the percent of firms that introduced product and process innovation which came mainly from external sources are were introduced mainly to meet regulatory requirements. Table 5 shows that 38% of all firms surveyed have a formal innovation strategy; 36% of all firms have a formal structure or process for making innovation happen and have a department or a group of persons dedicated to innovative activity; 32% of all firms have a dedicated full-time leader for innovation projects; 13% of all firms have a dedicated innovation or R&D budget and 11% of all firms successfully filed patents/trademark/industrial design/copyright registration in last 3 years.

We examine innovation and various firm characteristics shown in Table 6. This would be useful to learn whether there are differences in product and process innovation patterns across varying firm characteristics. Firstly, product innovation is examined. For foreign versus local firm ownership, of the 47 firms that introduced a product innovation 81% are locally owned, 6% are foreign owned and 13% have mixed foreign and local ownership. Further, 32% of product innovators are part of a larger organization. Of the 17 firms surveyed, which were part of a larger organization, 15 had a product innovation. 55% of firms that introduced a new or significantly improved product are exporters. For firm size we defined four categories measured by the number of employees: micro (≤ 10 employees), small (11-50 employees), medium (51-200 employees) and large (> 200 employees). 22% of the firms that had a product innovation are micro firms, 37% are small, 28% are medium and 13% are large. It must be noted that 6 large firms were surveyed in the study, and all 6 undertook a product innovation in the last 5 years.

The age of the firm, which is measured by the number of years in operation, may be used as an indicator of firm experience. Firms are categorized as newly established (≤ 10 years experience), young (10-20 years experience), established (21-50 years experience) and well established (> 50 years experience). 23% of firms that introduced a product innovation are newly established, 51% are young, 23% are established and 3% are well established. Moreover, 12 newly established and 28 young firms participated in the survey with 11 of the newly established and 24 of the established firms having product innovations.

We now examine process innovation and firm characteristics. For process innovation and ownership, 82% of the firms that are process innovators are locally owned, 9% are foreign owned and 9% have both foreign and local ownership. All 3 firms in the survey that are foreign owned introduced a process innovation. 29% of process innovators are part of a larger organization. 17 firms surveyed were part of a larger organization and

11 implemented a new or significantly improved process. Considering firm size, 20% of firms that are process innovators are micro, 31% are small, 29% are medium and 20% are large. While 7 large firms participated in the study, 6 of those undertook process innovation. 46% of firms that introduced a process innovation are exporters. For firm age, 19% of process innovators are newly established, 47% are young, 31% are established and 3% are well established. Unlike product innovators where younger firms tend to innovate, process innovators seem to be older firms since 10 out of 13 established firms implemented a process innovation.

Table#6: Innovative firm characteristics

Firm characteristics	Product innovator (%)	Process innovator (%)
Local versus foreign		
Locally owned	81	82
Foreign owned	6	9
Mixed (local and foreign ownership)	13	9
Subsidiary firm		
Yes	32	29
No	68	
Exporter/non-exporter		
Yes	55	46
No	45	54
Firm size		
Micro (≤ 10 employees)	23	20
Small (11-50 employees)	36	31
Medium (51-200 employees)	28	29
Large (> 200 employees)	13	20
Firm age/experience		
Newly established (≤10 years)	23	19
Young (11-20 years)	52	47
Established (21-50 years)	23	31
Well established (> 50 years).	2	3

Source: Authors' compilation based on survey data collected.

5.2.1. Sadhna Petroleum Services Company

Sadhna Petroleum Services Company was founded in 1993 in Trinidad and Tobago and has established itself within the local oil and gas industry as a key player in the provision of drilling, work over, completion, reservoir management and project management services. The company has successfully executed projects onshore and offshore with several local and internationally based companies in various capacities. Sadhna Petroleum Services has expanded operations by setting up subsidiaries regionally, first into Suriname and more recently Guyana. Today the Sadhna Petroleum Group is comprised of: Sadhna Petroleum Services Co. Ltd., Sadhna Petroleum Services (Suriname) N.V., Sadhna Petroleum Services Co. Inc. (Guyana) and Sadhna Exploration and Production, Guyana Inc.

Sadhan has operated in Trinidad and Tobago for over 20 years with well-qualified professional staff. The company has therefore built up a wealth of explicit knowledge on the oil and gas sector and its experience has led to a build-up of tacit knowledge on Trinidad and Tobago's oil and gas sector. In terms of innovative activity, the company continuously seeks to adopt and adapt new technology when they become available. The Sadhna Petroleum Group has also innovated by introducing a number of turnkey products (integrated drilling and completion services). These turnkey products have been as per client specification, on time and within budget. The firm does this by managing subcontractors, and closely interacting with suppliers and competitors, which have led to knowledge sharing and the formation of strong relationships and in some cases partnerships. There is, however, little interaction with government institutions and universities. Also, by offering turnkey services to oil and gas exploration and production companies, Sadhna Petroleum Services is in a better position to negotiate pricing. This has been crucial in order for the company to compete with large foreign owned oil and gas KIBS firms. Additionally, it has allowed the firm to establish an excellent track record and reputation.

The company also implements various process innovations to ensure that the highest health, safety and environmental control systems are implemented and to create a safe and accident free environment for all stakeholders. Thus, Sadhan Petroleum Services interacts and collaborates with various industry stakeholders in Trinidad and Tobago and regionally in Suriname and Guyana, thereby acting as a facilitator, carrier and source of knowledge and innovation while being a lead firm responsible for providing clients with innovative oil and gas services. The case of Sadhna Petroleum Services illustrates that Trinidad and Tobago oil and gas KIBS firms are facilitators, carriers and sources of knowledge and innovation within the local economy and regionally in Guyana and Suriname.

Several factors have contributed to Sadhna Petroleum Services success. The company has many years of experience, which has led to a build up of tacit and explicit knowledge of the oil and gas services sector. By offering turnkey services the firm was able to offer more competitive price negotiations compared to its competitors, particularly from international oil and gas service providers. In addition, the introduction of new and improved products as new technology becomes available as well as several process innovations related to health, safety and environmental standards kept the firm ahead of its competition. The company also shares information and collaborates with its stakeholders thereby increasing the likelihood of innovation. Lastly, the firm has highly qualified skilled workers.

The company has nevertheless stated that strong international competition in the oil and gas services sector has been a primary obstacle to its growth. In fact, this is what motivated Sadhna Petroleum Services to begin offering turnkey services so that it can negotiate pricing from a much stronger position compared to its international counterparts. Moreover, given the fall in energy prices and falling production locally there has been a reduction in exploration, drilling, and maintenance and construction activity. Additionally, in the company's thrust towards continuous expansion locally and regionally it must keep adding to its fleet of equipment and seek out and adapt new technology to remain competitive. This has been costly and financing for local oil and gas KIBS firms from the local banking sector is not always easily available given a lack of understanding of the sector and the large portion of intangible assets services firms are likely to have.

Also, the firm stated that there has been a lack of government support for stimulating innovative activity and knowledge sharing. Further, there is minimal interaction from government institutions and universities and other public research institutions.

5.2.2. Tucker Energy Services

Tucker Energy Services is one of the oldest local oil and gas KIBS firms in Trinidad and Tobago and was set up in 1939. While the company is family owned, it is managed by qualified professional staff and operates as a private multinational corporation headquartered in Houston, Texas. The company seeks out and identifies niche markets in which its competitors do not excel or do not wish to enter. Tucker Energy Services is perhaps the most successful local oil and gas KIBS firm to penetrate foreign markets. Apart from Trinidad and Tobago, it also operates in the US, Canada, Belize, Colombia, Venezuela, Suriname and Brazil. The firm provides oil and gas services in the upstream and downstream sectors and offers an extensive range of products and services with special expertise in cementing, directional drilling and mud engineering.

Tucker Energy Services places a special emphasis on knowledge sharing and innovation in order to compete with global leaders in the oil and gas services industry. The company actively engages in knowledge sharing and collaborative learning. The firm aims to build strong relationships and is willing to share ideas with customers, suppliers, and even competitors, while receiving feedback, which contributes to product and process innovation (Swift, 2014). However, similar to the case of Sadhan Petroleum Services, there is minimal knowledge sharing and innovation co-operation with the public knowledge infrastructure.

The company's Houston office works closely with its suppliers to ensure that its technology is not limited to internal knowledge only. In addition, it imports and adapts the necessary technology where it exists and transfers it to its clients. Additionally, the firm carries out training programs for customers and foreign firms in "spreading the Trinidad Model". This leads to the sharing of explicit knowledge and tacit knowledge based on the firm's learning experiences from its many years of operating in Trinidad and Tobago's oil and gas sector. Tucker Energy Services conducts R&D locally in Trinidad and Tobago. According to the company, Trinidad and Tobago provides a rich test bed for developing new technology and adapting existing technology as the oil and gas production fields in the country range from very low to very high yielding (in terms of equivalent barrels of oil per day), which requires different tools and different approaches in each case (Swift, 2014). By being adaptable to both types of environments, Tucker Energy Services has been able to use this diversity in production environments to specialize and build-up tacit knowledge and develop expertise in selection of "fit for purpose technology," that is, the right tools for the job. The case study illustrates that Tucker Energy Services acts as a facilitator, carrier and source of knowledge and a leader in innovation in Trinidad and Tobago and regionally in other Caribbean and Latin American countries, and even internationally in the US and Canada.

Tucker Energy Services has been successful in the oil and gas services industry locally, regionally and internationally to a large extent, because it entered into niche markets where its competitors do not operate. While this is a risky growth strategy it has worked in their favor. In addition, the firm's special emphasis on knowledge sharing and innovation as well as building relationships with all stakeholders has also been critical to its success. The

company also has many years of experience and has acquired tacit and explicit knowledge from operating throughout the oil and gas value chain of Trinidad and Tobago in new and mature production fields, allowing it to introduce new and adapt a wide range of technology. Tucker Energy Services also has a highly qualified skilled staff for carrying out its operations.

Tucker Energy Services has however identified several obstacles to its growth. The firm stated that international competition is a major obstacle. It is difficult for Tucker Energy Services to compete with large international oil and gas service providers given that the R&D expenditure of these international firms is as large as Tucker's total revenue. Further, the company felt that Trinidad and Tobago's local content policy, apart from being ineffectively implemented, is biased towards multi-national companies putting domestic firms at a disadvantage. Another key constraint identified by Tucker Energy Services is government bureaucracy and the lack of government support in Trinidad and Tobago for innovative activity, for instance in filing patents and other copy right issues which make innovation a challenge and create disincentives to innovate. Also, there is a general lack of support from the government, universities and other public research institutions for knowledge sharing and innovation. Tucker Energy Services noted that the government played little or no role in the company's innovation efforts. The company also complained that there is a lack of access to finance, public and private for business expansion and innovative activity. Also, while the local labor force is highly skill, there is in some instances a lack of certain technical skills. There is therefore a need for universities and training institutes to review and update course content and skills being delivered to students. Lastly, the fall in both international oil and gas prices and local production is likely to negatively affect the firm's revenue as drilling, exploration, maintenance and construction projects are postponed or even canceled.

5.3. Oil and gas KIBS firms and diversification

The recent fall in international oil and gas prices and declining local production has once again brought to the forefront the issue of diversification in Trinidad and Tobago. The government and the Energy Chamber of Trinidad and Tobago have identified the energy services sector as a sustainable route to long-term economic transformation of the country and competitive advantage since the sector provides considerable employment and export potential in the absence of oil and gas reserves. The Ministry of Planning and Sustainable Development in its "Building Competitive Advantage - Six Strategic Business Clusters and Enablers" report identified the energy services sector as an important sector for diversification of the Trinidad and Tobago economy. The report stated that the government shall seek to export services to countries that are now beginning to develop their energy sector, thereby creating higher value energy products in know-how and increasing the export of knowledge products (Ministry of Planning and Sustainable Development, Building Competitive Advantage - Six Strategic Business Clusters and Enablers, 2012). The report identified the following specific oil and gas services for building capacity for export: ocean towing, heavy lift barge transportation, logistics and project management.

According to the Energy Chamber of Trinidad and Tobago, the oil and gas services sector is the most dynamic and competitive services sector in the country, with an international

reputation for excellence and high skill levels and capabilities. The Energy Chamber however believes that there needs to be a focus on established firms who are able to compete in international markets rather than establishing new and emerging sectors and the energy services sector has a core group of specialized and experienced firms who have enormous potential to be internationally competitive and enter into new export markets (The Energy Chamber of Trinidad and Tobago, 2015, Diversification and the Energy Sector). Furthermore, Trinidad and Tobago has over 100 years of experience in the oil and gas industry and the supporting infrastructure, capabilities, reputation and international network to grow and develop the energy services industry (The Energy Chamber of Trinidad and Tobago, 2015, Diversification and the Energy Sector). [5]

Oil and gas services are many and include banking and financial services, seismic surveys, drilling, computer and information technology related activities (hardware, software and ICT services), analytical laboratory and testing facilitation, operations and maintenance support, mechanical fabrication and erection, instrumentation, engineering and electrical services. These services are not only important for the oil and gas sector but also other industries. The oil and gas services sector can therefore lead to diversification into new sectors. For instance, the oil and gas industry is a major user of IT infrastructure and telecom bandwidth, which could be used to develop an e-business sector to support business activity in all sectors of the country. Additionally, knowledge and skills developed from the local fabrication of structures for offshore production platforms and processing plants can be applied to boat building, machine shops and pressure vessel manufacture. This in turn would lead to the development of services that support the maritime and fishing industry.

5.3.1. Trinidad Offshore Fabricators (TOFCO)

TOFCO was created as a joint venture agreement between Weldfab of Trinidad and Tobago and Chet Morrison, a Louisiana-based company in 2003, because of a real need for platform construction and fabrication services in Trinidad and Tobago and the wider Caribbean. Before TOFCO was established all offshore production platforms in Trinidad and Tobago with the exception of the Kairi1 platform were constructed in foreign countries, mainly in the US coast, and imported. With Chet Morrison and Weldfab as parent companies, the infrastructure was established for design and construction efficiencies and expert engineering knowledge, along with access to cutting-edge equipment. The business network and shared technologies allowed TOFCO to serve as a one-stop solution for any fabrication and support services for the oil and gas industry. This was the formation of an entirely new sector within the energy services industry locally. At the time the company was being set up, local firms lacked the knowledge and expertise to offer platform fabrication services. The partnership between Chet Morrison Contractors and Weldfab resulted in a sharing of knowledge and innovation co-operation between a foreign and local oil and gas KIBS firm. Since its formation TOFCO has developed solid, reliable relationships and maintains close interaction with suppliers and customers.

It was not easy for TOFCO to offer an entirely new service to Trinidad and Tobago's oil and gas services sector. Local platform fabrication was encouraged by a general industrial policy of local participation by nationally owned oil and gas KIBS firms and supported

5 http://www.ttenergyconference.org/2015/01/diversification-and-the-energy-sector/

by a specific public policy on local content that encouraged oil and gas exploration and production companies to develop local capability and competitiveness. In the first instance bp Trinidad and Tobago contracted TOFCO to construct an offshore platform. The protectionist component took the form of premiums, which elevated the cost of local fabrication above what might have been achieved through international competition (Warner, 2011). Over time however, as the productivity of TOFCO improved, the premiums for subsequent platforms were reduced. Eventually contracts were awarded on a fully internationally competitive basis for cost, quality and schedule (Warner, 2011).

TOFCO was born out of "risk" with an initial investment capital in excess of US$ 10 million.[6] It was risky while working on the first platform since the company was not sure when another contract would come up. Also, since the firm was new, it had to build a team of skilled and capable engineers, operations personnel and administrative staff. It would have been a huge risk to close off operations for six months then to get those same workers rehired when the next project comes up. However, the excellent work performed on the first platform resonated throughout the industry leading to later contracts for TOFCO since there was a large demand for platform fabrication services in Trinidad and Tobago. Today TOFCO is a leading provider of fabrication, construction and offshore services for the oil and gas industry using local talent, skills and expertise.

The company has gained international prominence for the construction of award winning project platforms. Presently, the company has completed 9 platforms: bpTT Cannonball, EOG Toucan, BG Poinsettia, Poinsetta1, bpTT Cashima, bpTT Mango, EOG Oil Bird, bpTT Savonette and BHP Angostura. The first platform was completed in 2005. Most of the engineering design and project management for all platforms took place locally, through a joint venture between Fluor Daniel, an international firm and Summit Engineering and Construction, a local engineering company, and presently platforms are 100% locally designed and constructed. The BG Poinsettia platform is the largest deck ever built in Trinidad and Tobago. This has demonstrated that local KIBS firms can compete with their international counterparts.

TOFCO's 37 acres waterfront fabrication facility is located at the LABIDCO Industrial Estate in the Gulf of Paria, La Brea Trinidad. This provides a convenient location and fast response times for customers. The firm has a 600 feet bulkhead waterfront property that includes a dock with a 40 feet water depth, which allows for limitless navigational clearance for load-outs and 24 hour scheduling capabilities. The company is also in the process of constructing a world-class fabrication shop with an attached warehouse storage space and a larger welder-training lab to train and test 17 welders as opposed to previously training and testing 4 at a time. This will allow the company to be more competitive with future bids as piping and small deck extensions can be fabricated within a covered facility, with improved productivity and schedule certainty. TOFCO is also looking to expand its fabrication services internationally to South America and Africa including Brazil, Guyana, Venezuela, Ghana and Nigeria.

TOFCO is seeking to further diversify its energy services. Since 2014 the firm has been venturing outside of its core business of structural fabrication and construction into

6. http://www.newsday.co.tt/news/0,39211.html?ref=binfind.com/web

electrical and instrumentation capabilities. The company has also expanded to the refurbishment and maintenance of offshore rigs providing procurement, fabricating, blasting and painting, storage, equipment rentals and consulting services. TOFCO has also diversified into the downstream sector working on refineries and petrochemical plants. TOFCO is also seeking to diversify outside of the oil and gas sector. It has begun to provide ship repair services at its fabrication yard in LaBrea. Before this dry-docking only took place at one location in Trinidad and Tobago- in Chaguaramas. TOFCO is seeking to transfer its expertise in piping fabrication, sandblasting and painting into ship repair and maintenance services. These are significant steps forward for TOFCO as well as the local dry docking sector. The case of TOFCO illustrates that diversification into new sub-sectors within the oil and gas services sector as well as new sectors outside of oil and gas services is taking place in Trinidad and Tobago.

TOFCO's success can be attributed to several factors. Government industrial policy to encourage local platform construction and fabrication played a major role in TOFCO's success and in creating this new sector in Trinidad and Tobago. The industry benefitted from a protectionist component, which took the form of premiums, and over time, as TOFCO's productivity improved, the premiums were reduced and eventually removed completely. Further, the joint venture agreement between a local and foreign firm has allowed for the necessary infrastructure for design and construction efficiencies, equipment, business networks, knowledge sharing and innovation cooperation. A significant amount of entrepreneurial risk and capital funding were also involved in TOFCO's success. TOFCO also continuously seeks to diversify its product base thereby spreading risk and increasing revenue streams. Additionally, TOFCO maintains close interaction with suppliers and customers. The firm also has skilled and capable workers.

There is however several challenges faced by TOFCO. The company faces fierce international competition, particularly in a low-price environment where capital projects have either been postponed or shelved. Falling international hydrocarbon prices accompanied by lower oil and gas production locally has resulted in a reduction of capital projects, which have negatively affected the company's revenue. This has increased pressure on TOFCO to be more efficient and to deliver services at more competitive prices. Furthermore, Korean firms that dominate the fabrication industry have superior capacity, including in-house engineering and government subsidies, which have boosted their financial strength making yards such as Daewoo and Samsung hard for TOFCO to compete with. Additionally, in the platform fabrication sector the timely delivery of projects is very important and a firm that cannot meet its commitments is likely to lose customers. TOFCO has experienced problems with the delivery of projects in the past. It was forced to outsource to a US Gulf Coast company the construction of jacket and piles for bp Trinidad and Tobago's Juniper platform after it lost 97 days because of industrial unrest and the impounding of a Chinese vessel transporting steel and other material inputs. Moreover, contractual obligations required bp Trinidad and Tobago to produce its first gas from Juniper in 2017 or face penalties, so TOFCO was left with no choice but to outsource. For TOFCO to remain competitive such delays must be avoided in future projects.[7]

7. http://energynow.tt/blog/tofco-forced-to-use-texas-fabricator

6. Employment capabilities and human resource development

While oil and gas contributes very little in terms of employment in Trinidad and Tobago given its capital intensive nature, oil and gas services is said to be a major employer within the oil and gas sector, employing about one third of all oil and gas workers. Nevertheless, Trinidad and Tobago's oil and gas sector has contributed significantly to the country's employment capabilities and human capital development, not only within the oil and gas and services sector but outside as well. Government revenue from the oil and gas sector has helped to fund the Government Assistance for Tuition Expenses Program (GATE), which makes tertiary level education affordable and accessible to all citizens. Oil and gas revenue has also helped fund Technical Vocational Education and Training (TVET) through the Youth Training and Employment Partnership Program (YTEPP). Although in recent times, given the fall in revenue, the government has intentions of re-structuring these programs.

Trinidad and Tobago has a highly trained and experienced workforce with skills that are required in oil and gas exploration and production and oil and gas services. Both the government and private sector have played a role in local human resource development to support the oil and gas sector and the overall level of development of the country (Report of the Energy Sub-Committee for Vision 2020, 2003). This has resulted in the country having an oil and gas sector workforce with internationally recognized qualifications working all over the world, including the North Sea, the Middle East and Africa. In addition, the majority of workers in the local oil and gas services sector are highly skilled nationals of Trinidad and Tobago, working in both local and foreign companies.

Trinidad and Tobago has a national structure of oil and gas industry training at all levels which can take a person entering the industry at craft level, through technical qualifications and on to university level training. The government has invested significant resources in training graduate-level and technician and craft workers in the oil and gas sector through various tertiary institutions. Government initiatives in education and training in the oil and gas sector include support of and establishment of universities, specialized learning centers and the development of academic curricula relevant to meet the industry's requirements. The National Energy Skill Centre (NESC) and the University of Trinidad and Tobago (UTT) are two national institutions specifically set up to address the need for tertiary level education and training in the oil and gas sector. UTT is a partnership between key oil and gas industry players and the government where applied undergraduate level engineering training is available. The NESC Drilling Academy was opened in 2013 to provide formal training in specialized drilling for the oil and gas sector. Also, the geosciences program at the University of the West Indies (UWI) has been expanded to include more students to meet the expanding needs of the oil and gas sector.

The government has combined individual craft apprenticeship programs into national programs under the NESC, and the National Social Development Program (NSDP). The NSDC was set up to increase the skill training capacity in the country. Both institutions service the needs of all industrial sectors in Trinidad and Tobago and are not just limited

to oil and gas. The technician component of apprenticeship and in-house training has been merged into UTT and College of Science, Technology and Applied Arts of Trinidad and Tobago (COSTAATT). COSTAATT was created to provide the highest quality tertiary education and training for specialized skills in a range of professions not limited to the oil and gas sector, identified on the basis of the continuing education needs of the population and to meet the demands of an expanding and diversified economy. The government also established, in collaboration with US and Canadian educational establishments, a number of educational and vocational initiatives to increase skill and know-how thereby providing a large supply of competent labor.

Companies in the oil and gas sector in Trinidad and Tobago give numerous scholarships annually for craft, technician and professional level training relevant to its areas of business operations. Oil and gas companies have been increasing budgetary allocations for specialized professional development programs at all levels for their staff to ensure that they have the most up to date skills. The ease in availability of industry relevant courses has encouraged oil and gas firms to fund employee participation and program instructors. Moreover, international companies provide education and training to employees, even in areas outside of the oil and gas industry. Also, Trinidad and Tobago has oil and gas KIBS firms, which take the form of specialized research institutions, that may directly contribute to employment capabilities and human resource development of the country, as shown in the case study of the Kenson School of Production Technology below.

There are some challenges to employment capabilities and human resource development in Trinidad and Tobago's oil and gas sector. There is a lack of interaction between the training institutions and the oil and gas KIBS firms to ensure that specific industry needs are being addressed. The apprentice program is addressing this gap in some sub-sectors, but this needs to be extended across the industry. The Energy Chamber of Trinidad and Tobago and the National Training Agency have been working with a group of oil and gas KIBS firms to help them establish company-level competency assurance systems that meet the requirements of international operators**.** Also, the fall in oil and gas prices may impact employment in the oil and gas sector, including energy services. The Energy Chamber's Energy Services Sector Survey for the fourth quarter of 2014 showed that there was a significant decline in the level of optimism in the energy services sector and some uncertainty about employment. Further to this, oil and gas KIBS firms indicated that they would be looking to reduce costs to deal with the challenging economic environment, which may have a negative impact on labor.

6.1. Kenson School of Production Technology

The Kenson School of Production Technology was set up in 1995 in Trinidad and Tobago to provide industry relevant training to persons seeking entry at the technical level of the oil and gas industry and persons seeking to re-train or enhance their technical skills. It was started as a direct response to the growing need for competent operators in the upstream oil and gas industry in the country. The school is a subsidiary of the

Kenson Group, which was set up as an oil and gas service provider in Trinidad and Tobago in the upstream sector in 1994 and is locally owned. The Kenson Group has 4 companies in total: 1) Kenson Production Services, 2) Kenson Operational Services, 3) Kenson School of Production Technology and 4) PF Engineering and Construction Company. The company is a leader in the oil and gas industry in Trinidad and Tobago, has grown from 10 employees to over 400 and offers various services to major oil and gas exploration and production companies.

From its inception the school has trained over 1,400 persons who are employed in various levels of the oil and gas industry locally and internationally. The Kenson School of Production Technology has invested in practical facilities that mirror the offshore production environment and offers students' hands-on training that reduces the learning curve when they actually enter the work place. This differentiates Kenson School of Production Technology from other technical schools. The school provides short courses and workshops for non-technical persons and the general public, including secondary school students, teachers, auditors, accountants and customer service representatives. It also provides custom designed training programs and courses to meet the client's needs. Technical courses offered include Offshore Production Operator Training, Land Based Production Operator Training, Process Technology, Natural Gas Technology Technician Training, Compressed Natural Gas Installation Technician, Process Engineering Suite, Process Technician, Electrical Maintenance Technician, Instrumentation Maintenance Technician and Mechanical Maintenance Technician.

The Kenson School of Production Technology is a premier training institute in the oil and gas sector in Trinidad and Tobago. The school has entered into special alliances and has developed in-house capabilities to provide training. The school has approvals from local and international institutions. Also it partners with international institutions to provide the most up-to-date and relevant training and course content. The school was registered with the Accreditation Council of Trinidad and Tobago in 2009 as a post-secondary institution and is legally authorized to offer a wide range of programs to the public. In 2010 the school was awarded Center Approval Status with City and Guilds International and was approved to deliver the International Vocational Qualification in the oil and gas program. The school is also an Approved Training Provider and learning affiliate of the Energy Institute of the UK. In 2014 Kenson School of Production Technology won an award for Quality in Tertiary Education (QuiTE) for excellence in Teaching and Learning by the Accreditation Council of Trinidad and Tobago.

The Kenson School of Production Technology does not limit training to persons living in Trinidad and Tobago only and has been engaged in exporting its services. The school received an award for New Energy Services Exporter of the Year in 2012 by the Energy Chamber of Trinidad and Tobago to recognize its export of knowledge services. In 2013 an agreement was signed with GITA Allied Solutions, a private company that operates in Nigeria and Trinidad and Tobago for training Nigerian students. This led to Nigerian students being trained in Trinidad and Tobago and 10 students undertook studies in Instrumentation Maintenance for 10 weeks. In addition, the school was successfully audited by the Nigerian government and approved to train students under the Niger Delta Amnesty in Nigeria. The school has also worked with Uganda to enhance its local human

resource capabilities, which has an emerging oil and gas sector. Since 2011 the school has trained 11 Ugandan students and 24 in 2012 at the Uganda Petroleum Institute of Kigumba. Further, in 2012 the Kenson School of Production Technology signed a Memorandum of Understanding with the Uganda Petroleum Institute making it the channel for all training to be undertaken in Trinidad and Tobago for students from the institute.

Most recently, in 2014 Islas Malvinas (Falkland Islands) was interested in training their oil industry workers with support from the Kenson School of Production Technology. The Falklands' oil industry is in an embryonic stage of development and faces many human resource challenges. The training of the local workforce is necessary for local firms to compete with international multinational corporations and to stimulate local employment. The Falklands is interested in adding value to workers through training and Trinidad and Tobago provides valuable knowledge and experience in this area. The Kenson School of Production Technology visited Falklands to promote Trinidad and Tobago's oil and gas industry training services and this represents an important export market in the future.

The Kenson School of Production Technology has become a successful training institute locally and internationally because it offers practical hands on training and experience to its students. It also offers courses tailored to meet the client's needs. Further, it was able to enter into special alliances with local and international partners allowing it to develop its internal capabilities and deliver the most up to date course content. It also obtained approvals and accreditation from local and international institutions making it attractive to local and international students. Further, while the company aims to build local capabilities in Trinidad and Tobago, it also actively seeks out export markets as part of its strategic vision.

The fall in international oil and gas prices and production locally has nevertheless negatively impacted the firm since a contraction in projects has negatively affected the demand for training services, as exploration and production companies look for ways to cut back on expenditure. Furthermore, as Trinidad and Tobago and other countries focus more and more on oil and gas resources that are harder to extract from mature and deep-water fields given its falling reserves, new skills are required. Thus, if the Kenson School of Production Technology is to remain relevant and competitive, it must continuously update the skills and courses offered. It may continue to do so by entering into partnerships and alliances with international institutes. Further, there are complaints from the oil and gas services sector that while Trinidad and Tobago has a highly educated and skilled workforce, there are certain key industry skills lacking. Kenson School of Production Technology may wish to strategically identify these needs to fill important market gaps. Additionally, another difficulty faced by the firm is that in expanding its operations internationally, it is restricted to the African and South American markets for exporting its services because of significant barriers to entry in the oil and gas training market in northern developed countries, which make it nearly impossible for it to enter.[8]

8. http://www.theworldfolio.com/interviews/blair-ferguson-executive-director-of-kenson-school-of-production technology-n1063/1063/

7. Environment and sustainability

Extractive industries may have a huge negative environmental impact on a country. In Trinidad and Tobago the oil and gas sector contributes the most to environmental degradation and pollution. Poorly planned seismic tests and drilling, flaring of excess gas, deforestation from on-site operations and oil spills throughout the supply chain can be highly pollutant. This may affect the environment including air, land and water, and wild life and human life. It may also negatively affect other economic sectors like fishing, tourism and agriculture. For instance, polluted water from oil and gas operations including gas exploration, production, refining and marketing can escape into streams and rivers and eventually reach the sea. Also, oil spills and waste from drilling can damage marine and mangrove ecosystems and lead to the accumulation of oil on the shoreline. It has been estimated that an average of 2,000 barrels of oil spill occur annually in the marine area around Trinidad and Tobago (Report of the Energy Sub-Committee for Vision 2020, 2003). Additionally, the petrochemical industry produces hot water and harmful effluents, which affect aquatic life and vegetation. Drilling can also generate water with elevated chloride levels, which pollutes the soil. Also, lubricating oil and petrol leaks from tanks and pipelines at gas stations threaten surface and ground water resources.

In January 2013 the government of Trinidad and Tobago through the Ministry of Energy and Energy Affairs developed a National Oil Spill Contingency Plan for oil spills on land and offshore. The objective is to preserve and protect human health and the environment from the risk of oil and chemical spills (National Oil Spill Contingency Plan, 2013). The plan is mindful of the importance of precautionary measures and prevention in avoiding oil pollution in the first instance, and in the event of an oil pollution incident, prompt and effective action will be taken in order to minimize damage. The government is committed to ensuring that appropriate measures are taken in accordance with the relevant legislation, regulations and standards and international best practices. The plan is kept current through updating whenever changes to key agencies and/or personnel are made and reviewed annually and revised based on experiences from actual incidents, drills and simulation exercises, to take into account any change in the hazard/threat and changes in technology.

Reducing the negative environmental impact of the oil and gas sector provides opportunities to develop local capabilities and skills in the process of prevention and mitigation and can be seen as an opportunity to incorporate participation from universities, oil and gas KIBS firms and local communities in the solutions. Trinidad and Tobago oil and gas KIBS firms can assist in environmental protection and sustainability by offering the relevant services given that there is a large and growing demand for these services. Since the early 1990s oil and gas KIBS companies have introduced environmental services in Trinidad and Tobago. However, currently the country has no hazardous-waste disposal systems and waste from the oil and gas sector has to be exported. Environmental protection and sustainability present a significant opportunity for oil and gas KIBS firms to innovate and expand services offered.

7.1. Oil Mop Environmental Services

Oil Mop Environmental Services was set up in Trinidad and Tobago in 1993 and is locally owned. The company aims to provide reliable and cost effective environmental and waste management services. It was built on the growing need to ensure that environmental and waste management practices and standards are upheld in Trinidad and Tobago and regionally. Oil Mop Environmental Services has the capability to provide a range of environmental and waste management services to various clients not limited to the oil and gas sector only but also government and municipalities and the manufacturing sector. The services provided by Oil Mop Environmental Services include: oil spill response, steam pressure washing, oil recovery and recycling, waste oil treatment, incineration, bulb disposal, tank cleaning, vessel cleaning, waste water treatment, drum crushing (steel and plastic containers), pumping services and equipment rentals. The firm has been successful at expanding in the Caribbean through a successful oil collection program and has opened an office in St. Maarten and Suriname through a joint venture. The company is interested in further regional expansion.

Oil Mop Environmental Services seeks to establish long-term relationships with customers and provide practical solutions by careful consideration of the local and international economic conditions, adherence to local and international standards, human resource management and use of the latest technology to maximize the utilization of resources. It thrives to meet occupational health, safety, environment and social responsibilities by complying with all legal and other requirements as a minimum and adhering to international industry standards and best practices. Facilities are operated in a manner to protect the environment and the health and safety of employees and all other stakeholders.

The company provides adequate and continuous communication, education, training and resources to all employees to adhere to the company's strict Health, Safety and Environmental policy and promotes a culture that encourages communication with employees in the identification of hazards, risks and prevention of accidents. It ensures that all incidents are reported, documented and appropriate corrective and preventative measures are implemented to prevent a re-occurrence, and emergency response systems and contingency plans are in place. The company's management system is continuously monitored for improvement. It tries to use products, programs and processes that preserve the environment and prevent, reduce, mitigate and control pollution hereby reducing negative environmental impacts in Trinidad and Tobago and the Caribbean. Also, as part of its corporate social responsibility, Oil Mop Environmental Services supports and promotes green initiatives in communities to contribute to a cleaner environment.

Oil Mop Environmental Services has been successful because of several factors. It was able to expand its operations regionally because it entered into joint venture agreements. It also works closely with and establishes long-term relationships with its customers thereby offering tailored services to meet their needs. The company aims to meet its occupational, health, safety, environment and social responsibilities and adheres to international industry standards and best practices, thereby offering the highest quality

services. Further, it provides continuous education and training to its workers ensuring that their skills are most up to date.

The fall in energy prices however, along with revenues of oil and gas exploration and production firms and local production, may negatively impact the demand for environmental and waste management services. Oil and gas exploration and production companies may wish to cut back expenditure and therefore not pay for environmental and waste management services to properly dispose of their waste. Furthermore, the role of government in setting and enforcing regulations is key to minimizing negative environmental impacts. Moreover, a government that enforces regulations can stimulate more innovative and effective environmental management thereby increasing the demand for environmental services. However, government support in Trinidad and Tobago for environmental protection and management has been minimal with significant room for improvement.

7.2. Kaizen International

Kaizen International, based in Alberta, Canada, has been operating in Trinidad and Tobago since 1995; first as a joint venture, as NM Kaizen Environmental Services, and from 1997 as Kaizen Environmental Services Trinidad. Operations at Kaizen Environmental Services Trinidad are supported by Kaizen International, which has a highly qualified international team of environmental specialists and scientists. Over the years the firm has grown and evolved into four operating divisions in Trinidad and Tobago: 1) Kaizen lab (environmental laboratory for analytical testing); 2) project services (assess and meet clients' environmental targets); 3) waste services (turnkey solutions to waste management); 4) and environment products (sales and rental of detection and monitoring systems and a full inventory of spill response equipment and supplies).

Kaizen lab operates a rigorous quality assurance and quality control program based on international standards for laboratory competence. It upholds environmental responsibility, as all effluent is monitored and all unused samples, chemical reagents and waste are carefully segregated and disposed of at the Kaizen Waste Treatment Facility. The company is committed to serving its customers in a professional manner by balancing environmental sensitivity with economic concerns and providing effective solutions to environmental problems that are consistent with corporate ethics and the health and safety of all employees and stakeholders. The company has also expanded regionally and has established Kaizen Environmental Services Guyana with Kaizen Environmental Services Trinidad acting as the main office.

Kaizen Environmental Services engages in knowledge sharing on the importance of environmental preservation and the technologies and equipment available. The company made a presentation to the Association of Upstream Operators of Trinidad and Tobago on the Supply of Services for oil spill response. The theme of the presentation was the development of a National Tier II response organization for Trinidad and Tobago. Further,

the Kaizen Environmental Spill Response Section was set up in 2003 with the aim of becoming the premier spill response service provider in the country and the first National Tier II response organization able to respond to oil, chemical or hazardous material spills on-shore and offshore.[9] The section has implemented a rigid management structure to ensure clear reporting, communication and document control for effective management of all incidents from inception to closeout. This ensures customer satisfaction, while satisfying internal and external requirements. Furthermore, Kaizen Environmental Services has invested considerable resources into an intensive equipment stockpile to keep track of latest technology for spill response. [10]

Kaizen Environmental Services employs adequately trained personnel with a wide range of experiences, skills and abilities dedicated to continuous improvement, always developing fresh and innovative ideas to provide a unique service. Kaizen Environmental Services has trained responders throughout Trinidad and Tobago and established internal and external training needs to ensure there is no lack of expertise and professionalism within the section. The company has completed numerous international spill response training and certification courses ensuring that the services offered are benchmarked against internationally accepted standards. Most recently, the company completed the Premier Oil Spill Response Training at The National Oil Spill Response Research and Renewable Energy Test Facility in New Orleans and Texas.

The spill response section has conducted numerous spill response training exercise for clients, demonstrating its response capabilities while promoting community awareness and development. These include the annual spill response and equipment deployment exercises at various locations in Trinidad and Tobago including Toco, Guayaguayare and Grand Riviere. Additionally, Kaizen Environmental Services participated in the second annual SanCity Green Expo 2013, which was hosted by the San Fernando City Corporation of Trinidad and Tobago. The company's involvement was to showcase its state of the art range of products and to educate the public on the various services the company provides in order to reduce waste and promote environmental sustainability. The company's participation in the expo provided individuals and companies with knowledge and understanding of how it operates by ensuring that Trinidad and Tobago has a safer, cleaner and greener environment. Also, the company conducts spill awareness and training sessions regionally in Guyana and Suriname.

Kaizen Environmental Services Trinidad has been successful given the support it receives from Kaizen International, which has a highly qualified international team of environmental specialists and scientists, first class lab facilities and other environmental technology. Further, the firm employs highly skilled workers and also seeks to continuously train them with the most up to date skills, particularly in oil spill response. Nevertheless, the firm states that organizational/ managerial culture, finances, labor force skills and qualifications, protection against copycats, level of information on available technologies, compliance requirements to international standards, lack of information on markets and

9.Tier Two Spills are small or medium-sized spills where significant impacts are possible and area or national support for adequate spill response is required.
10. These include spill response vessels for a variety of marine application, rapid response trailers fully equipped for fast mobilization of equipment, 4WD Pick Up vans to access various terrains, temporary storage tanks, pools, berms and storage equipment for onshore and offshore storage of collected material, containment booms –solid flotation and inflatable booms for near shore and offshore containment, transfer pumps (trash, diaphragm, pneumatic), kimmers and power packs for recovery operations, dispersant and dispersant application systems, spray systems for application of chemical (mist blowers, back pack sprayers), transportation equipment, sorbents and absorbent products and a wide range of personal protective equipment.

uncertain demand for innovative goods or services are all obstacles to its innovation efforts. Further, similar to Oil Mop Environmental Services, given falling energy prices along with revenues for oil and gas exploration and production firms and production locally, the demand for environmental and waste management services can be negatively impacted as companies seek to cut costs. Additionally, the government can do more to enforce environmental standards thereby increasing the demand for environmental and waste management services.

8. Lessons learnt and policy recommendations

The study of oil and gas KIBS firms in Trinidad and Tobago offers many lessons for the future of extractive industries. Firstly, Trinidad and Tobago has made full use of its oil and gas resources by successfully diversifying away from a solely oil based economy to monetizing its gas resources, followed by the establishment of its well-developed downstream petrochemical sector. This provides opportunities for KIBS firms to operate and share knowledge and engage in innovation along the entire oil and gas value chain. The government did this by creating forward linkages in the gas sector through the formation of Atlantic LNG and by entering into the LNG export market. This allowed for a greater capture of value added in the oil and gas value chain. Today Atlantic LNG is one of the largest global producers of LNG in its four-train liquefaction facility and employs over 700 full-time workers, of which 98% are nationals of Trinidad and Tobago. The company also employs numerous oil and gas KIBS firms for maintenance of its production facilities.[11]

In 2004 Trinidad and Tobago developed a local content strategy with a long-term vision of diversification away from the extractive sector by using oil and gas resources in order to reduce reliance on the sector. The strategy recognizes that local capability development requires a period of special preference in terms of participation and training, and that diversification requires support measures for local firms to capture new business opportunities. The country's local content strategy focuses on local capability development, education and training, and diversification and entrepreneurship. Trinidad and Tobago attempted to boost local capability development by increasing local oil and gas KIBS firms' participation in the energy sector as they are given the opportunity to work, learn and acquire knowledge through some preferential treatment in order to be competitive, while multinational exploration and production firms are required to contract local KIBS firms once they provide the services needed. Nevertheless, as earlier stated, there are several shortcomings which make Trinidad and Tobago's local content policy ineffective.

The government has also invested heavily in education and training specifically targeted at oil and gas, as well as outside of the sector through several initiatives, including the support of universities and funding for tertiary education, the creation of specialized training centres and the design of relevant industry academic curricula. Furthermore, multinationals are encouraged to provide education and training to workers in crucial areas and high value added skills, to contribute to the development of future business, even in areas outside of oil and gas. With regards to diversification of the economy and entrepreneurship, the government intends to work closely with the private sector to develop the capacity to supply local oil and gas needs, increase the formation of new firms and encourage innovation and exports and the creation and support of clusters with other industries that have natural synergies with oil and gas. Also, the government created the CED, which focuses on enterprise development, not just in oil and gas but across all sectors.

Trinidad and Tobago's local content strategy also recognizes that foreign content and encouraging foreign firms to form joint ventures with local firms is important for growing

11. http://www.atlanticlng.com/about-us/atlantic-at-a-glance

and developing the oil and gas services sector. The case of diversification into platform fabrication locally through TOFCO resoundingly demonstrates this. More specifically, local platform fabrication was encouraged by an industrial policy of local participation by oil and gas KIBS firms and supported by a policy of local content that encouraged foreign oil and gas exploration and production companies to develop local capability and competitiveness. TOFCO's first offshore platform was contracted by bp Trinidad and Tobago despite having a protectionist component, which took the form of premiums, which elevated the cost of local fabrication. Over time the productivity of TOFCO improved and the premiums for subsequent platforms were reduced and contracts are now awarded based on a fully internationally competitive basis.

While Trinidad and Tobago has had some successes in developing its oil and gas KIBS firms, there is much more that can be done. The following outlines recommendations to promote the growth and development of these firms and uses successful country examples where possible:

1. *Information dissemination and data collection*

   The government and other economic actors should have a thorough understanding of the potentially important role oil and gas KIBS firms may play in moving Trinidad and Tobago away from an extractive to a knowledge based economy. This may require further in-depth research and wide spread communication of the findings on the role oil and gas KIBS firms play in knowledge sharing, innovation and productivity, diversification, human capital development and environmental protection and sustainability. Additionally, there is limited data available on Trinidad and Tobago's energy services sector and the activities of oil and gas KIBS firms. Systems for data collection and dissemination on macroeconomic variables such as employment, exports and value added to GDP by oil and gas services, as well as microeconomic data such as firm level challenges, innovation and productivity, are essential for this type of research. Data on future trends of the country's rig rate and new drilling campaigns and planned rig and plant maintenance and inspection are also important for oil and gas KIBS firms for planning and decision making in terms of re-structuring and cut backs in operations and staff and the need to seek out export markets.

2. *Increasing the supply of knowledge and technology development*

   While the government of Trinidad and Tobago has established various tertiary education and training institutions for increasing skills and knowhow in oil and gas sector, there is a lack of R&D and innovation resources. For instance, Trinidad and Tobago has no institution dedicated to R&D in energy services. Given the importance of the energy sector, the government should increase R&D and innovation in this sector. This may be done through public investment and private sector initiatives as well as public private partnerships. An example in this regard is the Colombian Petroleum Institute as a R&D and innovation centre created by the Columbian government in 1985. The institute works with the Colombian Petroleum Company (Ecopetrol), which is state, owned on R&D, innovation and science and technology in the energy sector. It has an intricate well-connected network of 20 laboratories and 33 pilot plants for conducting R&D. The institute hires highly qualified personnel,

provides technological support and works on joint projects with Ecopetrol. This has resulted in many new technology products, copyright registrations and trademarks for Columbia (Gallego and Jaramillo, 2015). Trinidad and Tobago can adopt a similar approach in creating a R&D and innovation centre for its oil and gas sector.

3. *Financial support for R&D and innovation*

   There is a lack of R&D and innovation funding for oil and gas KIBS firms in that there is limited support from the government and local banks do not understand the sector and are unable to assess risk and develop appropriate financial instruments. It is also more difficult for service firms to access funding in general given the large amount of intangible assets, which are difficult to cost. The government of Trinidad and Tobago should increase funding and access to finance for oil and gas KIBS firms and research institutions for R&D and innovative activity in the oil and gas services sector. In this regard the government could adopt an innovation funding approach similar to what was implemented in Norway.

   In Norway oil and gas KIBS firms can apply for innovation funding from Innovation Norway, which is a state-owned company and a national development bank formed in 2004. Additionally, Innovation Norway and the Research Council of Norway are financing the development of regional oil and gas clusters. The Research Council of Norway is a Norwegian government agency responsible for awarding grants for research and promoting research and science and provides advice to the government concerning research related matters. Also, Norway established the Industrial Development Corporation of Norway (SIVA), which is a state enterprise responsible for government investment in incubators, science parks, industrial parks and real estate through partial ownership of other companies. These initiatives have been very successful in growing KIBS firms, through strengthening Norway's capacity related to R&D and innovation (Sasson and Blomgren, 2011).

4. *Technology transfer and adaptation*

   Based on the findings from this study, innovation from oil and gas KIBS firms in Trinidad and Tobago comes mainly from external technology, which is then adapted to suit local conditions, rather than being internally generated. The government should therefore actively encourage technology transfer and adaptation, thereby increasing the demand for knowledge. Trinidad and Tobago could adopt an approach of technology transfer similar to Brazil.

   In the 1970s, when Brazil discovered large hydrocarbon resources, a quick process of technology transfer was required (UNCTAD, 2012). At first, the Brazilian Petroleum Corporation (Petrobras) used foreign KIBS firms. However, in the 1980s focus was placed on the development of domestic technology through licensing agreements with international suppliers. From the licensing of technologies developed by foreign firms, the Brazilian oil and gas sector had access to the latest technology and could adapt it to suit the domestic environment. This has resulted in Brazil being a global innovation leader in deep-water and ultra-deep water exploration and production technology today (UNCTAD, 2012).

5. *Coordination of actors and information sharing*

In Trinidad and Tobago there is currently no platform for dialogue among all oil and gas stakeholders, including the government, the business chambers, KIBS firms and exploration and production firms. The coordination of actors and information sharing is important for crafting a national strategy to grow the country's energy services industry. It is also necessary for balancing the demand and supply of knowledge by creating the necessary linkages between actors to allow for knowledge sharing and spillovers and innovation. The government should have frequent communication and interaction with oil and gas KIBS firms since this type of open dialogue would provide an opportunity for oil and gas KIBS firms to inform the government of the challenges faced. Information exchanges and innovation co-operation between oil and gas KIBS firms and research institutions, particularly government institutions and tertiary level education institutes, is also important. From the survey results oil and gas KIBS firms were least likely to use the public knowledge infrastructure for knowledge exchange and innovation collaboration. A channel for communication between KIBS firms and exploration and production companies is also crucial so that the demand of exploration and production firms, and the supply of services by KIBS firms can be matched. Such communication can increase innovation, productivity and investment decisions.

An industry wide coordination and communication strategy can be developed and implemented for technology transfer and adaptation, innovation and creating the right business environment. Also, construction of the necessary information infrastructure, such as communication facilities, network environment and information platforms to build an environment to promote knowledge flow and exchange, is necessary. This will reduce the start-up and operation costs for oil and gas KIBS firms. A structured network of partnerships similar to what was done in Brazil can be implemented.

Since 1996 Petrobras established structured networks of partnerships called Centres and Networks of Excellence Practice, to support innovation through networking and interacting with various stakeholders from within and outside the company (Sigam and Garcia, 2012). The method mobilizes a set of physical, financial and knowledge resources and technologies focused on achieving excellence in a particular knowledge field and developing high quality products. This has resulted in strong linkages with universities and academia. Petrobras was able to produce fit for purpose solutions for its energy challenges and resulted in growing KIBS firms in Brazil's oil and gas industry. A similar approach can be adopted in Trinidad and Tobago to increase coordination and communication of all stakeholders in the energy sector.

6. *Human capital development*

Oil and gas KIBS firms in Trinidad and Tobago identified a lack of professional capabilities as an obstacle faced in business operations. While the government of Trinidad and Tobago has invested significant resources in training at the graduate-level as well as at the level of technician and craft workers through various tertiary

education institutions, there is not a close alignment between these training institutions and oil and gas KIBS firms to ensure that the labor force has the specific industry know-how and skills required. The development of KIBS firms requires a high level of science and technology and high quality human resources. The government should increase the country's talent pool through increased training and education, both academic and vocational. Additionally, the government should promote vocational qualification certificate system and standards. More importantly, communication channels must be established so that skills and capabilities match the requirements of firms.

In this regard, in order to promote competence within the Norwegian Centre of Excellence, the Norwegian Offshore and Drilling Engineering Competence Centre (NODE) was established in 2009 (Sasson and Blomgren, 2011). Given the growing demand for education and training in the oil and gas sector, the Competence Centre provides KIBS firms with further education opportunities tailored to meet the specific needs of the industry. For instance, to strengthen engineering competencies, the Competence Centre developed bachelor and master-level programs in mechatronics in cooperation with the University of Agder to provide courses tailored specifically to what the industry required. Also, in 2010 a masters level course in logistics and project management directed towards oil and gas suppliers was launched again to fulfill a need in skills required. Trinidad and Tobago can establish a similar institution or encourage its institutions to provide training that meets the industry needs.

7. *Enhancing export capabilities and promoting oil and gas services exports*

Given the decline and variability in activity in the local oil and gas industry and falling international energy prices, the government should actively encourage and support local KIBS firms to enter foreign markets. The export of energy services also presents a sustainable route for long-term development in the absence of oil and gas locally. Moreover, the international market for oil and gas services is huge and growing. The Energy Chamber led trade missions have had some successes in increasing exports, but the program needs to be significantly expanded. Also, while Trinidad and Tobago has established exportTT Ltd to increase the country's exports, the lack of focus specifically on energy services may prevent oil and gas KIBS firms from realizing their true export potential. The experience of oil and gas KIBS firms from Norway and the UK entering foreign markets may provide some lessons for Trinidad and Tobago.

In Norway, oil and gas KIBS firms have successfully entered and established themselves in foreign markets (Sasson and Blomgren, 2011). This has been done through the setting up of foreign subsidiaries. The maturing of oil fields and decreasing production in the Norwegian continental shelf propelled local firms to export oil and gas services. To achieve this, Norway first set up institutions to increase local content and the government then supported KIBS firms to enter foreign markets. The government established the Norwegian Oil and Gas Partners (INTSOK) in 1997 to work with firms throughout the industry, to expand business activities in the international market on the basis of their experience, technology

and expertise. The government and the oil and gas industry financed it jointly. Today INTSOK functions as an international business development agency by effectively promoting the Norwegian offshore industry's capabilities to clients in foreign markets and providing market information to its partners. The focus is on increasing exports of large Norwegian oil and gas KIBS firms as well as SMEs.

Similarly, the UK established the Offshore Supplies Office back in 1973, when the country discovered two major oil fields in the North Sea. This was to ensure that UK KIBS firms benefited from the oil discoveries and could compete with international suppliers on equal terms. The office audited and monitored purchases made by exploration and production firms operating in the UK North Sea and was required to submit quarterly reports listing the names of successful bidders and the list of UK firms which had bid on the contract or had been approached. While the government did not have penalties for low levels of local content, it was expected that these oil exploration and production companies would find it difficult to be successful in future bid rounds. Following this, during the 1990s the country's strategy for the energy services sector changed from increasing local content to supporting local KIBS firms to enter export markets as the North Sea oilfields had begun to mature. The government set up the Oil and Gas Taskforce in 1998, now called PILOT, to facilitate partnerships between the oil and gas industry and the government. Its aim is to keep the industry competitive and increase exports and to promote continued dialogue between government and industry (Warner, 2011).

8. *Environmental sustainability and protection*

The government of Trinidad and Tobago should set and enforce high environmental standards and regulations for the oil and gas sector. This will not only protect and conserve the environment but also push oil and gas KIBS firms to be at the forefront of environmental sustainability services. This can lead to new investments that improve the conditions under which innovative environmental solutions can be developed and even exported. The case of Norway highlights this push towards innovation and technology development focused on environmental sustainability.

Norway is among world leaders in climate-sensitive, environmentally friendly oil and gas services and exploration and production technology, and is committed to further reducing discharges and emissions (Sasson and Blomgren, 2011). It has done this through two mechanisms: implementing environmentally friendly solutions and continuous introduction of industry standards. Miljø Footprint is a project initiated by NODE to account for environmental challenges in the oil and gas industry and to give the cluster a collective environmental image. Another project, the 'Lighthouse Project', which is supported by the Ministry of Petroleum and Energy, aims to develop environmental standards for the industry that can give it a competitive advantage based on its environmental attractiveness. Additionally Innovation Norway developed a methodology to determine the environmental characteristics of products and services of the oil and gas industry. These initiatives have increased the environmental competence of Norway's oil and gas KIBS firms.

9. Conclusion

Since natural resources are finite, resource rich developing countries should take advantage of the opportunities created by extractive industries. The objective of this paper is to illustrate that extractive industries should not be viewed as isolated enclaves engaged solely in primary activity, but can be real drivers of economic development, particularly through the role-played by KIBS firms. These firms have substantial potential for innovation, productivity and diversification, as well as human capital development and environmental sustainability.

The study showed that while Trinidad and Tobago's oil and gas sector makes important contributions to GDP, government revenue and exports, but contributes little to employment, the energy services sector is growing and its share of GDP has been increasing, although only slightly since 2001. Furthermore, the energy services sector employs about one third of all oil and gas sector workers. There are also approximately 20-30 local KIBS firms with the capability and expertise for exports around drilling exploration and development wells, while other services with export potential include construction, port development, rig positioning, logistics, inspection, pipeline and subsea services.

The findings of the study also show that Trinidad and Tobago has been steadily building its institutional capacity for the supply of knowledge and the government has established and supported a number of STI based institutions. However, the study also indicates that there is not enough initiative and incentives in stimulating the demand for knowledge and creating the necessary linkages and interactions between actors to allow for knowledge sharing and spillovers, particularly from the public knowledge base. Nevertheless, the paper shows that Trinidad and Tobago oil and gas KIBS firms act as facilitators, sources and carriers of knowledge and innovation within the extractive sector, other sectors and the country's national STI system. Moreover, the case of Sadhna Petroleum Services and Tucker Energy Services illustrate that local firms are facilitators, carriers and sources of knowledge and innovation within the domestic economy and regionally, and even internationally.

Based on the primary data collected, the study found that market and other external information sources were the most widely used source of knowledge for innovation by the firms surveyed, followed by sources internal to the firm, while public sector sources were the least used. In terms of innovation co-operation customers were the most used partner for collaboration followed by government and public research institutions, then suppliers, consultants, commercial labs, or private R&D institutes and other enterprises within the firm's enterprise group. While, the least used partners for innovation co-operation were competitors and universities or other higher education institutions.

The study showed that oil and gas KIBS firms operating in Trinidad and Tobago are product and process innovators. Moreover, the majority of the product innovations are new to the domestic market. The product innovations introduced positively impacted firm performance in terms of sales, quality of products, new customers, exports and productivity. Nevertheless, the majority of the product innovations came from

external knowledge sources through imported and licensed technology. On the other hand, fewer firms reported that their process innovation improved firm performance but improved health safety and environmental standards and were perhaps more a matter of necessity to meet regulatory requirements. In terms of innovative activity, a much lower percent of firms engage in innovative activity, which brings about internal knowledge creation and innovation compared to the percent of firms that introduced product and process innovation.

This paper indicates that oil and gas KIBS firms represent significant opportunity for diversification of the Trinidad and Tobago economy, since energy services can be applied to other sectors and have export potential. The case of TOFCO illustrates that diversification into new sub-sectors within the oil and gas services sector, as well as new sectors outside of oil and gas services, is taking place. Another finding is that Trinidad and Tobago's oil and gas sector has contributed tremendously to human capital development within the oil and gas sector and outside as well. The country has a highly trained and experienced workforce with internationally recognized skills that are required in the oil and gas sector. Additionally, oil and gas KIBS firms, which take the form of specialized research institutions directly, contribute to employment capabilities and human resource development, with great potential for export of knowledge services, as shown in the case study of Kenson School of Production Technology. The study also showed that Trinidad and Tobago's oil and gas sector contributes significantly to environmental degradation and pollution. Nevertheless, this has resulted in the emergence of local oil and gas KIBS firms with the capabilities and skills for environmental preservation and sustainability, as demonstrated by the examples of Oil Mop Environmental Services and Kaizen Environmental Services Trinidad.

The study found that there are many lessons to be learnt from Trinidad and Tobago's extractive sector. Trinidad and Tobago has made full use of its oil and gas resources by successfully diversifying away from a solely oil based economy to monetizing its gas resources, followed by the establishment of its well-developed downstream petrochemical sector. This provides opportunities for KIBS firms to operate and share knowledge and engage in innovation along the entire oil and gas value chain. The country has a local content strategy with a long-term vision of diversification away from the extractive sector by using oil and gas resources in order to reduce reliance on the sector. The strategy recognizes that local capability development requires a period of special preference in terms of participation and training, and diversification requires support measures for local firms to capture new business opportunities. Trinidad and Tobago's local content strategy also recognizes that foreign content and encouraging foreign firms to form joint ventures with local firms is important for growing and developing the sector.

In terms of room for improvement, the study found that there is a lack of data on the energy services sector and future trends to inform decision-making. Also, Trinidad and Tobago's local content policy lacks the legislative provisions to ensure compliance and dedicated resources to monitor implementation and measure targets. The country's National STI system includes many suppliers of information. However, the demand and transfer of information is limited particularly from the public knowledge base. Additionally, there is a lack of government policy to develop and encourage knowledge sharing and collaborative

learning, and to foster innovation and technology transfer. Also, while the government and private sector have expanded educational and training opportunities, there is not a close alignment between training institutions and oil and gas KIBS firms to ensure that the labor force has the specific industry know-how and skills required. There is also a lack of funding and support for R&D and other innovative activity. Lastly, there is a lack of government policy and the necessary institutions to encourage new business creation, exports of energy services and environmental sustainability and protection.

The paper recommends that in transitioning from an extractive to knowledge-based economy, Trinidad and Tobago's public policies must focus on science, technology and innovation and at creating and diffusing knowledge. Innovation policy has become a central theme of industrial policy and increasingly the term is being used to replace it. Policy in an innovation systems approach is focused on linkages and interactions within and among actors in the national STI, together with action that will improve the innovation output and productivity of the entire economy. It seeks to build a country's knowledge base through increasing the knowledge infrastructure and human capital development, stimulate the demand for knowledge and knowledge sharing and stimulate entrepreneurial activity and exports. Also, the relevant data must be made available for research and to inform decision-making.

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APPENDIX

Knowledge intensive business services in the oil and gas sector in Trinidad and Tobago

A study by the Sir Arthur Lewis Institute of Social and Economic Studies on behalf of the Inter-American Development Bank

Questionnaire

1. GENERAL INFORMATION

1. Name of respondent:

2. Job title:

3. Phone:

4. E-mail:

5. Name of firm:

6. Year firm was established:

7. Type of firm:

☐ Sole proprietorship
☐ Partnership
☐ Public limited liability company
☐ Private limited liability company
☐ Government
☐ Cooperative
☐ Other, **specify**

8. Is the firm:

☐ Locally owned ☐ Foreign owned ☐ Mixed ownership (local and foreign)

8.1. Ownership of Equity:

% **National:**

% Foreign	Country

9. Is your firm part of larger establishment? ☐ **Yes** ☐ **No**
(If answer is 'No', go to question 10)

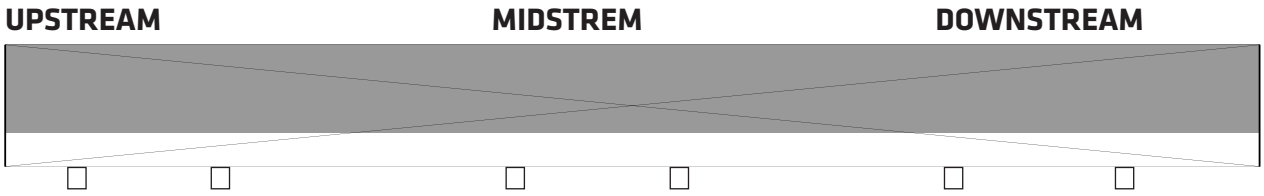
9.1. In what country is the larger establishment based?

10. Please give the following basic general information on your firm:
10.1. Number of employees, as at end of last financial year:
10.2. Annual sales (in US$), as at end of last financial year:
10.3. Annual exports (in US$), as at end of last financial year:

11. How many customers do you have?

12. How many services does the firm offer?

13. At what stage of the oil and gas value chain are services offered (tick box(es) below)?



14. In which geographic markets did your firm sell goods and services in the last financial year and what is the contribution to total sales?

Geographic location		**% of total sales**
Trinidad and Tobago	☐ Yes ☐ No	
CARICOM[12] (excluding T&T)	☐ Yes ☐ No	
Latin America	☐ Yes ☐ No	
US	☐ Yes ☐ No	
Europe	☐ Yes ☐ No	
Africa	☐ Yes ☐ No	
Other (specify):	☐ Yes ☐ No	

15. How much capital is invested in the firm (in US$)?

16. How much long term debt does the firm have? (in US$)

17. What do you estimate your return on capital invested to be over the last five years (2010-2014)?

2. INNOVATION13 AND INNOVATIVE ACTIVITY[14]

2.1. Sources of information and co-operation for innovation activities

18. Does your firm have a specific, formal innovation strategy? ☐ **Yes** ☐ **No**

29. Does your firm have a formal structure or process for making innovation happen?
☐ **Yes** ☐ **No**

20. Does your firm have a department or a group of persons dedicated to innovative activity?
☐ **Yes** ☐ **No**

21. Does your firm have a dedicated full-time leader for innovation projects? ☐ **Yes** ☐ **No**

22. Does your firm use any of the following information sources for innovation activities ?

a) Within the firm enterprise or enterprise group ☐ **Yes** ☐ **No**
b) Suppliers of equipment, materials, components, or software ☐ **Yes** ☐ **No**
c) Clients/customers ☐ **Yes** ☐ **No**
d) Competitors/other enterprises in your sector ☐ **Yes** ☐ **No**
e) Market sources ☐ **Yes** ☐ **No**
f) Consultants, commercial labs, or private R&D institutes ☐ **Yes** ☐ **No**
g) Universities or other higher education institutions ☐ **Yes** ☐ **No**
h) Government or public research institutes ☐ **Yes** ☐ **No**
i) Conferences, trade fairs, exhibitions ☐ **Yes** ☐ **No**
j) Scientific journals and trade/technical publications ☐ **Yes** ☐ **No**
k) Professional and industry associations ☐ **Yes** ☐ **No**

2.2. Product innovation[15]

24. What types of services are provided?

12. Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago.
13. An innovation has been implemented, if it has been introduced on the market (product innovation) or used within a production process (process innovation). The product or process should be new (or significantly improved) to the enterprise (it does not necessarily have to be new to the enterprise's market).
14. Innovative activities are all those steps necessary to develop and implement technologically new or improved products or processes.
15. Product innovation is the creation and subsequent introduction of a good or service that is either new, or an improved version of previous goods or services.

☐ Only services demanded by client companies
☐ Services that may not have been demanded before
☐ Both

25. Do you ever offer services that a potential client company does not, at that point in time, use?

☐ **Yes** ☐ **No**

26.1. How successful have you been in getting such new services accepted?

Never				**Always**
☐ **1**	☐ **2**	☐ **3**	☐ **4**	☐ **5**

27. Has your firm introduced a new or significantly improved good/service in the last 5 years?

☐ **Yes** ☐ **No**

If yes, please provide product innovation information on table below

If answer is 'No', go directly to Section 2.3.

28. Were any of these new of significantly improves good/service successful?

Product innovation	
Was the technology imported?	☐ Yes ☐ No
Were new machinery/equipment/ software bought to contribute to the improvement?	☐ Yes ☐ No
Was the improved or new machinery, equipment or software the result of the use of a licensed technology?	☐ Yes ☐ No

Did the improvement or new service require changes in the: a)firm production methods	☐ Yes ☐ No
b)firm processes	☐ Yes ☐ No
c)firm organizational structure	☐ Yes ☐ No
Did the improvement or new service require: a) new employees	☐ Yes ☐ No
b) new knowledge and skills	☐ Yes ☐ No
c) training	☐ Yes ☐ No
Did the improvement or new service: a) increase the number of services offered to the market	☐ Yes ☐ No
b) increase the quality of the services offered	☐ Yes ☐ No
c) increase sales	☐ Yes ☐ No
d) increase the number of new customers	☐ Yes ☐ No
e) increase exports	☐ Yes ☐ No
f) reduced average cost	☐ Yes ☐ No
How was the innovation/technology financed? a) own resources	☐ Yes ☐ No
b) private partners	☐ Yes ☐ No
c) public sources	☐ Yes ☐ No

2.3. Process innovation

28. Did your firm introduce new or significantly improved methods of manufacturing or producing goods or services in the last 3 years? ☐ **Yes** ☐ **No**

29. Did your firm introduce new or significantly improved logistics, marketing, delivery or distribution methods for your inputs, goods or services in the last 3 years? ☐ **Yes** ☐ **No**

30. Did your firm introduce new or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing in the last 3 years? ☐ **Yes** ☐ **No**

If answer to ALL questions under 2.2 is 'No', go to section 2.4.

31. Did any of the above innovations covered under 2.2

a) Reduce input materials and energy per unit output?

No **Significantly**

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

b) Labor costs per unit of output?

No **Significantly**

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

c) Reduce environmental impacts or improved health and safety effects?

No **Significantly**

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

d) Meet regulatory requirements?

No **Significantly**

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

32. Did your firm co-operate[16] on any of your innovation activities (product and process) with the following institutions?

a) Other enterprises within your enterprise group ☐ **Yes** ☐ **No**

b) Suppliers of equipment, materials, components or software ☐ **Yes** ☐ **No**

c) Clients or customers ☐ **Yes** ☐ **No**

d) Competitors or other enterprises in your sector ☐ **Yes** ☐ **No**

e) Consultants, commercial labs, or private R&D institutes ☐ **Yes** ☐ **No**

f) Universities or other higher education institutions ☐ **Yes** ☐ **No**

g) Government or public research institutes ☐ **Yes** ☐ **No**

16. Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation.

2.4. Factors hampering innovation activities

33. Did your firm successfully file patents/trademark/industrial design/copyright registration in the last 3 years? ☐ **Yes** ☐ **No**

34. Does your firm have a dedicated innovation or R&D budget? ☐ **Yes** ☐ **No**

35. What percentage of annual expenses is allocated to innovation activities?

36. What are the obstacles faced by your firm for innovation?

a) ☐ organizational/managerial culture
b) ☐ finances
c) ☐ public funding
d) ☐ labor force skills and qualifications
e) ☐ protection against copycats
f) ☐ level of information on available technologies
g) ☐ compliance requirements to international standards
h) ☐ international competition
i) ☐ cooperation with partners
j) ☐ lack of information on markets
k) ☐ difficulty in finding cooperation partners for innovation
l) ☐ market dominated by established enterprises
m) ☐ uncertain demand for innovative goods or services

37. How much competition/rivalry is posed by foreign oil and gas service firms?

None **A great deal**

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

38. Is there a preference for companies to use local suppliers as opposed to foreign suppliers?

None **A great deal**

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

39. Do foreign oil and gas service companies enjoy any of the following benefits/ competitive advantages over local firms?

a) government support ☐ **Yes** ☐ **No**

b) greater experience/knowledge/know-how in the sector ☐ **Yes** ☐ **No**

c) access to more skilled and knowledgeable workers ☐ **Yes** ☐ **No**

d) greater access to latest information in the sector ☐ **Yes** ☐ **No**

e) greater access to market information ☐ **Yes** ☐ **No**

f) greater access to finance ☐ **Yes** ☐ **No**

g) other ☐ **Yes (specify) .....** ☐ **No**

40. Has Trinidad and Tobago's local content policy resulted in your firm being more innovative? ☐ **Yes** ☐ **No**

41. Can any of the following policies/programs improve innovation undertaken by oil and gas service providers?

a) communication between your firm and clients on the goods/services required ☐ **Yes** ☐ **No**

b) collaboration on R&D with universities and other research institutions ☐ **Yes** ☐ **No**

c) funding for innovation ☐ **Yes** ☐ **No**

d) increasing knowledge and skills of the workforce ☐ **Yes** ☐ **No**

e) trade missions ☐ **Yes** ☐ **No**

f) public private partnerships ☐ **Yes** ☐ **No**

g) other ☐ **Yes (specify) .....** ☐ **No**

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