INTERNATIONAL HELLENIC UNIVERSITY

Dissertation Roadmap

"THE TECHNOLOGY FORESIGHT IN THE OIL AND GAS INDUSTRY – AN EXPLORATORY OVERVIEW OF THE ENERGY FIELD."

Evangelos Trilivas

SID: 3303180008

SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

Master of Science (MSc) in Energy and Finance

NOVEMBER 2019

THESSALONIKI – GREECE

(Final Report)

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Evangelos Trilivas

SID: 3303180008

Supervisor:	Prof. Charisios Achillas
Supervising Committee Members:	Assoc. Prof. Name Surname
	Assist. Prof. Name Surname

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Abstract

The topic which has been thoroughly examined is the Technology Foresight in Oil and Gas industry an exploratory overview in the Energy Field focusing in worldwide shipping trading of fossil fuels and in detail Crude Oil and Natural Gas.

The supervisor during the preparation of the dissertation was Mr. Achillas Charisios who was one of the responsible professors for the Project Management Classes. The sources which will be used will be referred on the pages to follow.

Evangelos Trilivas

Date: 08November2019

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Acronyms and Abbreviations

3-D : Three dimensional

CAGR : Compound Annual Growth Rate

CNOOC: China National Offshore Oil Corporation

CPS : Cyber Physical Systems

CSR : Corporate Social Responsibility

DOE : Department of Energy

ECA : Emission Control Areas

EEDI : Energy Efficiency Design Index

EGCS : Exhaust Gas Cleaning System

FAA : Federal Aviation Authority

FSRU : Floating Storage and Re-gasification Units

GDP : Gross Domestic Product

GMP : Gas Master Plan

GTL : Gas to Liquids

HSFO : Heavy Sulfur Fuel Oil

IATA : International Air Transport Association

ICT : Information and Communication Technology

IEA : International Energy Agency

IMO : International Maritime Organization

LNG : Liquefied Natural Gas

LSFO : Low Sulfur Fuel Oil

MMBtu: Million British Thermal Units

MTOE : Million Tons of Oil Equivalent

O & G : Oil and Gas

OECD : Organization for Economic Cooperation Development

OPEC : Oil Producing and Exporting Countries

QABP : Qatar Advanced Biofuel Platform

SEEMP: Ship Energy-Efficient Management Plan

Chapter 1: Introduction

1.1 Background Study

The majority of industries have made use of existing opportunities to develop novel markets and products to meet the growing global demand and keep as well as satiate the growing need for innovations demanded by the consumers. However, the oil and gas sector has been lagging a factor that has resulted in the oil and gas (O&G) industry not exploiting the inherent abilities of modern technological advances. Currently, the O&G industry is at a critical transformation point and the world on the cusp of an evolution. The main factors that are pushing for the amendment of technologies and different approaches applied in the oil and gas sector are the global push for clean as well as sustainable energy and the rise of novel technologies. This puts organizations in this sector under immense pressure to align their operations in order to unlock barriers as well as enhance overall efficiency.

Sovacool (2016, p. 207) suggests that despite the impact of these factors, the O&G sector has been typically undemanding compared to other industries in the issues of leveraging novel technologies to optimize and innovate its system's performance. While organizations have addressed the lower oil prices with positive approaches meant to reduce the impact on the environment, increase efficiency, and lower operating costs, they should also make these gains sustainable (Chu and Majumdar 2012, p.294- 295). This makes it evident that in order to become significant in the future, the gas and oil industry must transform its operations in light of the existing challenges. It is critical for players in this industry to adopt fully new solutions in order to kick start the industry's technological revolution and attain the highest level of technological advancements.

Over the decades, the O&G industry has had to steer through challenging times; after an extended period of high and increasing rig counts, the 2014 and 2015 fall in oil prices, as well as capital-intensive projects and investments. These conditions forced oil companies that had heavily invested based on promising predictions to reduce or even stop their operations. Responding to the current technological advancements, O&G industry executives should regard digital technologies with the capacity of transforming operations and creating additional revenue from the current capacity. The effective utilization of digitalization in the O&G industry could come a long way in reducing capital expenditure by at least 20%. In addition, this could reduce operating costs by approximately three to five percent. It is critical to note that organizations in the O&G industry were the pioneers of the inaugural digital age as they were utilizing linear programming, advanced process controls, and 3-D seismic long before advanced analytics, the internet, and big data became popular (Strategy and pwc, 2016). The utilization of these technologies enabled these organizations to releasing new hydrocarbon resources and in delivering efficient services across the value chain.

Regardless of the technological lag that has been apparent in the gas and oil industry, the latest technological advancements look promising as they position the organizations in this industry for a second digital era that has the potential of unleashing unmatched productivity, boosting performance, and reducing costs. It is therefore up to the organizations to harness the most suitable technologies to bolster their operational strategies. Embracing and making better use of the existing technologies has the potential of delivering very high returns for these organizations. Adopting a digital approach will position and enable the organizations to venture new growth opportunities since it is evident that this industry is tailor-made for this evolution since its operations extend to diverse regions with lengthened supply chains and intensive capital investments. The clarity, objectivity, and visibility delivered by advanced analytics and digital technologies have the potential of giving the O&G industry operators the ability to increase agility and bolstering enhanced strategic decision-making approaches. The digitalization of the O&G industry will be instrumental in assisting the O&G organizations to reach this potential by bolstering processes in many ways. The majority of O&G industries have begun to harness these facilitators to push for enhanced performance.

The demand for energy has increased by 35% over the past 15 years and it is forecasted to increase by 7% between 2015 and 2030. This is indicative that the demand will be virtually flat mainly because of the stagnated growth in global population, productivity, as well as the continuous growth in energy inefficiency (DNV-GL 2017, p.18). To achieve this, need for continuous investments over this period will be mandatory in order to maintain the production levels necessary to meet the constantly increasing demand. However, the contribution and mix of renewables will grow because of the strong growth in wind and solar energy. From a model developed by DNV GL in their report, it is evident that oil will experience a flat demand over the commencing years with its peak coming in 2022. This increase in demand will be attributed to emerging economies. The largest growth markets in this instance will be India, Sub-Saharan Africa, South East Asia, and China. This will be countered with a decline in demand in the Pacific Organization for Economic Cooperation Development (OECD) nations, Europe, and North America. This decline in demand in these regions will be mainly because of the transitions in the transport market that will result from a shift to electrifying commercial as well as domestic transport and the enhanced efficiency of the next-generation engines powered by diesel and petroleum. Whilst transport being the major demand source of oil, dependence on oil for this purpose is set to decrease from 104j/annum in 2015 to 51Ej/annum by the year 2030 (DNV-GL

2017, p.19). The increasing utilization of electric automobiles will significantly influence this. In 2016, the non-oil energy sources accounted for approximately nine percent of energy utilization in transportation in 2016(DNV-GL 2017, p.19). Moreover, this demand might grow to fifty percent come to 2050. There relatively small direct oil demand in buildings and manufacturing industries and this is set to reduce significantly in both sectors reaching the lows of 9Ej/annum in manufacturing and 2Ej/annum in buildings (DNV-GL 2017).

With regards to gas demands, this has grown significantly over the past three decades and it is forecasted to increase in the coming two decades. In 2017, the demand for gas managed to grow by 3% in comparison to 2016. The high pollution levels in China have seen moves by the government to do away with coal burning in industrial boilers. In the New Policies Scenarios to 2040, the consumption of gas globally increases at an annual averages rate of approximately 1.8% per annum (Boston Consulting Group 2019, p.2). This growth rate might be smaller compared to the 2017 3% growth rate but it is much higher than the typical 0.5% annual growth. According to British Petroleum 2019, p.19), increasing productivity (GDP per person) drives the better part of global growth that elevates at least 2.5 million people from low income and accounts for approximately 80% of the world’s expansion. The British (Petroleum 2019, p.19) report further suggests that emerging economies do account for at least 80% of the global expansion output with India and China accounting for almost half of that growth. Therefore, this qualifies these two countries as potential markets for oil in the future.

The main hurdle in the gas industry is that much of this product is subject to importation and there are no proper and enough infrastructures in place. Greenhouse gas emissions from gas and oil operations inclusive of both methane and carbon dioxide emissions are currently equivalent of about 5,200 million tons of carbon dioxide. There is an emerging robust debate in the scientific community and the public concerning the outcomes of the shale revolution on a number of economic and environmental issues inclusive of climatic changes. On the contrary, the lower supply costs in the natural gas industry have been instrumental in reducing coal consumption in the American power sector. Consequently, this has toned down the carbon dioxide (CO_2) emission levels in the power sector.

Low prices of natural gas have had an influential hand in cutting down electricity prices thus making it harder for the nuclear plants to have lucrative operations. The lower energy prices are bound to increase energy consumption that will ultimately increase emissions. The majority of economic investigations on association between the shale revolution and adverse climatic impacts have focused primarily or exclusively on natural gas. It is quite apparent that a case with excess natural gas will enhance carbon dioxide emissions compared to a case with limited access and resources. With strict climate policies, excess gas cuts down the costs of compliance for the whole economy. However, these authors do fail to regard the potential effects of methane emissions.

Air Transport Department, Cranfield University (n.d. p.6) reports suggest that increasing fuel prices have a significant role in airline costs. Previously, fuel prices were secondary to personnel costs. However, this trend has since changed because of the volatility of the fuel prices. This has, therefore, made the fuel expenses to be the main challenge in the aviation industry because of its high and volatile prices. The International Air Transport Association (IATA) forecasts that these costs are still bound to increase significantly in the future. The report also states that there has been a rapid increase in the prices of jet fuel that have resulted in jet fuel costs to be among the primary expenses in the aviation industry. Similarly, fuel costs for general aircraft users make up between 25% to 45% of the life cycle of operating and owning a small aircraft. Considering that the aviation industry fosters economic growth and provides critical social benefits, it is essential that the industry and the respective policymakers be updated of the past variations and the possible future effects that are triggered by increasing fuel prices. It is evident that carbon constraint policies may lead to an increase in the price of jet fuels because of the growing production costs. Therefore, the comprehension of such operational effects of increasing fuel prices may inform such policies. This report will look into the ways that the increasing fuel prices will affect the operations in the aviation industry.

In the shipping industry, there seems to be an inevitable evolution with regards to the use of O&G since the novel maritime rules are forcing the ship operators to utilize liquefied natural gas (LNG) as a cleaner, greener, and safer alternative. Clark (2018 p.1) suggests that the International Maritime Organization (IMO) amendments will be implemented in January 2020. The policy will reduce the global allowable sulfur content to 0.5% m/m. This limit is achievable in the following ways; one, through the installation of certified emission technology on the vessels, or two, utilizing energy sources that compile with the 0.5% m/m limit. Bengtsson, Fridell, and Andersson (2012, p.452) are of the opinion that the utilization of LNG is minimizing the emission of sulfur oxides and nitrogen oxides by a significant percentage. This move is a result of the immense pressure put in the maritime industry to reduce its emissions as it plays a significant role in global warming. Apart from global warming, Tietenberg and Lewis (2016, p.510) make it apparent that the wastes from the shipping industry are a health hazard to humans as they expose them to chronic conditions such as cancer and reproductive effects. German Advisory Council on Global Change (1998) report also seconds this claim since according to the report; health conditions such as cancer are mainly attributed to exposures to environmental stress. Environmental stress in this context is caused by pollutants from industries such as shipping.

Despite these challenges, Lorange (2005) suggests that countries are making the needed economic as well as political adjustments to ensure that they remain relevant in the shipping industry. For instance, the economic development in China plays an instrumental role in the global maritime markets since it is relatively easy to do shipping business in this nation as it has implemented the majority of foreign-registered tonnage. Bouwman et al (2004, p.118) are of the opinion that Information and Communication Technology (ICT) plays an instrumental role in reducing costs and increasing productivity in many economic sectors. In O&G organizations, ICT can be helpful in reducing operational costs. Given the concern of increasing oil prices, the question of whether ICT can assist in this regard pops up frequently. The O&G industry experiences very high volatility that affects developing economies, as they are not able to deal with such market conditions. Therefore, determining ICT's role in the O&G industry could be critical in analyzing the economic development views of the developing economies (Rosendahl and Hepsø 2013).

Modern technologies and ICT have provided novel opportunities to enhance economic performance in every stage of the O&G supply chain. It is apparent that these technologies have an influence on both upstream as well as downstream operations in the O&G sector. For instance, in upstream operations, the ICT technologies and other related approaches may provide probabilities for enhancing crude oil extraction rates as well as expanding the existing crude oil reserves and much more. The comprehension of the magnitude in which ICT might assist in extending the lifespan of existing oil reserves as well as helping in discovering new ones may give accurate forecasts regarding future oil supply. This could help bring stability in the industry and hence help in allying the consumers' and the investors' fears and ultimately put downward pressure on oil prices. The study will delve into the facts discussed in this introduction part and the consequent effects that they will have on the O&G industry in the future.

1.2 Purpose of the Study

There is a great and growing demand for gas and oil products. This demand causes their prices to become highly volatile and thus hard to regulate. The gas and oil industry also has a great challenge since it poses a threat to human beings and the environment because of the emission of gases such as methane and carbon dioxide where the latter plays a very instrumental role in the greenhouse effect that increases global warming. Unfortunately, human beings still need O&G products as one of their major suppliers of energy, especially in the transportation sector. It is evident that aviation, as well as the shipping industry, relies heavily on the gas and oil products for their operations. The fuel costs cover over 50% of the total expenditure in the maritime and aviation industry (Airlines of America, 2018). This means that for these industries to help in regulating the emission of toxic gases as a result of using their current energy sources, they have to come up with new engines that utilize different energy sources like electricity or wind or alternatively, they should seek for ways of cleaning the emissions from their vessels (Pinder and Slack, 2004). This study, therefore, purposes to look into the oil and natural gas industry and try to forecast the future of this industry as it faces a lot of challenges mainly because of the strict environmental regulations and the volatility of its prices that adversely affects its market demand (EUCI, 2018). In addition, the study will purpose to examine the different ways that the ICT sector can help in assisting the O&G sector in different ways such as emission reduction and discovery as well as maintenance of already existing wells.

1.3 Aim of Research

The background of this study makes it apparent that the O&G industry is a critical sector in the global economy as the majority of the industries and population depend on O&G as their main source of energy. However, the industry faces a lot of challenges such as competition from alternatives, unstable demand, and prices, as well as numerous environmental rules and regulations. Therefore, the main aim of this study is to try to forecast the future of the oil and gas industry with regard to the challenges that it faces. The study will also make a point of looking into how this industry will affect the aviation and maritime industry and the alternatives that the stakeholders in the transportation industry will have as well as the changes they can make in order to continue using the conventional sources of energy (O&G). Lastly, this study aims at researching on the different ICT enabled strategies that the O&G industry can utilize to alleviate its apparent threats.

1.4 Objectives of the Study

i. To analyze the O&G industry and try to forecast its future
ii. To look into the various factors that threaten the O&G industry
iii. To discuss alternatives to the O&G products
iv. To evaluate the effect that the O&G industry has on the future of the aviation and shipping sector
v. To investigate the different ways that the ICT sector can help the O&G industry in alleviating its current challenges

1.5 Research questions

i. What does the future hold for the O&G industry?
ii. What effects will the environmental regulations have on the O&G industry?

iii. How will the O&G industry affect the aviation and shipping industries?

iv. How will the ICT sector help in enhancing the O&G industry?

1.6 Problem Statement

According to the World Economic Forum (2017), it is evident that the O&G industry has played a significant role in the industrial revolution. This sector has been at the forefront of supporting different technological innovations and inventions, especially in the transport industry. Aviation, as well as shipping industries, typically depend on O&G products for their operations. It is made evident by the significant amounts in terms of expenditure that the aviation and shipping companies utilize in oil and gas products in order to keep their operations up and running. However, despite its economic contribution, the O&G industry still faces challenges because of its unstable market prices, unstable demand, and environmental issues brought about by the emission of gases like methane and carbon dioxide (European Environment Agency 2017).These challenges pose a great threat to this industry and it is critical that different approaches are employed to ensure that the future of the O&G industry is protected as it is of great economic significance in national as well as global scales. Therefore, it is prudent for the relevant stakeholders to look into these mentioned challenges and try to come up with viable solutions. These solutions will play a significant role in securing the energy needs of the future while ensuring that there is a decrease in pollution and an increase in the generation of clean or green energy.

1.7 Significance of the study

Securing the future for the coming generations is a very critical factor that raises a lot of concern. It is critical to note that among the ways of securing a better and sustainable future is through maintaining a healthy environment as well as ensuring that there are reliable and effective energy sources that will help in running the economy. Over the past years, non-renewable resources such as oil and gas have been the main sources of energy. However, emissions, especially from the oil-based machinery, pose a great threat to the global environment as they facilitate the greenhouse effect (European Environment Agency 2017). Aside from this, the volatile market prices experienced in the O&G sector makes individuals, as well as organizations, opt to utilize alternative sources of energy such as electricity, solar, or wind (British Petroleum 2019). This study, therefore, is significant in the essence that it addresses these shortcomings and informs the relevant stakeholders about the future of the gas and oil industry in relation to the changes that need to be made as well as those that are already implemented to secure the future of this industry. The research will delve into maritime and aviation regulations aimed at reducing pollution, effective ways that ICT can help in improving the O&G industry, how LNG will help in pollution reduction, as well as factors that affect the demand for oil and gas. Studying these factors is critical, as it will come a long way in forecasting the future of the O&G industry, which is a very significant sector in the global economy.

1.8 Dissertation Structure

This study will start with the introduction part that contains the background of the study and in this section; there will be critical discussions of the various aspects that affect the O&G industry. This discussion will enable the readers to get a general outlook of what the study intends to address. Afterward, the research paper will define the aims, objectives, significance, and purpose of conducting the research. These will act as guidelines to the readers as they will help them in discerning the specifics of the research work. The literature review section will then precede and in this section, the study will look into different journals, books, articles, and other relevant sources that will help discuss the topic in question. These materials will act as secondary sources of information that will help in conducting quantitative analysis. The next section of this study will be the methodology part that will help in informing the readers of the different approaches that the study will utilize in the collection and analysis of data. Afterward, there will be the analysis of data and finally, there will be a discussion of the results that will help in providing recommendations after which the study will be concluded.

Chapter 2: Literature Review

2.1 Oil and Natural Gas Demand

2.1.1 Oil Demand

According to the International Energy Agency (IEA), there was a decrease in oil demand from 2018 to 2019. 2018's oil demand was revised downward by almost 70,000 barrels per day (b/d) to approximately 1.2 million b/d. In addition, its forecast for 2019 was also reduced by 90,000 b/d to 1.3 million b/d. these revised estimates are as a result of the looming trade wars between China and the U.S. these wars have triggered tension in the Middle East thus affecting oil production. McKinsey (2019) echoes this suggestion and further states that the volatile prices as a result of the trade wars between China and the U.S. have been instrumental in the effect on demand for oil on a global scale.

According to a report by OPEC (2012), there exists a divergence between Organization for Economic Cooperation (OECD) nations and non-OECD nations since the oil demand for the latter managed to grow by approximately 930,000 b/d annually. Non- OECD countries that have this high demand for oil include Russia, China, and India. The demand across the 36 OECD member nations declined by 300,000 b/d. However, the report by British Petroleum (2019) suggests that it is critical to note that this effect was mainly felt within the Asian as well as European OECD members since oil consumption in the United States increased. With this regard, McKinsey (2019, p.25) suggests that although OPEC will have dominance in dictating the oil supply and demand growth, non-OPEC supply will increase less rapidly mainly because of the utilization of biofuels as well as other unconventional supplies. Consequently, McKinsey (2019, p.25) further states that the core consumption of oil will shift to Asia whilst the core production of this commodity will shift to the Middle East. It is, therefore, apparent that there is a need for continuous investments for the supply of oil in order to satisfy the anticipated demand growth for the commodity since energy security remains an instrumental driver of policy.

The IEA report also revealed that there was a global supply drop in April 2019 of 300,000b/d. The main producers who contributed to this downfall were Canada, Azerbaijan, and Iran. Growth in the production and supply by the non-OPEC countries is set to increase by 1.9 million b/d versus 2018's 2.8 million b/d. This is proof that the decrease in demand for oil products is imminent. A report by (OPEC 2017) in the case of Iran, which used to be OPEC's third-largest producer, the decrease in its production is not because of decreased demand but it is mainly attributed to the U.S. sanctions. Concerning this drawback, Weisbrot and Sachs (2019) state that the lagging growth in supply and demand because of the sanctions is developing challenges for the OPEC and group of countries that had hoped to end their oil supply restrains as soon as possible. Instead, the EIA, IEA, as well as OPEC have maintained that they will not extend their output cuts at least until the end of 2019. However Gross (2019) suggests that despite the challenges faced in the oil industry, there was an increase in oil demand especially in developing countries in 2018. A report by B.P (2019) purports that China and India accounted for 0.7 million b/d and 0.3 million b/d respectively. This was almost two-thirds of the world's demand increase for oil. In addition, the United States experienced a 0.5 million b/d growth in the demand for oil. This was attributed to the increase in the demand for ethane.

The growing significance of petrochemicals in pushing demand for oil was also apparent in the global product breakdown since products with a close relation to petrochemicals (LPG, naphtha, and ethane) accounted for almost 50% of the net growth in demand in 2018. Therefore, according to B.P (2019), the subsequent limited demand in 2019 is attributed to the worsening forecasts of the world trade; however, IEA expects the developing countries to boost this growth towards 2020. In addition, B.P (2019, p. 4) reports that the oil market from the third quarter or 2018 experienced high volatility attributed to the spreads, quality of spreads, as well as price levels. After reaching highs of $71 per barrel and $85 per barrel in October, monthly WTI and Brent prices ended the year at $49 per barrel and $57 per barrel respectively. During the same time, the time spreads shifted from moving backward to contango since the inventories increased above their five-year average and the expectations for global demand became worse despite a substantial increase in supplies. OPEC’s policy reversal in the third quarter of 2018 and the consequent steady decrease in non-OPEC and OPEC production that proceeded, aggravated by the year that U.S. shale supply increased rapidly, accompanied by low demand, have led to stock build ups that have caused the current market imbalance in the oil industry. Despite this imbalance and the 2019 supply outlook, the biggest uncertainty in the oil industry remains as demand for oil and the global economic prospects. Currently, according to (B.P 2019, p. 2),it is evident that the OECD countries are losing their thrust, while the trade tension between America and China and the decrease in the growth of exports are all bearish aspects of the market that are bound to affect adversely the demand and supply of oil.

Xu (2019, p. 26) purports that the demand for oil is yet to exhibit strong growth signs in 2019 and therefore, it is expected to remain strong at 1.4 million b/d, with most of the growth anticipated to originate from the developing economies. According to forecasts by Xu (2019), the oil market in 2019 should return to normalcy with price Brent prices anticipated to recover to $68 per barrel on a yearly basis. However, the underlying forces of demand and supply that move the anticipated price recovery will still be volatile.

2.1.2 Natural Gas Demand

When considering all the fossil fuels, natural gas happens to be the one that has the lowest emissions of carbon dioxide per unit of consumed energy. Consequently, natural gas is among the most popular fuels for nations that advocate for lower carbon dioxide emissions. For at least 15 years, the growth in the demand for natural gas has grown significantly. This growth is six times more compared to the tripling of global oil consumption during the same period. Below is a graphical illustration of the growth in the demand for natural gas from 1965 to 2018. The illustration makes it evident that this demand has been interrupted for many decades.

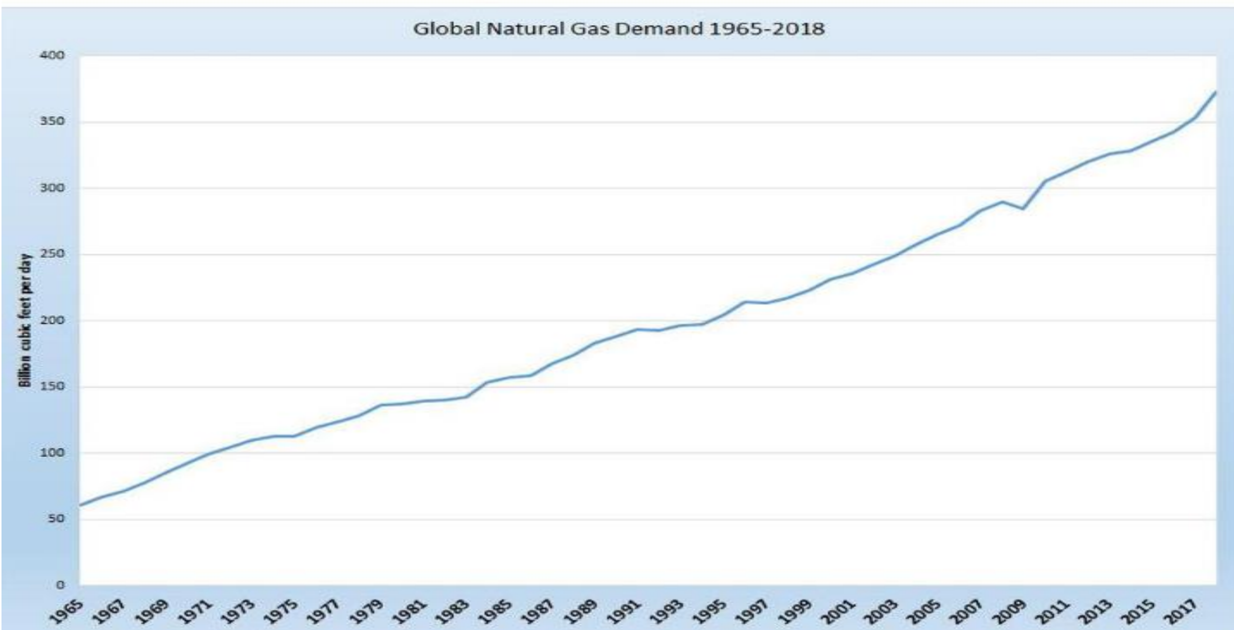

Figure 2.1 Global Natural Gas Demand from 1965 to 2008. (Rapier, 2019)

Rapier (2019) suggests that America remains the global leader in the production as well as consumption of natural gas. In 2018, the United States consumed approximately 79.1 billion cubic feet of natural gas. This was nearly the natural gas consumption of the entire Asian Pacific, which consumed about 79.9 billion cubic feet and 80% in excess of Russia's 44.0 billion cubic feet. This difference is very significant bearing in mind that Russia precedes America as the second-largest consumer of natural gas globally. Apart from Europe that had a 1% decline in natural gas demand, the consumption of natural gas in other global regions is increasing significantly. The average per annum natural gas consumption in the Middle East has grown by 5.6 while in Asia, this demand increased by 5%.

Greenlay (2019) suggests that the Shale gas boom managed to assist the United States to become the world's number one producer of natural gas. In 2005, Russia was leading in this field, as the U.S. was second in line. However, between 2005 and 2018, America had a 70% increase in its natural gas production and thus became the leading producer in this niche. According to Rapier (2019), America managed to produce 21.5% of the world's natural gas while Russia managed to produce 17.8%in 2018. Below is a graphical illustration the U.S., Russia, and the Middle East production of natural gas from 1985 to 2018

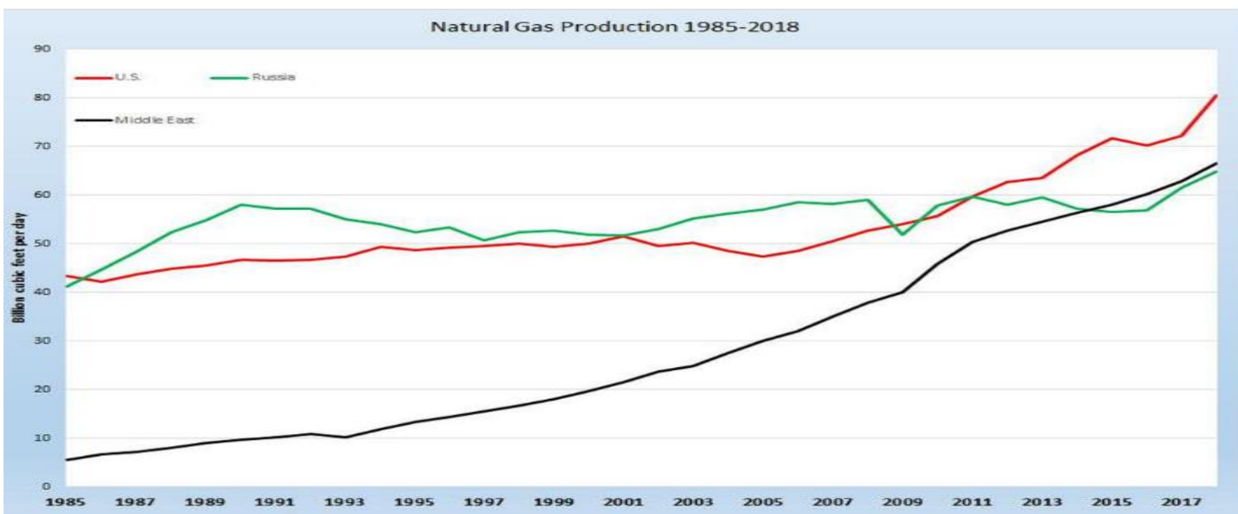

Figure 2.2 Natural Gas Production in the U.S., Russia, and the Middle East from 1985 to 2018 Source (Rapier, 2019)

It is critical to note that the increased production of natural gas is indicative that there is a growing demand for this product. For instance, in the United States, there are growing concerns regarding pollution. This has made several stakeholders vouch for cleaner and greener energy sources. Consequently, there has been an apparent growth in the production and consumption of natural gas in both domestic as well as industrial setups. Despite the U.S. being the leader in natural gas production, Russia dominates in the global trade of this energy source since it accounts for approximately 26% of the global natural gas exports. This statistic by Iea.org (2019) is proof enough that the U.S mainly produces natural gas to meet its growing domestic demand. However, the U.S. is still striving to meet global demands since its natural gas exports are also increasing significantly. From 2017 to 2018, the U.S. LNG exports grew by almost 65%.

Iea.org (2019) supports the fact that the demand for natural gas has been increasing rapidly according to this author, the demand for natural gas increased by almost 4.6% in 2018. The main factors attributed to this growth were the shift away from coal consumption, strong economic growth, and weather-related demand. Gas accounted for almost 50% of the global growth in energy demand. The largest consumers of natural gas in 2018 were the U.S. and China. The adoption of gas due to its growing demand makes it the biggest contributor to the constant meltdown of the coal-powered U.S. energy mix. China, which happens to be the world’s second-largest economy, is also following suit as it aims to enhance its environment by getting rid of air polluting energy sources. The International Energy Agency predicts that in the coming years, China will account for almost 40% of the world’s natural gas demand. In addition, iea.org (2019) forecasts that up to 2024, the demand for natural gas in China will grow by approximately 8% mainly because of slow economic growth in the country.

The majority of the new supply required to meet the globally increasing demand will come from the United States since increasing production from the country’s shale fields has forced drillers to search from new markets. The report by International Gas Union (2019) states that in 2018, the Unites State’s natural gas output surged by approximately 11.5 %. This growth in production as earlier mentioned is mainly because of the steady increase in demand for natural gas. These increasing supplies will reach foreign markets in the form of LNG, which is a form of the natural gas chilled to its liquid form. According to reports by IEA, the U.S. could top Australia and Qatar as the world’s top exporter of LNG by 2024. IEA has forecasted that due to the growing demand for Natural gas, the LNG capacity from Australia, Russia, and the U.S. will constitute 90% of export growth. IEA notes that Qatar has plans to increase LNG production capacity but the nation is yet to confirm the investment.

2.1.3 Oil and Gas Trends

A report done by Markets and Markets (2019) suggests that it is expected that in the coming five years, the compound annual growth rate (CAGR) for natural gas and oil automation market will be at least 6.7% mainly because, in this industry, reliability, and safety are very critical. Currently, the supply chain of the O&G industry automation a necessity since it will assist the producers in the integration of information and provide them with power, control, and safety solutions to enable them to respond appropriately to the dynamic global demand. The model designed by DNV-GL (2017) purports that there will be a decrease in production costs by 2024 mainly because of the automation and digitalization in this industry. Almost 50% of senior oil and gas experts agree the greater use of automation, as well as digitalization, will increase profitability in the oil sector in the coming five years. It is critical to note that with digitalization, the O&G organizations will be able to produce safer products a fact that will increase the demand in the O&G industry.

Research by Naturalgas.org (2013) shows that the coming five years will be setting the pace for gas to become the main energy source as it will be the only fossil fuel to have a peak in demand around 2035. Gas and sustainable energy sources will have an increase in demand since they will play an instrumental role in meeting future environmental requirements such as low carbon dioxide emissions. The majority of large oil organizations purpose to increase the amount of gas in their reserves and these amounts are set to increase significantly in the coming ten years. This move by these organizations is to ensure that they decarbonize their portfolios by investing in cleaner energy such as gas that will have a huge demand in the next ten years. A DNV GL (2017) survey forecasts that North Africa, the Middle East, as well as North East Eurasia will increase their natural gas output come 2040 in order to meet the growing global demand. In addition, this survey states that in order to meet this growing demand there will be a global installation of at least 276,000 kilometers of on-shore pipelines by 2024. This means that there will be an increase in the pace of the midstream projects to meet the demand for integrating the shifting demand and supply geographies. DNV-GL report further suggests that the past 30 years have experienced rapid growth in the global demand for gas and that this growth is bound to continue for the coming two decades. In addition, the author purports that come 2035, the demand for gas will hit a peak that is 14% greater than the one reached in 2017.

Concerning the oil sector, a survey by Barclays (2019) predicts that in the coming 30 years, there will be a significant decrease of 25%in oil demand. This decline will be attributed to the paradigm shifts in sector demand as well as regional energy consumption. However, Roelofsen et al. (2019) suggest that the global oil demand is forecasted to decline by 2050 mainly because of a significant reduction in oil demand from the global transportation industry. This decline in demand for oil by the transportation industry is set to begin from 2025 onwards. However, research done by the African Development Bank (2009) suggests that demand for oil is set to grow in developing economies such as Sub-Saharan Africa and in the Indian Subcontinent. The oil demand for the latter is set to double in the next 15 years due to an increase in the country's transport sector demand for oil. With regards to Pacific OECD, Europe, and North America, DNV-GL (2007) forecasts that the oil refining markets will shrink come 2050 to processing levels that are a third of 2017 production levels.

DNV-GL (2007) further predictions show that the global oil output that was approximately 30,000 million barrels per annum (Mbbl/yr) in 2015 will remain relatively constant in 2020, 2025, as well as 2030 before decreasing to 27,500(Mbbl/yr) in 2035, 24,600(Mbbl/yr) come 2040, 21,500(Mbbl/yr) come 2045, and lastly, 18,400(Mbbl/yr) in 2050. In addition, DNV-GL (2007) suggests that China, which is the current second-largest producer of refined oil, is expected to reduce its net demand to 80% of 2017 production levels by 2050. During this time, it is anticipated that China's oil demand from its power sector will be terminated. China's oil demand is however expected to double come 2030 and ultimately go back to 2017 production levels by 2050. The refinery oil demand in other global regions will also be driven significantly by similar technology and policy shifts in the building and transport sectors.

The IEA however purports that even if governments and other stakeholders take the necessary steps to attain the pledges they have made with the aim of tackling energy insecurity and climate change; the global energy consumption is still forecasted to grow by 36% from 2008 to 2035 rising from 12,300 million tons of oil equivalent (Mtoe) to 16,750 Mtoe. However, the annual demand growth is set to decrease progressively from 1.4% per annum from 2008 to 2020 to approximately 0.9% per annum during the 2020 to 2035 period as those government regulations are implemented. As previously mentioned, emerging as well as developing economies will be the main source of demand since they have higher population growth rates. Growing economies in developing and emerging nations contribute to the rapid growth in the demand for energy because of growing railway and road networks, greater ownership of automobiles, as well as increasingly complex trade logistics.

The IEA (2010) report suggests that the OECD economies' primary global energy demand shares have already decreased from 61% in 1973 to 44% in 2008, and it is forecasted to fall further to almost 33% come 2035 IEA (2010) forecasts that by 2035, fossil fuels (natural gas, oil, and coal) will remain as the cornerstone of global energy consumption. During this period, the oil will be the main fuels with its demand increasing from 85mb/d in 2008 to 99mb/d come 2035. The growth in price pressures in the global market, government incentives and policies aimed at achieving energy efficiency, as well as the costs of carbon emission will prompt the world's energy consumption to swap to low-carbon sources of energy and assist in the restraining of the growth of demand for fossil fuels. Consequently, the global energy consumption of fossil fuels will fall from 33% in 2008 to 28% in 2035.

2.2 Aviation and Shipping Industries and Oil and Gas Industry

Tietenberg and Lewis (2016) suggest that it is evident that the combustible fuels used operate aircraft and ships emit harmful toxic particles and gases when heated in order to produce energy. In addition, these authors insist that these pollutants have a very broad array of health impacts like pulmonary and cardiovascular diseases as well as different types of cancers. According to Pinder and Slack (2004), among the major emission sources of these toxins are the aviation and the shipping industry. Consequently, there has been increased pressure for these transportation industries to ensure that they adopt machinery that can utilize safer energy sources.

Chu and Majumdar (2012, p.294-295) advice that the best alternatives for these industries are the use of renewables, electricity, of LNG thus meaning that there will be a decline in the demand for natural gas and oil. To meet these demands, Sieminski (2016) states that oil and gas producers have been forced to employ technology to ensure that they reduce their global carbon print. In the case of natural gas, organizations have decided to increase the production of LNG that is a safer energy source. The aviation and maritime industries rely heavily on oil and natural gases and their transition to utilize alternative sources will be a major loss for the oil and gas producers.

The DNV-GL survey reports state that from 2020, ship owners and operators must implement the sweeping plans aimed at reducing the sector's greenhouse gas emission by almost 50% come 2050 with 2008 being the base year. After much dragging, oil traders, energy player, and shipping organizations are priming themselves to implement the utilization of cleaner and safer energy sources. Consequently, ship-owners and operators are switching to low sulfur fuel oil. This indicates that the oil refineries will have to advance their technology and produce low sulfur fuel oil in order for them to maintain their competitive edge and market share.

2.2.1 Aviation Industry

According to reports by ICAO (n.d, p.7), the global aviation industry strives at achieving carbon-neutral growth come 2020. In order to attain these objectives, the International Air Transport Association highlighted a four-pillar approach that includes economic measures, infrastructure, technology, as well as operations. Of these pillars, ICAO (n.d) argues that technology seems like the one that will most likely help in the reduction of toxic emission. The report further states that this technology pillar will include enhanced engine technologies, the use of lightweight materials, and the utilization of biofuels that will significantly reduce the greenhouse gas emissions than conventional energy sources.

The report by OPEC (2017, p49) holds a bold view that this factor forces the oil industry organization to enhance their technologies and try to come up with alternatives that will be in line with the post-2020 objective of reducing toxic emission. As discussed earlier, much of the aviation industry expenditure goes to the purchase of fuel and failure to meet their demands would prove to be a huge loss for the oil companies. In addition, non-renewable fuels such as oil are very expensive and volatile. Faa.gov (2011, p10) is of the opinion that this encourages the aviation industry to look for more stable energy sources like renewable ones that promise to reduce volatility in fuel prices.

According to FAA.gov (2011, p.10), the United States Federal Aviation Authority (FAA) dictated that the American airline industry will be consuming 1 billion gallons of renewable jet fuel annually starting from 2018. This objective is comprehensive of the renewable fuel targets for the United States Navy, United States Air Force, as well as the United States commercial aviation. Among the strategies, that FAA intends to implement, including the enhancement of development as well as the utilization of sustainable alternative sources of energy. This makes it evident that the FAA is already willing to adopt new technology and ensure that its operations are not interrupted by environmental rules and regulations concerning environmental safety.

Consequently, O&G companies have to do thorough research and development to ensure that they produce energy sources that will meet the goals of the FAA. This is a mandatory move for the oil and gas companies in order for them to maintain their market share in the aviation industry. In addition, according to FAA.gov (2011, p.11), the FAA intends to make sure that the aviation stakeholders look at the sustainability of the environment in their operations and planning. FAA is clearly discouraging the utilization of toxic energy sources since one of its goals is to reduce the aviation carbon print by using cleaner and greener renewable energy sources. With this as one of the strategies implemented by the FAA, the oil companies have a very difficult task ahead of them since producing more refined oil will mean that the operational and production costs would rise thus triggering a rise in oil prices. To reduce the operational costs, the oil companies will have to invest in technology that will give them a long-term solution to this issue and allow them to continue serving the aviation industry.

Apart from the environmental part, it is also prudent to delve into the economic aspect of this phenomenon. As mentioned earlier, the cost of fuel is the second largest after labor in the aviation industry. For the aviation industry to become more lucrative and expand as well as enhance its operations, it is sagacious that the executives in this industry to reduce their operational costs and they can attain this by the use of alternative energy sources that are less expensive. Currently, the global oil prices are volatile thus making them have adverse effects on their major consumers such as the aviation industry. The constantly rising and volatile prices are forcing aviation companies to seek cheaper alternatives. This ultimately poses a threat to the oil companies thus forcing them to invest in technology that will empower them to start producing cheaper, stable and more affordable energy sources for the aviation industry. To look into the effects that the aviation industry has on the oil and gas industry technologies, this research will look into Qatar Airways and how it is managing to deal with the transition process in collaboration with its fuel suppliers.

2.2.1.1 Qatar Airways Case Study

Qatar's flag carrier Qatar Airways has come to the realization that it is instrumental to help the country surpass the existing industry best practices concerning environmental and fuel management in order to make sure a sustainable future for its surroundings, staff, and the airline in general. According to reports by Qatar Airways (2018, p.49), this airline takes the responsibility of dealing with its impact on the global climate change, non-renewable wastes, and resources, as well as the quality of air. Qatar Airways, therefore, managed to create the innovative four-pillar corporate social responsibility (CSR) strategy that embraces integrated fuel management as well as the environment that eventually lead to sustainable development.

In its effort to attain the goals set by the five-pillar CSR strategy, Word Bank (2012, p.88) purports that the airline had acquired new generation aircraft that include Boeing 787s, Boeing 777s, and Airbus A320, Airbus A321, Airbus A350, as well as Airbus 380. Reports by ATAG (2017) suggest that when compared to a small family car, the Airbus 380 offers more fuel efficiency per passenger. This shows that this multi-billion-dollar investment by Qatar Airways will help further in enhancing the air in the regions of the airline's destinations thus reducing the emission of GHGs. In 2007, this organization was the first in the Middle East to host a visit from a Green Team that carried out a fuel efficiency investigation and presented the results and findings. Subsequently, Qatar Airways (2018, p.71) report notes that Qatar Airways implemented an updated fuel management system that when it was coupled with the airline's modern fleet, the company managed to have one of the lowest carbon footprints among its peers with just 94.5 grams per Revenue Passenger Kilometer (RPK) as opposed to their 109 to 111 grams per RPK (Word Bank 2012, p.91).

It is critical to note that Qatar Airways is an innovator when it comes to matters concerning the research of potential commercial utilization of jet fuel extracted from natural gas as a way of lessening the effects of aviation on both local and global air quality. Word Bank (2012, p.88) states that Qatar Airways has collaborated with organizations such as Shell, Qatar Petroleum, Airbus, Qatar Science & Technology Park, Rolls Royce, as well as Woqod with an aim of testing the utilization of cleaner and safer burning alternative energy sources on commercial flights. In conjunction with its partners, Qatar Airways is striving to develop a jet fuel blend that will include Gas to Liquids (GTL) as an alternative cleaner energy source for the aviation industry. According to World Bank (2012, p.89), Qatar currently has the largest GTL production plant in the world and Qatar Airways aims to be the global leader in the operation of commercial flights that utilize GTL kerosene. The World Bank (2012, p.89) report explains that in 2008, the company's Airbus 380 did the first flight test of s commercial airplane while utilizing GTL jet fuel.

The test flight was from Filton in the United Kingdom to Toulouse in France. In addition, the World Bank report further suggests that in 2009, the company managed to fly an Airbus A340-600 from London to Doha on a 50% blend jet A1 and GTL on all four engines. GTL fuel will, therefore, be probably utilized in a semi-synthetic blend with the conventional energy source. GTL fuel is free from aromatics and sulfur and consequently, the engines of the aircraft using this alternative energy source will emit fewer toxic particles and sulfur. The environmental advantages of this shift are being quantified and will most probably include the enhancement of air quality in airports and their surroundings. This alternative energy source, when compared to the conventional ones, has higher energy content by weight. Such cleaner-burning fuels are a major factor in the future air quality enhancement initiative for the aviation industry. This shows that Qatar Airways has played a very instrumental role in advancing technologies used in the oil and gas industry.

In addition to this, Word Bank (2012, pp. 90-91) purports that Qatar Science & Technology Park Qatar Petroleum, as well as Qatar Airways in 2010 started to jointly conduct an economic and engineering analysis prior to moving on to the creation of sustainable bio-jet fuel while also examining the supply and production approaches with the help of Airbus. Therefore, the launch of Qatar Advanced Biofuel Platform (QABP) was prompted a factor that made Qatar University and Rolls Royce join the project. In its quest to ensure that the technologies utilized by the O&G industry are aligned with their expectations, Word Bank (2012, p.90) suggests that Qatar Airways also collaborated with the United States-based Verno Systems Inc and QSTP and embarked on a very detailed and comprehensive study on suitable BTL jet fuel as well as possible by-products like bio-diesel.

The research analyzed all available bio-feed stock that would not have negative effects on freshwater or food supply chain. It also considered the current and future production approaches via a viability analysis. Based on the outcome of this comprehensive research, these partners agreed on establishing the QABP that leads activities in the following sectors; advanced technology development programs, detailed implementation and engineering plan for economically viable and production of sustainable bio-fuel products, as well as ongoing strategic and market analysis. These activities were mainly developed with the goal of running advanced bio-fuel operations, with Qatar Airways as the main beneficiary or end-user.

QABP was structured to include additional projects, partnerships, technologies, and investments on a global scale. QABP adopts a portfolio methodology in the making of enhanced bio-fuels across geographies, feedstocks, and technologies in order to attain short-term, medium-term, as well as long-term objectives. Through its extensive research, QABP identified specific feedstock that is processed and developed with the objective of providing easy access to BTL jet fuel for the utilization by Qatar Airways. Therefore, with reference to this case study, it is prudent to conclude that Qatar Airways has directly affected the technological advancement in the O&G industry since it has taken the necessary steps to ensure that it meets the set environmental requirements. This organization has managed to identify energy security and decrease its negative environmental impact to secure sustainable development and growth. Currently, the majority of aviation organizations rely on jet fuel derived from crude oil but this is changing since airlines have to use eco-friendly energy sources starting 2020. This factor has prompted the adoption of different technologies by both airline companies as well as oil and gas institutions.

2.2.2 Shipping Industry

The future for the maritime industry has many challenges as well as opportunities especially when considering its energy sources. The main challenge facing this industry is the optimal utilization of sources of energy and the minimization of environmental impacts especially concerning GHG emissions and other pollutants. Lee et al. (2019, p.1) are of the opinion that sustainability matters in the shipping industry have typically received less attention than the aviation sector. However, since the IMO regulations on the shipping sector increased as from 1997, stakeholders in this industry have started taking sustainability matters more seriously.

Technological advances are among the solutions that are helping the shipping industry in solving its environmental challenges and enhance its operational efficiency. Lee et al. (2019, p.4) also attest that the maritime industry has orchestrated rapid technological advancements in the oil and gas industry because of the environmental restrictions that are aimed at minimizing pollution in the waterways used by the shipping organizations. Orszulik (2008, p.367 - 369) purports that concerns regarding climate change have forced legislation to impose limits on GHG emissions. This means that there has to be a reduction in the consumption of energy by ships and they can achieve this through the utilization of cleaner energy sources like LNG. The United Nations (2013, p.66) report argues that this demand for cleaner energy sources by shipping companies prompts the oil and gas organization to invest in R and D as well as modern advanced technologies in order for them to come up with energy alternatives that will be acceptable in the maritime sector.

According to Fataliyev and Mehdiyev, (2018, p.68), the urgent need for the supply of cleaner fuel to the maritime industry has forced oil and gas organizations to invest in novel digital industrial technologies that are bolstered by evolutionary approaches of the Cyber-

Physical Systems (CPS). These integrated systems contain different digital innovation technologies and are poised to bring changes in the maritime industry. The shipping industry is pressurizing the O&G companies to invent technologies that will provide future shipping vessels with superior energy sources that will enhance propulsive efficiency. In addition, the competitiveness witnessed in the European maritime industries forces the maritime organizations to seek energy sources the meet environmental legislation. Consequently, such organizations have to work hand in hand with the oil and gas companies in order to come up with long-lasting solutions to this challenge. Below is a case study of how Maersk has managed to enhance its technologies in order to support its shipping subsidiary.

2.2.2.1 Maersk Case Study

The Maersk Group is a global conglomerate that operates in 130 nations. Apart from owning one of the largest shipping organizations, this company is involved in a broad range of operations in the logistics, shipping, as well as the oil and gas industries. A.P. Møller - Mærsk A/S (2017) states that to be able to meet with the maritime environmental regulations, Maersk Oil and Maersk shipping have taken the initiative of ensuring that the shipping operations remain functional by adopting new technologies that will provide cleaner energy sources. According to Hussain, E. (2011), in order for Maersk to achieve the sustainable energy objective, it had to collaborate with TNO, a Dutch oil and gas company with the aim of developing novel technologies for enhanced oil recovery.

The location of this joint research project was in QSTP in Doha, Qatar where both TNO and Maersk Oil have research centers. However, the operational costs related to the technology needed to produce cleaner energy forced the Maersk Group to demerge Maersk Oil. According to the company's management, this demerger was as a result of the costs of innovation and invention incurred by the subsidiary in trying to adopt technologies that will allow it to come with alternative energy sources that up to the standards set by the International Maritime Organization (IMO). The case study shows the negative effect that the technological advancements have had on some shipping companies since Maersk shipping will now be forced to acquire its fuel from other sources, which might be a bit more expensive.

Analysis of the Maersk case study further reveals the diverse ways in which technology is transforming major operations; in particular, autonomous shipping. According to Jakovlev et al. (2013), new computerized systems are emerging as a tentative solution to remotely control shipping vessels in order to minimize safety risks associated with human error. The researchers further posited that wireless ICT technologies facilitate communications between ships as well as that between ships and the shore. Subsequently, autonomous shipping technologies are lauded not only for their efficiency in navigational tasks but also in promoting safety, security and efficiency of transport levels. A different view, by Kretschmann, Burmeister and Jahn (2017) nonetheless highlights that despite the availability of such technologies, shipping companies will still be required to conduct cost-benefit analyses in order to determine whether they ought to invest in automated ships. However, the researchers observed that upon evaluating the costs and benefits of operating an automated ship against a conventional vessel, the autonomous ship provided higher economic value.

Financial analysis of operating autonomous ships as compared to conventional vessels (Kretschmann, Burmeister and Jahn, 2017) revealed that, over a 25-year period, the cost of operating the autonomous ship was 4.3m USD lower than the conventional vessel. The advantages were attributed to the reduction in crew levels as well as improved design which led to shorter travel periods. Other researchers examine the broader economic advantages of adopting technology in the marine and shipping industry. For instance, Bhardwaj et al. (2019) highlight that technology adoption in the shipping industry is majorly driven by economic rationality whereby, companies base their adoption decision on the efficiency brought about by its use in daily operations.

In the same vein, Schuldt (2011) reports that adopting autonomous logistics is advantageous as it reduces the computational complexity associated with the conventional logistics operation. As such, the central argument raised by the researcher is that, adopting autonomously controlled ships outperforms conventional vessels by increasing the resource utilization efficiency. Consequently, the adoption of technology in managing shipping logistics is observed to be beneficial on multiple accounts; facilitating resource utilization, enhancing automation of shipping operations such as dispatch, reducing safety risks by undertaking risky tasks autonomously and improving the competitiveness of shipping companies. However, Bhardwaj et al. (2019) have argued that before adopting technology, companies also require to assess their readiness in utilizing modern technology in their operations. Without proper preparation, employees are bound to either resist the technology or its use will not generate any benefits in the organization.

2.3 Impact of Maritime and Aviation Industry in Oil and Gas Industry

Maritime Insight (2015, p.13) report states that Europe states are among the most developed in this category meaning that they are the ones that rely heavily on the utilization of their maritime industry mainly because of activities such as importation, exportation, national security, as well as other commercial uses. Therefore, with the strict environmental regulations placed on the aviation and maritime industries, these regions are forced to adapt to new technologies in their oil and gas industries. ATAG (2017, p.14) states that apparently, the EU and the U.S., aviation and maritime industries are having a significant effect on their oil and gas companies. This is mainly because of the IMO advocates for the utilization of greener energy sources. In view of the OPEC (2017, p.14) report, it would be prudent to conclude that the gas and oil sectors in these regions are facing stiff competition from producers of alternative energy sources such as biofuels. The U.S., E.U. agricultural, and oil firms are now researching for long-term projects that would enable them to produce alternative safer sources of energy in order to supply for the maritime and aviation industries.

The competition at this phase in these regions is typically technical since the different organizations are looking for ways of providing the safest energy sources for the maritime and aviation industry. It is therefore critical to note that these two industries have had a significant effect on the gas and oil industries in the E.U., and the U.S. This is because these organizations have to ensure that they carry out thorough research and implement the needed technologies to ensure that they meet the environmental standards set by different stakeholders such as IATA and IMO. Energy (2017, p.30) argues out that among the positive aspects about this shift in preferred energy sources for the maritime industries is that for the production of biofuels, the oil and gas industry can still utilize their existing infrastructure but they have to make little adjustments. However, Popp et al. (2014, p.560) argue that using biofuels for transportation still comes with some challenges since if produced from the existing arable land they may affect food supply. Government policies to promote the utilization of biofuels in the transport industry are under challenges since there are other policies that are vouching for the use of electricity. This poses a great danger to the oil and gas industries in these regions.

Asia has also seen a shift in its oil and gas industry operations mainly because of the aviation and maritime industry environmental regulations. Asian oil and gas producers have also adopted new technologies to enable them to produce and distribute clean energy sources like LNG.

For instance, According to Oil and gas technology (2018), South Korea has recently acquired the ecoSMRT technology and has installed it in its latest LNG carriers. This technology offers efficiency, cost savings, as well as reduction of the carbon footprint in the marine environment. Energy Information Administration (2013), suggests that the National Oil and Gas Organization within Asia like the China National Offshore Oil Corporation (CNOOC), Malaysia's Petronas, Vietnam's PetroVietnam, India's Oil and Natural Gas Corporation (ONGC), and Thailand's PTT have taken the initiative to invest and develop Asia's oil and gas industry to ensure that they produce quality energy sources that the aviation and maritime industries can use. This increased participation by Asian oil and gas organizations to produce greener energy has seen European as well as American oil and gas leading companies to move some of their operations within Asia-Pacific in order to capitalize on the region's expanding market. Kato and Inai (2016) state that some of the notable activities in the region include the acquisition of Papua New Guinea's Inter Oil by Exxon Mobil's, Exxon Mobil and Chevron's bid to invest in Kazakhstan's oil projects, and British Petroleum's prospects to expand the Tangguh LNG project operating in Indonesia. Such are the impacts that the aviation and maritime industries have had on the technological developments in the Asian oil and gas industry.

With regards to the Middle East, Qatar Airways' case study explains it all. It is very apparent that this region's aviation and shipping industries have had a significant impact on the oil and gas organizations. These organizations are already conducting research and development programs to ensure that they are in resonance with the world in terms of providing safe and cleaner sources of energy in the aviation and maritime sector. From analyzing all these regions, it is apparent to note that the status quo of the oil and gas industry has changed mainly because of the regulations given to the aviation and maritime industries. These changes have forced the oil and gas industries to implement novel technologies that will ensure there is minimum emission of toxic gases from transportation vessels such as ships and aircraft. Adoption of these novel technologies will also be beneficial to the oil and gas producing companies since they will be dealing with products that have more stable prices as compared to crude oil that exhibits a lot of price volatility.

2.4 Lock-ins and Barriers

The European Environment Agency (2017, p.45) suggests that the existence of opportunities is not necessarily a leeway of exploiting them since some features that come with such opportunities may cause inevitable challenges or barriers. These challenges may come in the form of lock-ins or barriers. EEA (2017, p.45) defines barriers as apparent challenges that hinder progressive transitions and lock-ins as additional elements that hinder the transition from prior options that have limited the system to specific states or technologies. For example, the existing infrastructure, operational systems, or any related expansion plan is to be regarded as a lock-in. such lock-ins may have adverse effects on different industries since they may hinder or delay the utilization and spread of more sustainable systems or technologies.

The use of fossil fuels is one of the major lock-ins and barriers that are apparent in the shipping industry. The enforcement of the emission laws will be very instrumental in ensuring that there will be the proper transition from the use of conventional energy sources to the utilization of greener and more sustainable energy sources. From this example, it is evident that one of the ways of removing lock-ins and barriers is through the use of influential stakeholders such as IMO. However, to remove such barriers, there has to be viable as well as objective reasons. According to EEA (2017, p.45), another barrier or lock-in is the existence of non-developed ports across the globe.

Nonetheless, some ports still use conventional operational approaches that may not accommodate or serve vessels that are more complicated. For instance, Rojon and Dierperink (2014, p.25) argue that in cargo handling, the use of cranes can be challenging in the majority of wind propulsion equipment since high masts may hamper cranes. It is therefore prudent for IMO to also come up with predetermined standards that all the international ports should adhere to in order to alleviate challenges posed by such barriers and lock-ins.

Similarly, it is also prudent to note that shipping vessels have long life spans that extend to decades. Therefore, this means that some of the operating vessels will have either to undergo modification or face being faced out because of the current IMO emission regulations. However, to overcome such challenges, it would be prudent for the IMO to be making the necessary communications to the shipbuilding companies so that they develop vessels that will be in line with the IMO expectations. This will come a long way in reducing transitional costs as well as losses incurred by the shipping companies.

2.5 Impact of the Growth of Natural Gas on Technology Development

2.5.1 LNG Carriers

Because of enhanced living standards and increasing population, there is a growing demand for energy. Therefore, the trading of natural gas is forecasted to increase at an alarming rate. Unfortunately, the gas reserves are not evenly distributed worldwide thus making it hard for them to address the increasing worldwide demand thus making the utilization of LNG carriers a serious prerequisite. According to energy.gov (2017, p. 162), the trade of LNG is poised to be an instrumental catalyst in global economic growth. It is evident that the development of LNG will stimulate further investment in international as well as national infrastructure. The continuous discovery and extraction of natural gas have brought much focus on the LNG export projects that are mandatory in the monetization of these natural resources. The development of large gas resources is capital intensive and has a host of challenges. The availability of natural gas has fostered the development of Floating Storage and Re-gasification Units (FSRU's) that are utilized in the effective and flexible approaches of receiving as well as processing LNG shipments in order to satiate the world's gas demand in onshore markets. In addition, energy.gov energy.gov (2017, p.6) states that the FSRU's are also used as temporary solutions while companies await the development of onshore facilities.

Natural gas has managed to exhibit promising growth because of its lower prices as well as lower pollutant emissions as compared to other fossil fuels. Among the best options for transporting natural gas is through the utilization of LNG carriers. These carriers are among the complex, most expensive and potentially hazardous vessels that operate across the global oceans. Due to their risky nature of its cargo, these carriers have been built using state of the art technology to ensure the safety of the operators and marine life. The LNG carriers have seven components that make up a comprehensive system that fosters inter-component communication. This technology is mainly used in order to ensure that the natural gas being transported is in the right state and does not pose any danger.

Natural gas is a very sensitive cargo that forced the relative stakeholders to ensure that the LNG carriers are designed to meet certain specifications. This meant that companies that produce the LNG carriers had an obligation of researching on new technologies that would allow them to come up with carriers that would meet the expectation of the LNG carrier owners and their expectations. It is prudent that the demand for LNG gases is growing significantly and that as an energy source; it will be in high demand. This means that the LNG carriers will have to be built in such a way that they can carry enough cargo to meet the global demand. Consequently, there has to be continuous research and development regarding the LNG carriers in order to come up with appropriate technologies that would ensure that these vessels have the ability to carry enough LNG safely.

Cryogenic liquefaction is among the technological advances that came about due to the growing demand for natural gas. This technology allows the LNG carriers to reduce the volume of gas that they transport as compared to the original volume meaning that this technology enables the LNG carriers to meet the growing global demand for natural gas. It is apparent that the LNG market is experiencing significant changes from the overbuilding of the LNG carrier capacity. Many shipping organizations are suffering from the technological changes that result from the growing demand for natural gases that requires larger and more advanced carriers that meet the current IMO requirements.

As such, this has ultimately sabotaged the older ships and carriers that do not meet the stipulated requirements. energy.gov (2017, p.14) suggests that in the 1980s, the LNG carriers had a capacity of 125,000m^3 but new technology increased their capacity to 160,000 – 180,000 m^3 and later on due to the enhanced technology attributed to the growing demand for natural gas, this size increased to 216,000 – 266,000 m^3. However, the largest carries can accommodate up to 6,000,000,000 cubic feet of gas, which is equivalent to a day's average consumption for the whole of the United Kingdom.

The increasing demand and the development of the LNG industry are presenting the shipping industry with great challenges. For instance, relatively new and modern LNG carriers that were developed post-2000 have the risk of being excluded in future long-term charters. Consequently, the shipping companies are forced to convert them to other types of carriers. According to energy.gov (2017, p.14), converting them to FSRU's is the easiest and fastest.

Recently, because of the growing demand for LNG, shipping organizations have opted to convert ships to floating liquefaction (FLNG) facilities. In this manner, such organizations ensure that they remain relevant in the LNG market as they continue sourcing for resources needed to procure enough LNG carriers. energy.gov (2017, p.15) gives an instance a proposal for emerging economies such as Equatorial Guinea as well as Cameroon to convert their out-phased LNG carriers to FLNG facilities. These projects will be beneficial to both economies, as it will allow them shorter marketing time that will be cost-effective.

According to congressional research service (2019, p.8) report, the current energy trends and forecasts suggest that compared to low-sulfur as well as petroleum-based fuels, LNG may be cheaper. However, it is critical o note that the price volatilities in these commodities are correlated in some sense. Since 2008, the production of shale natural gas has significantly reduced natural gas prices in the U.S. the U.S natural gas spot prices at the Henry Hub in 2008 averaged at $3/MMBtu (million British Thermal Units). This price was approximately a quarter of the highest price before the shale was introduced a decade ago.

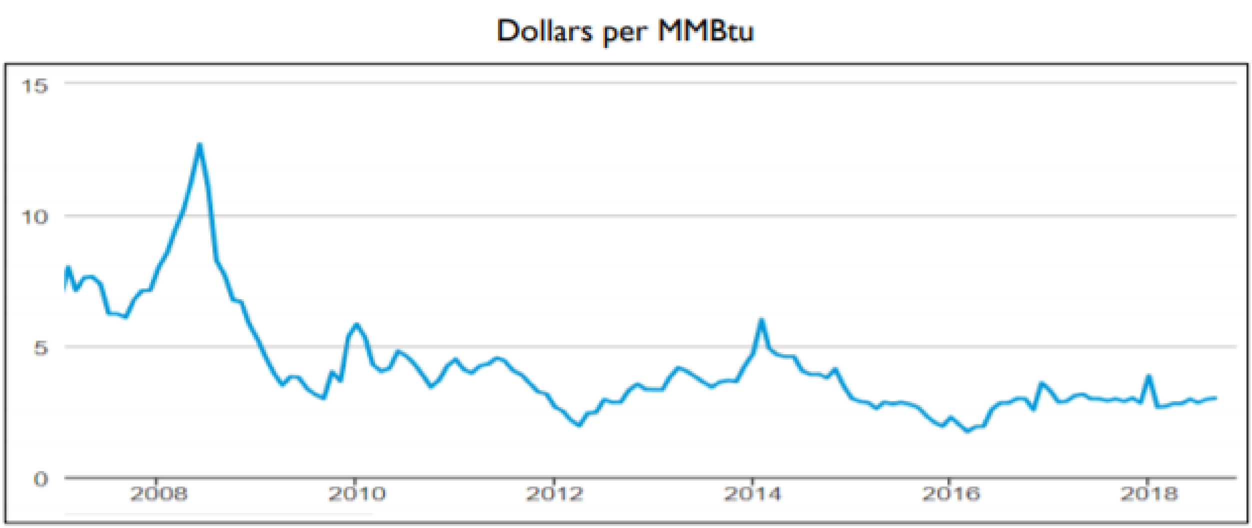

Figure 2.3 Price of natural gas in million British Thermal Units

Source: congressional research service (2019)

Congressional research service (2019, p.8) further suggests that that the conversion of natural gas into LNG adds the production cost by approximately $2/MMBtu. However, with additional service costs and producer charges, the total cost of LNG would be approximately $6/MMBtu. The shipping of LNG to Europe or Asia from the U.S. would increase from $1MMBtu to $2/MMBtu. Therefore, going by the figure above, the price of LNG delivered to overseas ports would cost around $7 to $8/MMBtu.

Regarding the LNG carriers, before one factor in the impact of the IMO regulations, it would cost the shipping companies a number of years before they are able to break even and become lucrative. Congressional research service (2019, p.9) states that by May 2018, the U.S. had 122 LNG carriers with another 135 under construction or ordered. The majority of these vessels were Norwegian flagged since the Norwegian government has subsidized LNG carriers and shipping vessels with the NO_x funds. This fund extends the LNG operated ships with an exception from the nation’s tax on the emission of NO_x.

According to the International Maritime Organization (2016), the IMO regulations are bound to make the demand and supply of LNG to grow significantly a factor that will also increase the demand for LNG carriers. However, according to the DNV-GL 2020 forecast study, the global demand for LNG in the shipping market will not be very high that it would affect the global supply. International Maritime Organization (2016) also states that the comparison of LNG and the shipping fuel cost should be based on the cost of delivering the fuel on the ship tanks. Many variables should be taken into consideration when estimating the price of the LNG bunker. The Henry Hub price is typically the feedstock gas price, every profit margins and costs involved in transportation, storage bunkering, and processing, and the estimates of these costs are dependent on the LNG pathway to the market as well as the supply chain.

Wan et al., (2015) states that in recent years, the importation of LNG in China has shown a continuously increasing trend that managed to reach 18 million tons by 2013. This amount according to Wan et al., (2015) accounts for approximately 47% of the total global LNG importation volume. This high demand for LNG in China has facilitated the global LNG trade and its application in the transport industry and specifically shipping. The figure below shows the growth of demand in LNG in China from 2009 to 2013.

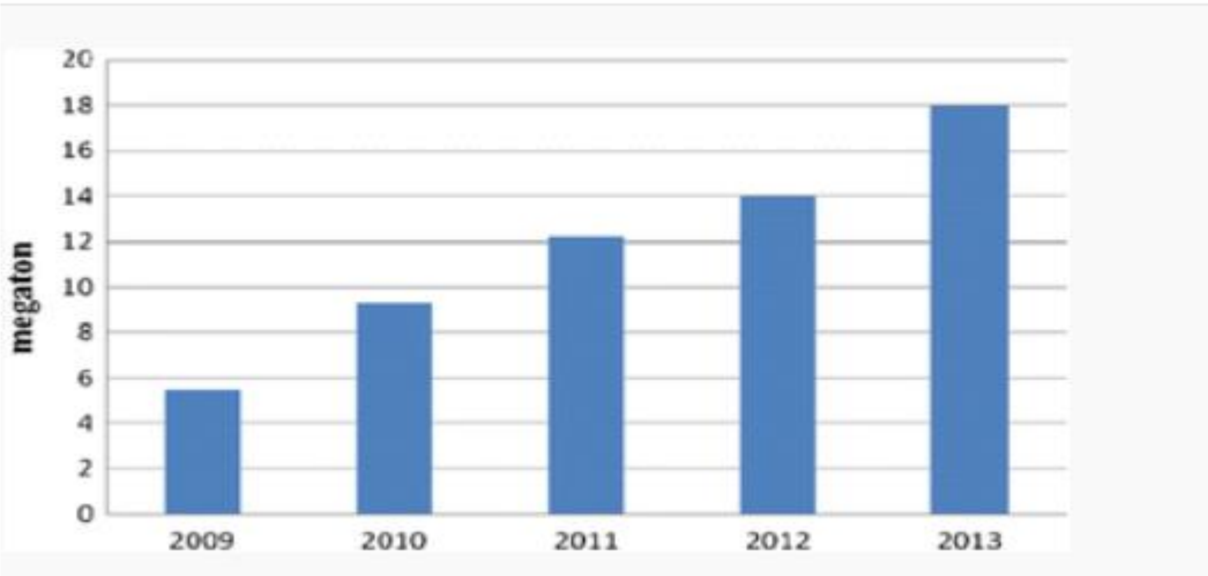

Figure 2.4 Growth of demand in LNG in China from 2009 to 2013
Source: Wan et al. (2015)

Despite the Chinese maritime industry being in its embryonic phases concerning LNG, oil organizations, stakeholders, as well as policymakers have shown tremendous interest in utilizing LNG as a marine fuel. For instance, Wan et al., (2015) suggest that after the IMO regulations, the Chinese shipping industry together with shipping organizations have been doing relevant studies on LNG carriers in inland waterways.

2.5.2 Refineries

Until around 2014, the United States used to import natural gas but this has since changed and the country is one of the leading producers of natural gas. The demand for this product is what prompted the U.S. to invest in the needed technologies to foster the extraction of natural gas. The demand for natural gases made the U.S. refineries invested in novel technology such as horizontal drilling and hydraulic fracturing that has allowed the industry to produce natural gas from low permeability formations such as shale. These technological advances were developed in part by the Department of Energy (DOE) technological investments in the 1980s and in part by the sector's continuous application as well as the development of those technologies. With enhanced work in rock mechanics and the comprehension of fracture propagation and development to improve production, these advances in technology have played a significant role in enhancing production that ultimately addresses the growing demand for natural gas. The figure below is a graphical illustration of how technological advances attributed to the demand for natural gas have affected its production in the United States.

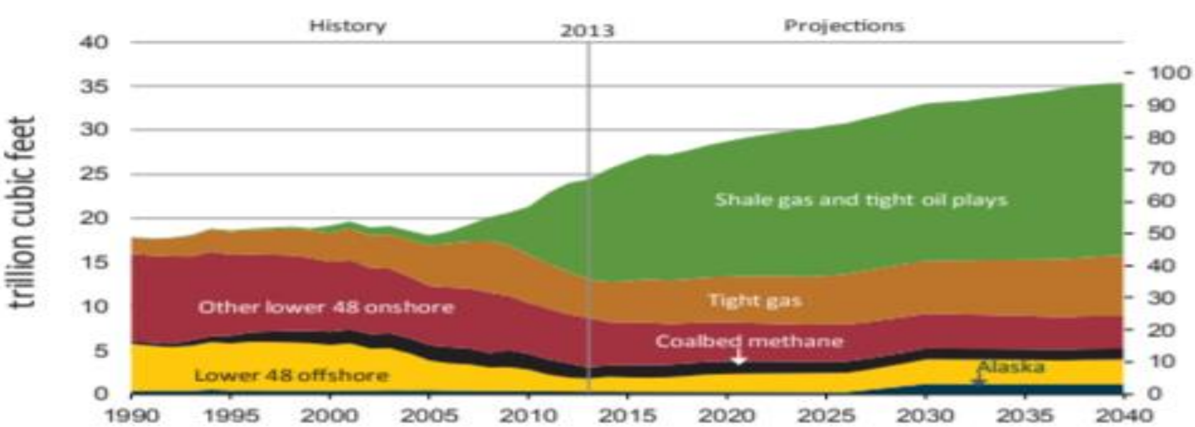

Figure 2.5 U.S. Natural Gas Production Growth

Source: energy.gov (2016, p.2)

As a starting point for the majority of economies especially those willing to develop gas resources and domestic natural gas markets, they need to have a Gas Master Plan (GMP). As much as each nation will have a unique GMP, there are few general principles and guidelines. Generally, GMP is a comprehensive framework of identifying and evaluating options for natural gas utilization for export as well as domestic use. In its quest to address the growing global demand for natural gas, GMP has a range of anchor or mega technology-based projects. Examples of these projects are GTL, Gas transmission, and distribution pipelines, methanol projects, as well as power projects.

According to Taraphdar, Yadav, and Prasad (2012, p.1), there are many advantages that come with the utilization of natural gas as the energy source for refineries. One of the advantages is the synergies created between the petrochemicals and the refinery that make the production process easier, safer, and faster. In addition, the utilization of natural gas in refineries helps in reducing the carbon footprints of the refinery companies. Taraphdar, Yadav, and Prasad (2012, p.6), further state that natural gas in the refinery process reduces carbon dioxide emission by approximately 30%. By replacing fuel oil with natural gas, the refineries are able to reduce the carbon dioxide emissions from the fired heaters by approximately 5-20%. Lastly, the researchers state that there will be a 25% and a 25 to 30% reduction in the carbon dioxide emissions from hydrogen generation and gas turbines respectively.

The IMO regulations will not only affect the main consumers (shippers) but also the refineries that generate large amounts of Heavy sulfur Fuel Oil (HSFO). Shippers will therefore have the obligation of shifting to Low Sulfur Fuel Oil (LSFO) or install scrubbers that would be purifying their emissions. This presents a major threat to the refineries, as they will lose their market if they fail to adopt the production of LNG. However, the refineries still have time to weigh their options since it is not yet clear to the ship owners on which is the best option of the two. When considering burning gas, the supply of these fuels is mainly in Northern Europe while LNG bunkering is still underdeveloped on the global scale. In addition, the lack of the needed infrastructure will limit the supply of LNG. This means that the shippers will have to use the scrubber technology thus making the refineries still relevant in the shipping industry. Shipping organizations thinking of switching to LSFO will have to factor in the higher cost of purchasing this product and supply restrictions in the short term. There is clearly no specific outcome for the refiners to prepare for come 2020. However, some options may include, proceeding with their operations and changing operations as the market aligns itself or adopting new and expensive technology that will convert HSFO to more IMO compliant fuels.

2.6 ICT Role in Oil and Gas Industry Technological Innovations

With organizational strategies being inseparably linked to technology, leading companies in different economic sectors are fundamentally and constantly rethinking on ways that they can envision, evolve, and deliver their IT solutions and infrastructure. Reengineering technology trends provide oil and gas organizations a guide on how to fundamentally overhaul their IT approaches from bottom-up and top-down in order to create enterprise and drive business expansion. In an industry where flexibility and speed are very critical, oil and gas organizations are utilizing automation, blockchain technology, cloud computing as well as other technology with an aim of transforming their platform and product offering, and back-office systems operations. Below is a discussion regarding the different IT approaches that can foster an evolution in the oil and gas industry to ensure that the environmental impact of their subsequent products is reduced significantly reduced.

2.6.1 Blockchain Technology

Blockchain technology has become instrumental in all industries and spheres and the oil and industry sector happens to be one of them. According to Klancir (2019), in 2017, this sector recorded net revenue of approximately $2 trillion in its upstream operations that contribute to approximately 2-3% of the global GDP. This part of the research paper will try to explain the impact that blockchain technology would have in the oil and gas sector if it were integrated into the downstream and midstream operations that are focused on sales, refinery, and transport that accounts for approximately $3 trillion that is around 6-8% of the global GDP.

One of the applications of blockchain technology in this energy sector is the refueling of airline organizations. According to Burns (2018), S7 airline and Gazpromneft-Aero have managed to develop and implement blockchain-based smart contracts that hasten the current efficiency and speed in correlative settlements during the refueling of aircraft. This process is also useful in financial aspects as it automates accounting and planning in fuel logistics. This is among the pioneering blockchain implementations and by utilizing it, the airline organizations have an opportunity of facilitating instant payments for fuel without overpaying or prepaying. By utilizing blockchain technology, oil and gas organizations can save around 5% in freight expenditure through enhanced invoice accuracy, removal of third-party service providers, and a decrease of overpayments. For instance, an organization generating an annual revenue of $10 billion and spends $600 million in freight operations could see a 5% reduction in its costs which is equivalent to $30 million in savings.

According to WEF (2016, p.5-10), the main challenges facing the O&G industry are transparency, cost and time, payments, and the supply chain. However, with the implementation of blockchain technology, the oil and gas industry can do away with these challenges. For instance, it is quite apparent that field personnel make mistakes when uploading data on oil field tickets. These alphanumeric codes are instrumental for inter-party communication, maintenance records, as well as data tracking. Furthermore, when processing paper tickets, the back-office personnel are prone to errors. Collectively, these errors lead to the need for reconciliations. Blockchain technology helps in such instances as it reduces the errors and makes the reconciliation process less labor-intensive as well as less expensive.

In a financially volatile industry like the O&G industry, the majority of enterprises in this sector are facing tremendous pressure to enhance productivity and reduce costs to be able to maintain decent revenue margins. In oil and gas trading, the conventional approaches expose the transaction processes to fraud and errors. However, Blicharz, Kisielewicz, and Oręziak, (2018, p.73) suggest that blockchain has the ability to solve this issue. In addition, these authors state that blockchain can make the transactions more transparent by ensuring that both parties have access to and can view all the transaction evaluations and records. Furthermore, both parties can see specific situations of each phase in the transaction process in order to enable them to have more control of the transactions.

Generally, the O&G industry is set to benefit a lot from the blockchain technology from transparency to efficiency, and much more. The drilling, production, as well as supplying activities involved in the oil and gas sector involves a multitude of stakeholders. Such a broad scale multi-party collaboration is what blockchain is designed to optimize and enhance operations as well as output. Implementation of this technology would play a great role in reducing losses for the oil and gas companies as it is made up of comprehensive and sequential processes that ensure transparency and consistency thus reducing the rate of human error.

2.6.2 Big Data Analytics

Despite its huge revenues, the profit margin of oil and gas is approximately 9%. This is so since the processes of finding and developing oil and gas while environmental impact and safety risks are quite difficult. Farris (2012) states that typically, the oil reserves are around 5,000 to 35,000 feet below the earth's surface and expensive well logs and low-resolution imaging are the readily available options for finding and defining the reservoirs. In addition to this, the production of oil while considering various factors like the available market and potential environmental risks is a complex process that calls for advanced technologies like the utilization of big data analytics.

Data science has the ability to help the oil and gas organizations to learn more concerning every subsystem, inject more confidence and accuracy in every decision, and ultimately reduce risks. In this instance, big data analytics will be instrumental. While this is a novel concept with regards to the oil industry, here are some of the solutions that this technology presents to the oil and gas sector.

- Creation and presentation of daily operational data that will be relevant in enhancing recovery rate and reduce operational costs.
- Integration of large volumes of data and incorporating them to help in the discovery of hydrocarbons while identifying the most suitable technologies for production.
- Assist the operators in the O&G industry in making the most appropriate decisions.

Big data analytics does not only entail the capturing and viewing of data but it also requires professional personnel to make a detailed analysis that assists in presenting smarter solutions to problems. This approach will allow the oil and gas enterprises to make faster decisions built on best practices. Eventually, these organizations will reduce their production costs while increasing their production volume.

In order to remain a viable industry, organizations in this sector should have the urgency of reducing their operational expenses. To achieve this goal, these organizations have to embrace technology. The integration of fast processing systems, comprehensive data, and the current computational approaches has digitalized oilfields since it allows geologists, engineers, as well as geophysicists to simulate entire oilfields. These simulations assist in discovering the most optimal oil extraction spots with the lowest drilling costs accompanied by maximum extraction output. Big data analytics cuts down the need for hiring many data operators and hence reduces staffing costs while enhancing overall efficiency in the industry.

According to Farris (2012), apart from the transactional and operational advantages that blockchain technology presents to the industry, this approach is also critical in decision-making. Farris (2012) further suggests that many challenges come up during the exploration, extraction, and development of oil and gas. These challenges are associated with the oil and gas development programs, 3-D data scanning of the underground wells, and the designing and maintenance of the oil and gas-related apparatus. Currently, it typically takes years from conducting feasibility studies up to the implementation stage. However, with the utilization of blockchain technology, this process will be faster and more efficient since this approach will not only lessen the workload but it will also calculate relevant data. Besides, in every phase, blockchain can avail tamper-proof records that will be significant in the designing of the process (Andoni et al. 2019, p.157).

In management decision-making, the majority of decisions are made in accordance with the data and information of the system as a whole. However, it is problematic to get data in real-time and most of the information is archived in an independent system. The data format, structure, and protocol of these systems are not usually interoperable or the same. Blockchain technology will in such cases, make data transmission and exchange more efficient thus enhancing the correctness as well as objectivity in decision-making. In addition, the majority of decisions in the oil and gas sector need the management personnel to vote and smart contracts, in this case, will be significant, as they will allow transparent and automated voting applications (Haufler 2010, p. 57).

2.7 How the Emission Laws will meet Global Future Goals and Restrictions

Corsi (2018) suggests that currently, the shipping industry is responsible for approximately 100million tons of CO_2 emissions annually which is equivalent to 2.2% of GHG emissions. This may appear as an insignificant amount but it is according to forecasts, this can rise between 50% to 250% if the necessary measures are not put in place. According to Corsi (2018), the IMO's GHG emission reduction strategies were divided into 3: short term, medium term, as well as long term. The short-term period is between 2018 to 2023, midterm runs from 2023 to 2030, while the long-term strategy runs from 2030 onwards.

The short-term strategy entails a number of measures that have their concentration on enhancing shipping efficiency. These measures included the implementation of research into enhancing energy efficiency performances and into the utilization of low carbon fuels, the development of efficient ports, as well as utilization of speed maximization to reduce emissions. Furthermore, this strategy also advocated for the development of national action plans aimed at addressing GHG emissions and taking further GHG emission studies that would assist in future policy measures. The medium-term document proposed more innovative emission reduction approaches that included market-based measures targeted at incentivizing the reduction of GHG emissions. Corsi (2018) suggests that this measure would be global and implementing it would be quite challenging. Lastly, the long-term strategy presented less defined alternatives that included the discovery of zero-carbon energy sources by 2050. This strategy is a great envision for full decarburization but Corsi (2018) terms it as vague.

IMO (2018, p.7) states that one can categorize the short-term measures as those whose effect directly reduces the GHG emissions from ships. Such measures could include the further enhancement of the existing energy efficiency framework with a focus on energy efficiency design index (EEDI) and ship energy-efficient management plan (SEEMP) while taking into consideration the result of the reviews related to the EEDI regulations. The short-term approaches would also include the development of the operational as well as technical energy efficiency measures for existing and new ships including taking into consideration the indicators aligned with the three-step approach that can be used in the identification and enhancement of the energy efficiency of shipping like Energy Efficiency per Service Hour, Individual Ship Performance Indicator, Annual Efficiency Ratio, as well as Fuel Oil Reduction Strategy. Lastly, the short-term measures should actively promote and support the efforts of the international community to reduce GHG emission in the maritime environment.

2.7.1 Cost-Benefit Analysis of Environmental Emission

2.7.1.1 Cost Benefits for Using LNG as Ship Fuel for Shipping Companies

Utilization of LNG as ship fuel has gained global attention since this energy source will be instrumental in reducing SO_X emissions by approximately 95%. Compared to conventional energy sources, LNG has lower carbon content that will reduce CO_2 emissions by 20 to 25%. In addition, it is also prudent to note that forecast state that LNG will be less expensive than the current energy sources. Currently, ship owners interested in utilizing LNG in order to reduce emissions are faced with a host of questions regarding the benefits as well as the costs of utilizing such technology. This research will take the assumption the costs of the main technologies when applied to different sized maritime vessels will help in predicting their benefits when compared to vessels that utilize energy sources that comply with the environmental regulations depending on the location and time of its operations. The references will be vessels utilizing maritime gas oils in emission control areas (ECA) by 2015, high fuel oil (HFO) utilized outside an ECA, and lastly, LSHO with around 0.5% sulfur content by 2020. The cost of implementing these technologies is then compared to the benefits that come from them.

The technology variables used for this purpose are; Scrubber, Waste heat recovery (WHR) and scrubber, LNG system (dual-fuel engine, tank, bunker station, gas line, gas preparation) and LNG system and WHR. For every approach, space requirements as well as costs, oil costs are approximated based on the current knowledge. Trips were chosen from three routes: Europe-Latin America, intra-European, as well as Europe Asia. For the main input parameter, the ECA exposure was utilized.

Vessel	Speed (knots)	Main engine power (kW)	Round trip(nm)	Default ECA share
2,500 TEU	20	14,500	5,300	65.1%
4,600 TEU	21	25,000	13,300	11.0%
8,500 TEU	23	47,500	23,000	6.3%
14,000 TEU	23	53,500	23,000	6.3%
18, 000 TEU	23	65,000	23,000	6.3%

Table 2.1 Inputs used in shipping vessels

Source: Sames et al. (2011)

The basic assumption regarding the fuel costs is a continuous increase as a result of the expected increase in the production of oil and gas as well as the increased demand for the products. Subsequently, LSFO and MGO would have a faster price increase as compared to LNG and HFO.

The price, in this case, started increasing as from 2010 and the starting prices were as follows, \$21.2/mmbtu for MBO, \$15.3/mmbtu for HFO, and LNG at \$13/mmbtu. The figure below is an illustration of the expected fuel prices from 2010 to 2030.

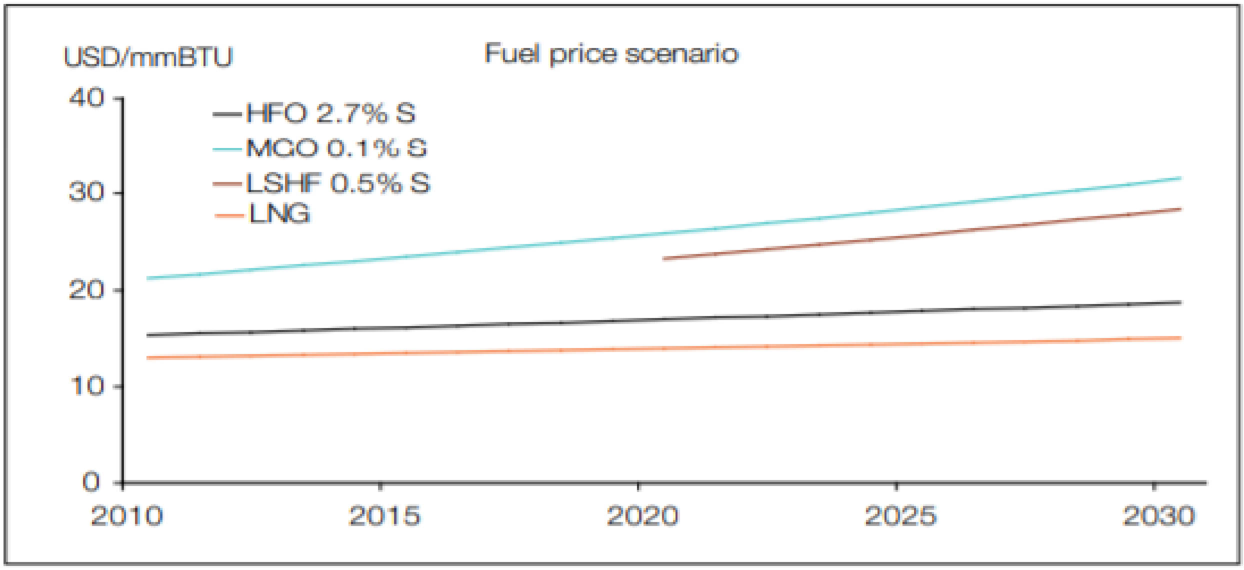

Figure 2.6 Expected fuel prices from 2010 to 2030

Source: Sames et al. (2011)

The yearly cost advantages in the study by Sames et al. (2011) as compared to the reference vessels while utilizing the recommended fuels depending on location and time. The cost advantages are the totals of the operating cost, fuel-saving costs, and lost earnings (which is negative). For 2,500 TEU's operating 65% in ECA's, cost advantages are forecasted by utilizing scrubber or LNG by 2020 when strict emission regulations are implemented. The payback time is lesser for solutions that do not have WHR because of its high cost of investment.

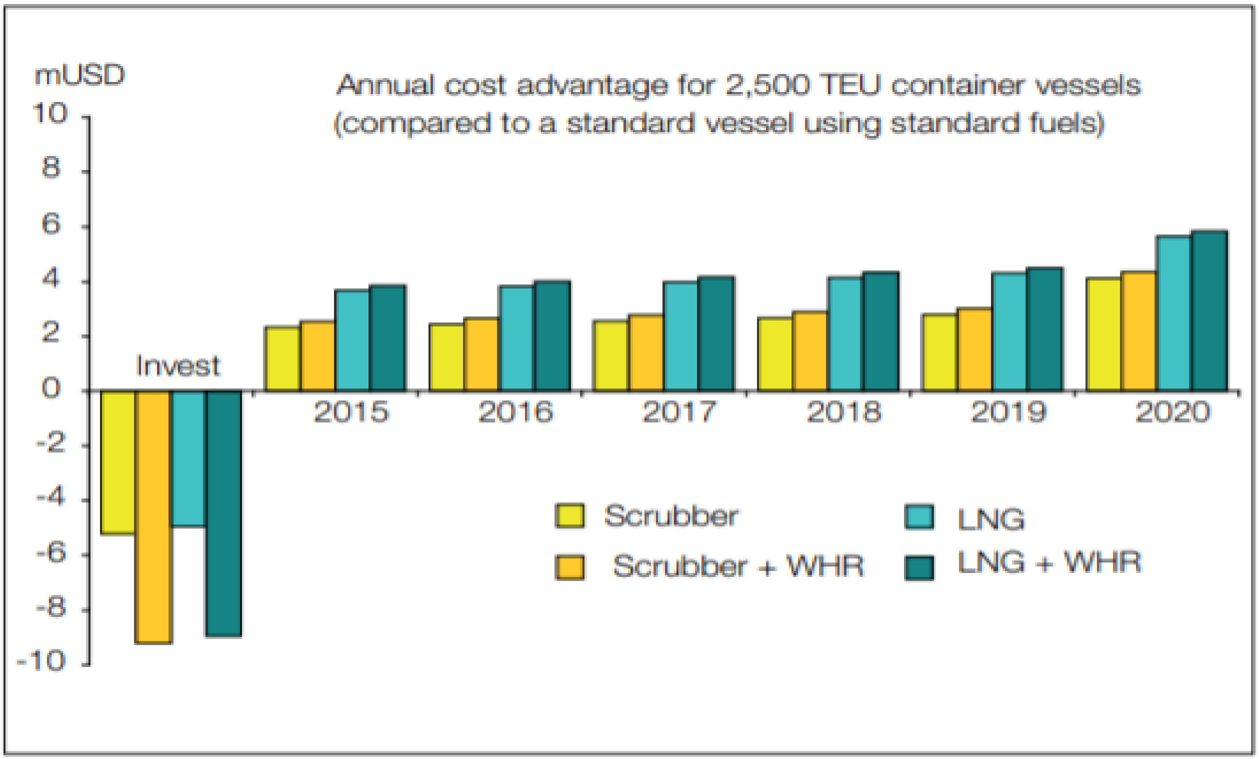

Figure 2.7 Yearly benefits for 2,500 TEU vessels

Source: Sames et al. (2011)

According to Sames et al. (2011), the benefits that come with technologies like scrubber or LNG are strongly dependent on their usage. Sames et al. (2011) argue that the higher the exposure to ECA areas the lesser the payback time for every variable with operations as from 2015. It is also prudent to note that the payback time is relatively shorter smaller carriers like 2,500 TEU and 4,600 TEU. With approximately 65% ECA exposure, the payback time for smaller vessels can be at least 2 years. Sames et al. (2011) further suggest that LNG systems offer shorter break-even periods than scrubbers. Furthermore, vessels using WHR technology have longer breakeven periods that are attributed to the higher costs of investment.

Sames et al. (2011) state that operations at ECA areas less than 20% of the time takes the scrubber system at least 60 months to breakeven. This means that breakeven in such a case is only achievable past 2020 after the introduction of LSHO.

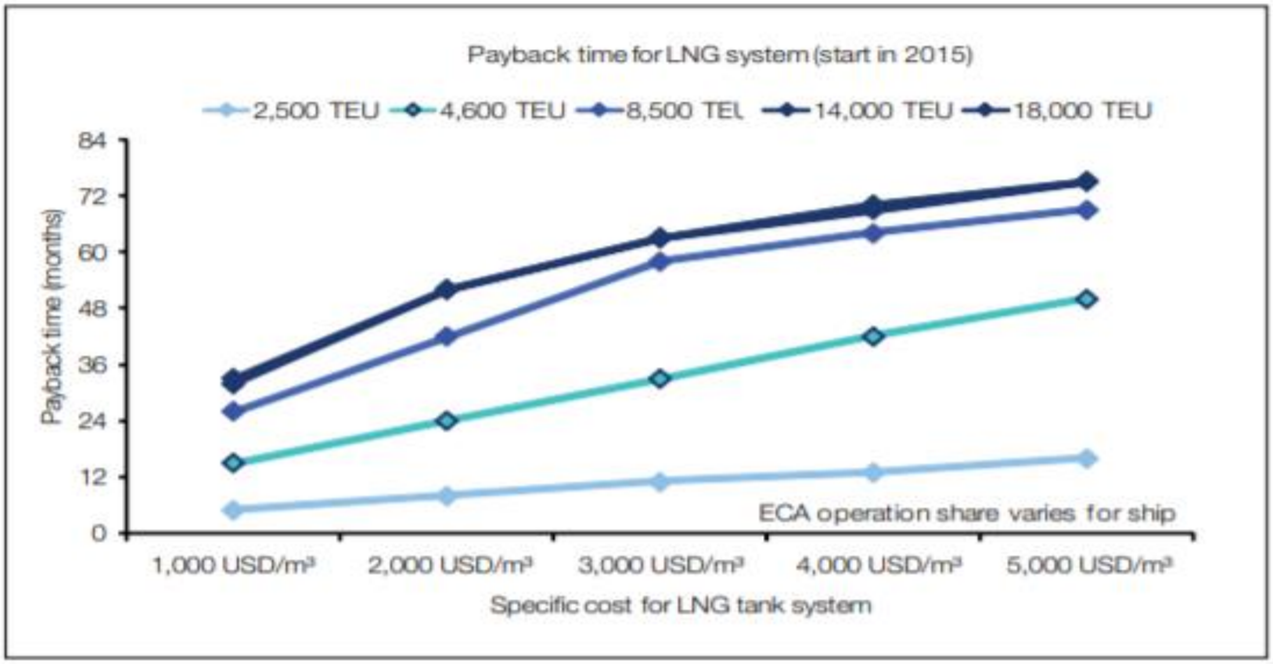

Figure 2.8 Payback time for LNG systems from 2015

Source: Sames et al. (2011)

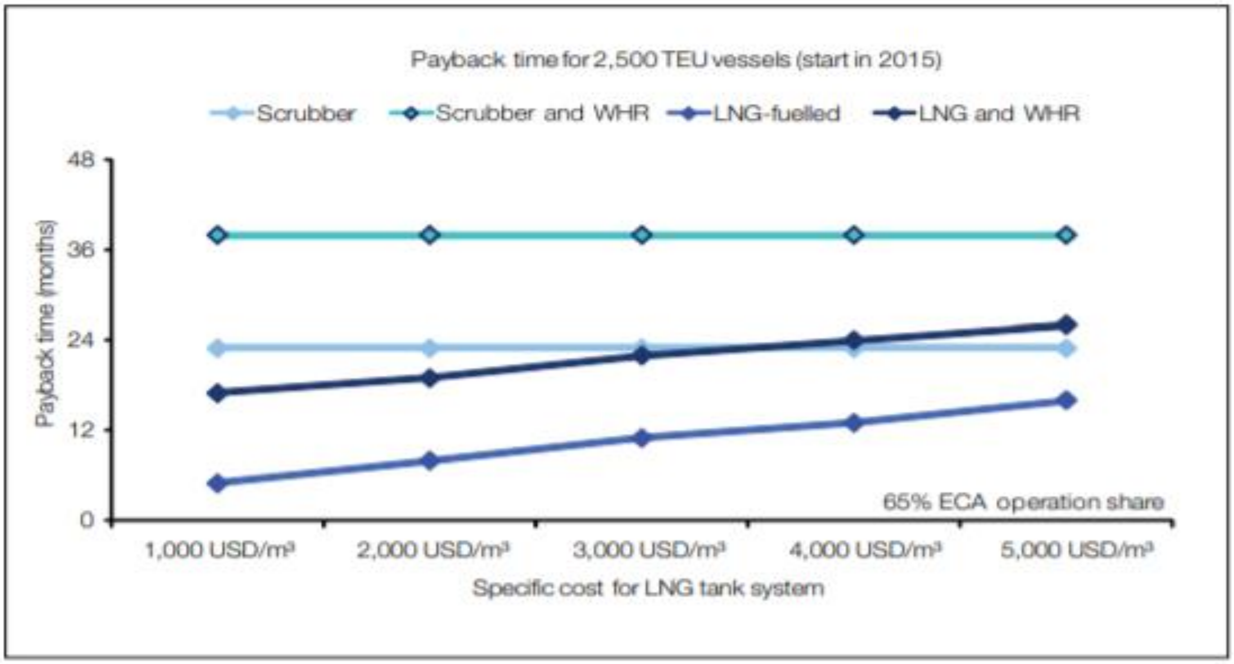

Figure 2.9 Payback time for 2,500 TEU carriers from 2015

Source: Sames et al. (2011)

4,600 TEU carriers that operate 11% of the time within ECA areas also give the ship owners shorter payback periods for LNG systems as compared to the installation of scrubbers. Just like the 2,500 TEU's, the WHR systems take longer to breakeven. Sames et al. (2011) state that WHR systems are beneficial in larger vessels and therefore, the payback time is shortened when an LNG system is complemented with a WHR system in a 14,000 TEU carrier. Sames et al. (2011) further state that LNG systems are more economical than scrubber systems for larger carriers. However, at higher ECA operation zones, the scrubber systems are more economical than the LNG systems. Therefore, upon utilization of standard assumptions, the LNG systems are more economical than scrubber systems.

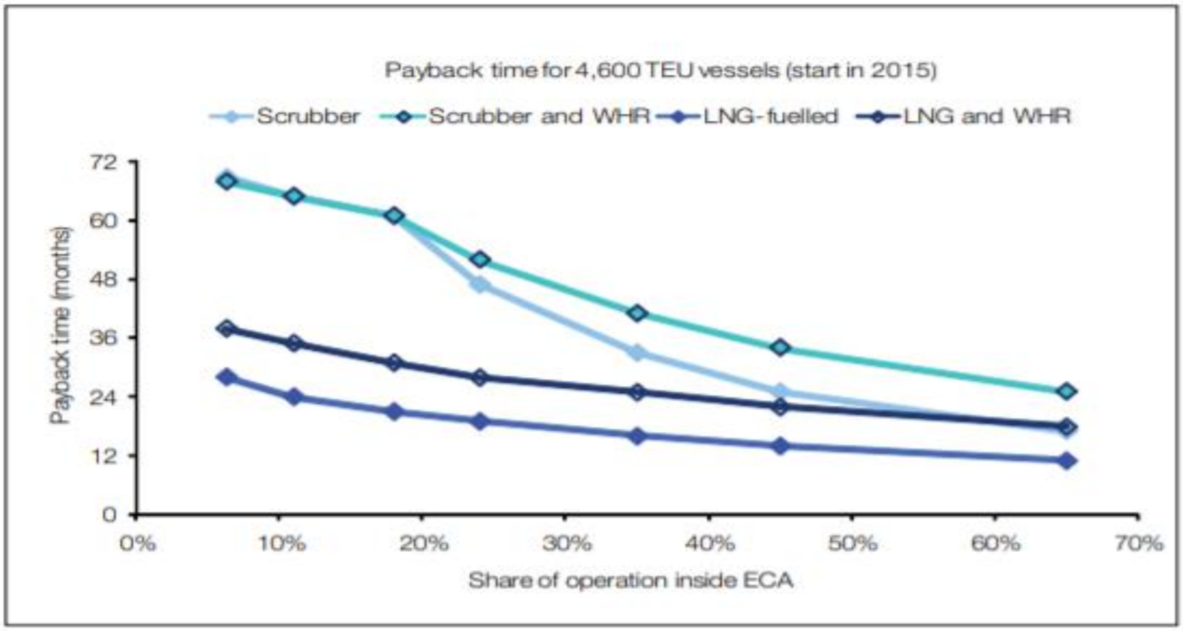

Figure 2.10 Payback time for 4,600 TEU carriers from 2015

Source: Sames et al. (2011)

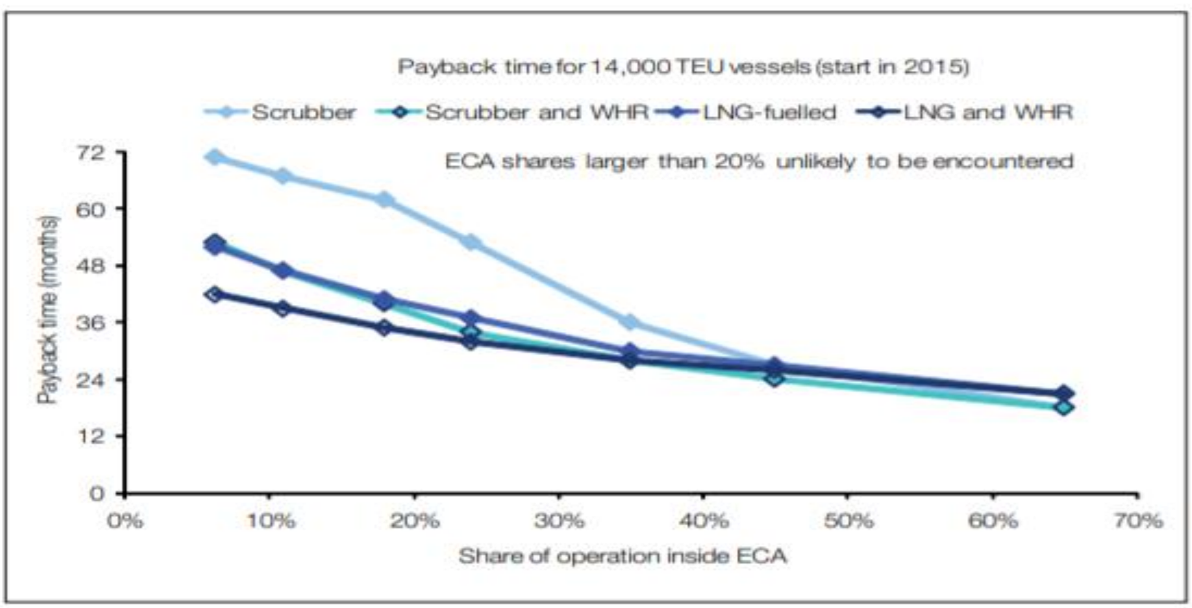

Figure 2.11 Payback time for 14,000 TEU carriers from 2015

Source: Sames et al. (2011)

In conclusion, it is prudent to note that the utilization of LNG as an energy source for the ships will lower emissions and with the right circumstances, it will reduce the fuel costs. The advantage of LNG over scrubbers is dominated by two major factors, share operation in the ECA area and LNG payback time. For 2,500 TEU vessels, a comparison for the LNG system and the scrubber, as well as the volatile LNG prices make it apparent that the LNG system is preferable only when LNG delivered to the ships is more costly or cheaper than HFO when the energy content of the fuels are taken into consideration. In the case of larger carriers that typically operate at lesser ECA shares like the 14,000 TEU, the LNG system has the shortest breakeven period and the incorporation of the WHR system makes this period even shorter. It is difficult to forecast the value of LNG delivered to carriers since the base LNG prices from the U.S to Japan vary by a factor of four.

2.7.1.2 Social Cost-Benefit Analysis of Emission Reduction in the Maritime Industry

According to Lee and Nam (2017, p.256), the existing emission laws such as the Marpol Annex vi will meet their future objectives in both economic and financial angles. A report presented by Hydrogen Council. (2017, 66-68) suggest that it is apparent that the global energy transformation is economically viable since the extra costs of the extensive energy transition would total to approximately $1.7 trillion yearly in 2050. However, the respective cost savings as a result of reduced environmental damage, better health, and reduced air pollution will outweigh these costs by far. According to Rosane (2019), the Remap case by IRENA suggests that savings in these mentioned areas alone would average $6 trillion annually. Moreover, the energy transition would play a very significant part in enhancing the socio-economic footprint of the energy sector globally. This transition will also enhance the global GDP, welfare, as well as employment.

The increased GDP attributed to the energy transition will have a cumulative gain of approximately $52 trillion from 2018 to 2050. For these laws to meet their objectives, there will be a need for capital intensive investments in the low carbon technologies. Gielen et al. (2019, p.42) suggest that the net cumulative investment for energy transition between 2018 to 2050 will have to increase by approximately 30% from $93 trillion in accordance with the currently planned policies to around $120 trillion in order for the process to be successful. Investment in energy efficiency and renewable energy will take in the bulk of the net energy investments.

2.8 Impact of Energy Taxes and Subsidies on the Shipping Industry

2.8.1 Energy Taxes (Carbon Taxes)

In April 2018, the IMO announced a target of reducing GHG emissions from the shipping sector by 50% below the 2008 levels come 2050. Consequently, the IMO introduced carbon taxation as it found this to be the best was to prompt maritime organizations to reduce their carbon footprints. The environmental argument presented by the implementation of carbon tax is becoming increasingly popular. According to IATA (2019), shippers have three main alternatives if they intend to meet the new environmental requirements dictated by IMO. First, they can operate using LNG, or secondly, they can continue utilizing High Sulfur Fuel Oil (HSFO) and process air emissions via a scrubber or an exhaust gas cleaning system (EGCS) which must be fitted on the ship. The last option is for the shipping companies to switch to low sulfur fuel like Marine Gas Oil (MSO) or Low Sulfur Fuel Oil (LSFO). It is critical to note that each option comes with its respective cost as well as benefits.

Lister et al. (2015, p.186) purport that as much as the carbon emission taxes support environmentally friendly activities, three factors that pose a threat to the shipping organizations and consequently, these organizations are not responding promptly to the IMO environmental policies. These factors include premature compliance, possible financial risks coming from uncertainty in the market, as well as regulatory uncertainty. It is quite evident to note that premature compliance might be punishing to the shippers. For instance, Halff, Younes, and, Boersma (2019, p.278) purport that LSFO and MGO are significantly expensive when compared to HSFO and the shipping companies do not have an incentive of utilizing these expensive fuels until required.

In addition, the authors suggest that scrubber and LNG options both entail intensive capital expenditure amounting to millions of dollars. Apart from that, the shipping companies will also have to incur the capital cost of acquiring new storage tanks and processing units as well as the permanent overhead cost of loading capacity to the newly procured equipment and the loss of deck space. Halff, Younes, and, Boersma (2019) are of the opinion that by rushing to implement these new standards, the shipping companies are running the risk of taking financial burdens that are unnecessary and avoidable. The volatility of the oil and gas prices makes it hard for the shipping companies to make the needed amendments so that they can meet the IMO's environmental regulations. For instance, investing in LNG engines is a viable option for maritime companies only if natural gas prices constantly remain low versus oil. This is to enable the companies to offset the cost of modifying their vessels over the lifespan of the vessel. However, the LNG option could be disastrous for the maritime organizations in case the prices of natural gas start to rally.

However, Burel et al. (2013) argue that carbon taxes will help the shipping companies since for instance, by taking the LNG options; these organizations can reduce carbon emission by around 25% and reduce operational costs by approximately 35%. McKinsey (2019) also agrees with IMO's move of introducing the carbon taxes since the author states that switching to LSFO will be advantageous to the shipping companies, as it will spare them the upfront cost of an LNG engine or installing a scrubber. All options that the maritime organizations have to make them avoid high carbon taxes are relatively difficult to adopt since by choosing one option would lead to the growth in demand of a particular product and hence its price will shoot up. For example, an increase in the demand for LNG would mean that natural gas prices will spring up and thus adding extra operational costs to the shipping companies.

According to McKinsey (2019), carbon taxes are bound to increase the cost of operating shipping vessels that run on oil. This will, therefore, see a prompt transition to renewable energy sources in the shipping industry. By embracing the utilization of green energy sources, the shipping organizations will reduce their dependence on fossil fuels and will be able to access a variety of energy sources, which will ultimately reduce their operational costs. The carbon taxes will be helpful in the shipping industry as they will raise the needed capital to enhance the shipping industry in developing economies like Sub-Saharan Africa, North Africa, as well as South East Asia. Generally, it seems that the imposition of the maritime carbon tax will be disadvantageous to the shipping companies since they will have to incur extra modification costs and most of them will restrain themselves from taking long trading routes like South America to China, or Asia to the U.S (Lee, Chang, and Lee, 2013, p.93).

2.8.2 Subsidies

According to European Environment Agency (2017), there are certain environmentally harmful subsidies that may have an adverse effect on shipping organizations since they will expose them to penalties that result from the 2020 sustainability approach by the IMO. These subsidies are intentionally placed by governments in favor of the producers and consumers in order to lower their costs or supplement their income. Tax exemptions for fuels are the main subsidies in this case. These subsidies have been beneficial to the shipping industry for a while but they will soon come at a cost for the shipping industry as the organizations in this sector will have to account for their levels of toxic emissions. In addition, the European Environment Agency (2017) also agree that subsidies in the transport industry such as shipping is a type of assistance through which costs associated with consumption or production are reduced. By utilizing these subsidies, Pupavac, Krpan, and Maršanić (2017) further explain that the government helps in enhancing the services provided by the transportation companies through the exemption of taxes. Consequently, when the shipping industry receives such subsidies, the organizations are able to grow and become more lucrative.

Although these subsidies seem lucrative, it is also critical to take note of the environmental risk that they pose to the people. With knowledge of the adverse impact that the emissions in the shipping industry have on the environment, the majority of people may boycott using these services or even hold protests against them. Such moves may have a negative effect on the shipping industry. It is already apparent that the protests by environmental lobbyists have forced the IMO to come up with strict emission caps that will have a financial effect on the shipping industry. Pupavac, Krpan, and Maršanić (2017) insist that at times, subsidies become a challenge when their application is inappropriate. For instance, subsidizing the fuel prices for the shipping industry only benefits a few individuals at the expense of the global climatic conditions. The risk versus the reward ratio in this instance is therefore much skewed to the risks thus making it not an appropriate move.

The current emission regulations should have a negative effect on many shipping organizations since they have an obligation of adhering to the set laws. This means the industry in some countries will incur heavy losses. However, a country like China may not face such challenges mainly because of the subsidies that the shipbuilding sector enjoys. These subsidies will mean that the Chinese shipping companies will not incur many expenses when modifying their ships to meet the standards set by IMO. Kalouptsidi (2018) explains that in the past decades, Chinese organizations have dominated the majority of capital-intensive sectors like auto parts, steel, as well as shipbuilding. For instance, the researcher further explains that in 2006, the country recognized shipbuilding as a strategic area and implemented necessary plans for its development and one of the plans was to subsidize several operational as well as production costs incurred in this industry. It is therefore apparent that these subsidies play and will still play an instrumental role in the Chinese shipping industry even post 2020.

This research typically relies on forecasted quantitative data. Despite the reliability and authenticity of the secondary sources of information and data used in this research, it is prudent to note that forecasts are not always accurate. Quantitative analysis of a dynamic and volatile industry like the oil and gas industry can result in different scenarios that depend on the interpretation of the collected data. Therefore, it is not advisable to rely completely on forecasting models and approaches like the one used in this research. This means that while using the findings in this research, it would be appropriate to incorporate other analysis tools to enhance accuracy. Making organizational decisions based on compromised forecasted data can lead to financial ruin.

The information obtained from the various reports as well as journals used in this research has its inferences based on market characteristics that existed in the past. Currently, the world is evolving at a very rapid rate and predicting the demand of a certain energy source is very limited. In 20 years from now, the world could be depending heavily on other alternatives that are not mentioned in the study. For instance, many factors affect the demand and supply of natural resources such as oil and gas. Occurrences like tax, competition, as well as weather play a significant role in determining the demand and supply of these energy sources meaning that they can all affect the accuracy of a forecast. This shows that the longer the forecasts provided in this research like the ones for 2050, the less accurate they are.

The expert opinions cited in the research may also be obsolete since economic, as well as political uncertainty, renders historical data obsolete. Developing foresight depending on market surveys, company leaders, or industry leaders exposes organizations especially those in highly volatile markets such as oil and gas at a very risky position. Stakeholders in such organizations should always monitor the existing fundamental and technical factors and evaluate the industry mainly based on that information. Lastly, it is also prudent to note that foresight, especially in lucrative markets like the one in the discussion, may be bias in order to lure investors. Therefore, it would be critical to use data from this research and other sources in order to validate or complement the information contained therein.

Chapter 3: Methodology

3.1 Introduction

The chapter describes the research processes implemented in this study. It provides detailed information regarding the approaches utilized in undertaking the study together with a justification for the utilization of the specific approaches. This section also explains the different research processes that include the selection of respondents, data analysis process as well as the data collection approaches used. In addition, this section will also look into the role of the researcher in quantitative research with regard to reflectivity. Finally, there will be a discussion of the reliability as well as the validity in quantitative research and the ways that these two requirements were adhered to in the research.

The present study explored the future of the oil and gas industry and looked into alternative ways that the industry can remain relevant in the coming years. According to the study, the main challenges that affect this industry are volatile prices, IMO regulations, as well as the emergence of alternative energy sources. However, the study also suggests that despite these challenges, the oil and gas industry still have remedies to these challenges with the utilization of advanced technologies being the best remedy.

3.2 Research strategy

Sekaran and Bougie (2016) suggest that a research strategy or methodology is dependent on the subject under investigation as well as the research questions. Consequently, the research format utilized in a study should be considered as a tool for answering the presented research questions. The aim of this thesis was to study the forecasts of the oil and gas industry and comprehend the stakeholders’ view concerning what the future holds for this industry. It is critical to note that the study did not aim to explore and predict exactly what the future holds for the oil and gas industry but instead, to investigate how the relevant stakeholders in this industry will conduct their operations in order to improve the industry and come up with viable solutions to the underlying challenges. This would ensure sustainability and a promising future for the industry.

3.3 research design

The approved research approach for the thesis was quantitative as it attempted to quantify the factors considered instrumental in the future of the oil and gas industry. According to Sekaran and Bougie (2016), the main advantage of using quantitative approaches in research is that they allow the researchers to examine the problems deductively thus enabling them to form a hypothesis derived from theory. These approaches give the researchers, controlled experimentation as well as testing that ultimately rejects or supports their hypothesis. It is also prudent to note that quantitative methods standardize every step of a study in order to reduce bias during the collection and analyzing of data. The biggest advantage that comes with this approach is that the results are reliable and valid. The quantitative approach was deemed the best option for this study since it entails numbers, such as evaluating gaps and forecasts on the different phenomenon. In this case, the researcher utilized questionnaires to collect data from different professionals in the oil and gas as well as the shipping industries. The following section gives the justifications behind the utilization of a quantitative approach in this thesis.

3.3.1 Quantitative Approach

According to Eyisi (2016, p.94), the first advantage of quantitative research is that it utilizes statistical data as a tool for saving resources as well as time. This approach places emphasis on figures and numbers during the data collection and analysis processes. Imperatively, this makes the quantitative approaches be perceived as scientific and objective in nature. The utilization of statistical data for analysis and description significantly reduces the effort and time that the researcher would have used in describing the different outcomes. Data (percentages, measurable figures, and numbers) can be conducted and calculated by computers using statistical packages such as e-views that save a lot of resources and time.

Secondly, it is critical to note that by utilizing scientific approaches in data collection and analysis, the generalization of the results becomes relatively easy since interactions made with a group can be generalized. In addition, the interpretations of the findings do not appear as mere coincidence as they come from reliable and quantifiable sources. Studies related to the forecasting of the oil, gas, and shipping industries can be reflective of the wider society in terms of patterns, samples, as well as the content.

Quantitative approaches typically rely on testing of hypothesis hence the researcher is not subjected to doing intelligent guesswork but instead, he or she should follow specific objectives as well as guidelines Eyisi (2016, p.94). Studies conducted using this approach are done in public or general fashion since they have defined guidelines and objectives and can, therefore, be replicated at any place and time and still produce the same outcomes. Lastly, Eyisi (2016, p.94) purports that the use of quantitative research methodologies eliminates the issue of bias from the research outcomes. In this instance, the use of questionnaires eliminated any influence from the researcher since the respondents filled the questionnaires independently and at their own discretion.

3.3.2 Questionnaires

The first reason for using questionnaires for this research is that they were cost-effective. The cost of preparing, sending, as well as receiving the questionnaires were economic to the whole research. It was also noted as stated by Sekaran and Bougie (2016) that questionnaires are practical since, during the study, all the information collected was secondary thus not objective as compared to the data collected from the actual stakeholders through the questionnaires. With reference to this study, another positive attribute that the questionnaire presented was the standardization of the questions presented to the respondents. The questions were well laid out and thus they played a great role in the testing of hypothesis. Finally, the questionnaires presented the researcher with data that was relatively easy to analyze.

3.4 Research setting

The research setting defines the place and the participants used in research. In this case, the data was collected from different stakeholders in the oil and gas industry as well as the shipping industry. All the participants were from the United States and they included different employees in different organizations. The organizations used in this research were, Viking Cruises, Farrell Lines, National Bulk Carriers, Atlantic Transport Line, ExxonMobil, Chevron, Devon Energy, and EOG Resources.

3.4.1 Sample Size

The research produced 100 questionnaires in which 50 were for the oil and gas industry while the other 50 were for the shipping industry. 64 respondents managed to present fully answered questionnaires. 33 were from the oil and gas industry while 31 were from the shipping industry. This response was advantageous to the research since the intention was to receive at least thirsty responses from both industries. Sample sizes dictate the volume of data present and therefore determine the level of confidence that researchers have on their estimates. It is prudent to note that the larger the sample size the larger the volume of information and hence a reduction in uncertainties. In addition, a large sample size gives the researchers greater power in detecting differences in the research. For instance, in this research, it will be able to help the researcher to tell how the level of experience determines how the different respondents view the future of the oil, gas and shipping industries in relation to the different technologies in question.

3.4.2 Sampling Techniques

This research utilized a stratified random sampling approach in the selection of the participants. This approach was fit for this study as it ensured a fair and equal distribution of the various variables under evaluation. The stratification was based on the oil and gas, as well as the global shipping industry with a specialization in American based multinationals in the respective industries. The companies used in this case included Viking Cruises, Farrell Lines, National Bulk Carriers, Atlantic Transport Line, ExxonMobil, Chevron, Devon Energy, and EOG Resources. The purpose of using different companies was to widen the sample size and reduce bias in the data collected.

3.4.3 Data collection

For the purpose of data collection, the researcher used questionnaires that had 2 sections and 7 questions in total. The questions were structured in a manner that ensured all participants answered the questions precisely and that there was no ambiguity in the responses. To achieve this, the researcher utilized a 3-scale approach for the first five questions that prompted the respondents to answer with either 1, 2, or 3 that represented the maximum, medium, and minimum respectively.

3.5 Ethical Considerations

Considering the significance of ethics when conducting research as well as other challenges faced in the research process, the researcher, in this case, ensured that all ethical requirements were adhered to while conducting the research in order to make it valid. First, the researcher ensured that all the respondents provided their consent to participate in the whole process of answering the questionnaires. After giving their consent, the researcher explained to them the purpose and process of the study. The respondents were given the free will of providing their names and signatures at the end of the questionnaires. This was an open request since some respondents preferred anonymity. The respondents were further assured that their responses would remain confidential and that no third party would have access to their responses. Emphasis on confidentiality was to establish trust with the respondents and hence allow them to answer the questions with honesty.

3.6 Data analysis

Since it is quantitative research, the analysis of data was done in order to achieve the objectivity reality that exists independently of an individual's opinions or perspectives. To achieve this, the study had to test hypotheses based on the research questions raised. With regards to the research questions, the hypotheses to test in this instance are;

H1: The oil and gas industry has a future

H2: Environmental regulations have an effect on the Oil and Gas industry

H3: The O&G industry affects the shipping industry

H4: The ICT sector will help in enhancing the O&G industry

To either accept or reject these hypotheses, the researcher utilized correlation as well as descriptive statistics in order to come up with objective results regarding the research questions.

CHAPTER 4: RESULTS

4.1 Introduction

The chapter presents the results gathered in the study. In order to ensure logical and analytical flow, the chapter is organized into three sub-sections. The first section describes the process employed in collecting data and various coding approaches utilized. The second and third sections present results from the two questionnaires adopted in data collection. A summary section is added to highlight core findings identified in the chapter.

4.2 Data collection using the questionnaires

In order to collect data using the questionnaire, the researcher employed a Likert scale from 1 – 5 where, 1 represented maximum, 3 medium and 5 represented minimum. However, this was only adopted in 5 of the 6 questions posed to the respondents. As such, the first five questions contain data on only three options (1 = maximum, 2 = medium, and 3 = minimum).

The sixth question, on the other hand, employed a checklist where respondents were required to only select one alternative from the listed options. The alternatives were effectively coded (1 = China, 2 = Asia, 3 = Middle East, 4 = USA).

4.5 Summary & Conclusion

The chapter has presented the results obtained from administering the various questionnaires. The first section detailed findings from the transport and mobility questionnaire whereas the second presented results from the energy and environment questionnaire. In the next chapter, analysis and discussion of the results is undertaken. From the research, it is quite apparent that the O&G industry is undergoing major changes and some of the stakeholders are hopeful while others are skeptical regarding the future of this volatile and lucrative industry. According to the respondents, the innovation levels in the technology field that impacts the O&G industry is quite promising meaning that the industry will deal with the current challenges that mainly come from the IMO regulations. One of the technological innovations is the use of LNG. Fridell and Andersson (2012, p.452) support the use of this sustainable energy source and suggest that it will significantly decrease the emission of sulfur oxides and nitrogen oxides. The synergy from the different market players in the O&G industry is a clear indication that the sector is willing to delve into research and development and come up with more viable energy sources.

Sieminski (2016) also backs this statement since the author suggests that the IMO regulations have forced the O&G organizations to embrace innovation and in the case of natural gas to start producing LNG which meets the requirements of the IMO. A report presented by ICAO (n.d, p.7) suggests that the global aviation industry strives at achieving carbon-neutral growth come 2020. However, to achieve this mandate, Air Transport Association developed 4 pillars that are economic measures, infrastructure, technology, as well as operations. However, ICAO regards technology as the cornerstone of the four and that it will play an instrumental role in ensuring that the industry reduces its carbon print. In addition, another report presented by OPEC made it apparent that the oil and gas organizations have been forced to invest in the industry in order to ensure there is sustainability.

Forecasts by other stakeholders concerning the future of the O&G industry go contrary to the sentiments given by the different respondents in the research. For instance, (Roelofsen et al., 2019) predicts that come 2050, the global demand for oil would have depreciated significantly. The main reason behind this decline would be the reduction in oil demand from the transportation industry. The main areas that would experience this decline in demand are the developing economies since according to a report presented by the African Development Bank (2009), the demand for oil is set to grow in developing economies such as Sub-Saharan Africa and in the

Indian Subcontinent. This corresponds with the respondents' answers as the majority ascertained that Asia which mainly consists of developing nations has the highest potential for future markets. DNV_GL (2007) report also echoes the fact that Pacific OECD, Europe, and North America will experience a decline in the oil industry by 2015.

The environmental regulations are among the reasons why the demand for oil is set to decline. Incentives and subsidies have played a great role in the development of the O&G industry since they support the organizations in their production and distribution of their products. According to the questionnaire survey, the respondents made it apparent that incentives, subsidies, as well as other government regulations have great influence in this industry. McKinsey (2019) makes it apparent that carbon taxes imposed by the governments increase operational costs for the O&G organizations and would prompt them to increase their prices a factor that will lower demand.

The ICT industry as portrayed in this study has great potential for improving the O&G industry. One of the technologies discussed in the literature review is big data analytics. Farris (2012) states that another ICT approach that can help in enhancing the O&G industry is block chain technology that will offer companies in this industry with great operational as well as transactional benefits that will be critical in decision making. Responses from the questionnaires also make it apparent that ICT is critical in the innovations to be made in this industry and the relevant stakeholders should make a point of creating awareness regarding this approach.

The shipping industry is among the main consumers of natural gas and oil. Therefore, this shows that impacts on the O&G companies directly affect the shipping industry. This research gives ample evidence that shows how the regulations against emissions from the oil products adversely affect the shipping industry. From the questionnaires, the knowledge of the respondents on the different technologies differs but their general opinion is skewed to show that there are higher chances for the shipping industry to enhance its operations through technological innovations. Currently, the main technological change in the shipping industry is the modification of the LNG carriers by installing scrubbers and WHR systems. Sames et al. (2011) suggest that many variables have to be taken into consideration when deciding the type of system to be installed in LNG carriers. These variables may include the size and the route used by the given vessel. However, with the globalization of the IMO regulations in 2020, the latter will not be a relevant variable in this context.

According to the responses in the questionnaires, it is evident that the respondents expect the shipping industry to grow over the coming years despite the current challenges. One of the components that can ensure this growth is technological innovation that even Lee et al. (2019, p.4) agrees that it is the major factor that is contributing to the rapid growth of this industry. According to Orszulik (2008, p.367 - 369) technology is a driving force in the advancement of the shipping industry but the government regulations are the main causal factors. The majority of the research participants suggested that government policies and incentives greatly affected the shipping industry. It is critical to note that without the IMO regulations, the technical advancements witnessed in the shipping industry would not be very significant. The Maersk and Qatar Airways case studies, for instance, show the extent to which different stakeholders want to go the extra mile to ensure they have the needed technology to make them compliant with the IMO and other government implemented policies. These case studies show the association between the aviation industry and the shipping industry with the O&G industry. A United Nations (2013, p.66) indicated that the demand for cleaner energy from these industries has prompted oil industries to seek new technologies and invest in R&D

CHAPTER 5: ANALYSIS & DISCUSSION

5.1 Introduction

The chapter analyzes and discusses the findings obtained in order to answer the research questions formulated at the onset of the study. The chapter is structured into one main section which is further sub-divided into several sub-sections based on the research questions in the study. A summary section is included in order to highlight key findings identified in the chapter.

5.2 Discussion of the results

5.2.1 Current status of the oil and gas sector

The first research question sought to identify the current status of the oil and gas sector in terms of its performance and nature of activities. Based on the categorization of the questionnaires used in data collection, it was observed that the nature of activities focused on transport and mobility as well as the generation of energy. Furthermore, it was observed that the transport function was decomposed into smart ports, coastal-based intelligence and hybrid propulsions whereas the energy function was further divided into renewable energy, data-based solutions and smart grid solutions.

The implication of the different categories is that, it revealed that the oil and gas industry had, over the years, enhanced the nature of its functions, advancing both energy production and transportation. Furthermore, data from the questionnaires revealed that there was an increased pace in the innovation levels in the sector across the different categories. For instance, refer to figure 4.2 (hybrid propulsions), figure 4.15 (coastal-based transport), figure 4.28 (smart port solutions) which highlight that all participants acknowledged the increased pace of technology in the field.

Similar findings were echoed by different research studies (Energy Information Administration, 2009; Kokal and Al-Kaabi, 2010) which revealed that, overall, the nature of technology adopted in exploring and extracting oil had improved significantly. For instance, the Energy Information Administration (2009) observed that enhanced oil recovery (EOR) techniques were currently being adopted in onshore oil production from shale. Likewise, Le (2018) accentuated that increased investment by the government and the rapid pace of technological development facilitated the growth of the natural gas industry.

5.2.2 Future of the oil and gas sector and threatening factors

The second research question investigated the future of the oil and gas sector and different factors that were likely to threaten it. To begin with, it was observed that the participants highly valued the importance of development in the industry and most of them also projected that over the next ten years, technologies would be implemented across the industry. Refer to figures 4.3, 4.16, 4.28, 4.29, 4.41, 4.42 and 4.54 which highlight the findings. The results reiterate diverse researchers (Mittal et al., 2017; Sakpal, 2019) who argued that the adoption of technology was unavoidable in the oil and gas industry due to rising pressure to enhance their competitiveness and the increased demand for oil and natural gas. Additionally, Mittal et al. (2017) revealed that technology would also be rapidly adopted in the future as companies focused on saving more costs as well as enhancing their productivity and safety.

With the third research question, the study was also focused on identifying the impact of the oil and gas sector on the maritime and aviation sectors. The data collected showed that participants highly ranked the levels of technological innovation in the industry. Refer to figures 4.2, 4.15, 4.28, 4.41, 4.54, and 4.67 which highlight the findings. Directly, the finding suggests that increased pace of technological development in the oil and gas sector improved other sectors that depended on it such as the aviation and maritime sectors. The findings reiterate different research studies (UNDP, 2017; ATAG, 2018) which accentuated that the growth of the oil and gas sector would lead to a commensurate enhancement of the aviation and maritime sectors particularly through the acquisition of more shipping vessels and airplanes due to availability of surplus fuel.

The findings also showed that participants highly ranked the government, policy incentives and research as well as academic technologies as key success factors in developing the different technological solutions in the oil and gas sector. The findings also reiterate the work of other researchers (Hoyhtya et al., 2017; Porathe, 2017) who cited the development of autonomous ships as a product of increased academic research as well as investment from both the government and private firms. Similar findings had been reported by different researchers, for instance, Van Straelen et al. (2009) observed that the adoption of research technologies enhanced the refinery process and led to the reduction of harmful gases. In separate research studies, however, Biscardini et al. (2018) and Dickson (2019) observed that the decline of oil discoveries in the near future and increased climate awareness and regulations. threatened the industry.

5.2.3 Role of ICT technologies in the oil and gas sector

The last research question investigated the role of ICT technologies in the oil and gas sector. From the data collected, it was observed that while 50% of the participants had low expertise in data-based services and solutions (figure 4.53), about 87.5% of them ranked the level of innovation at maximum (figure 4.54). Furthermore, 85% of the respondents identified the importance of development in the industry as being highly important (figure 4.55) while 60% of them agreed that there was high probability of the implementation of data-based solutions in the entire industry (figure 4.56). Similar findings were also observed with the smart ports questionnaire where respondents revealed that there was high innovation. The findings suggest that the oil and gas sector had improved significantly from the uptake of ICT technologies that utilized data.

The findings reiterated previous research, for instance, Morall et al. (2016) who revealed that ICT technologies enhanced the competitiveness of the maritime sector by promoting seamless communication. Similarly, Jordan (2019) previously observed that ICT technologies helped shipping companies track their cargo more effectively and additionally, transformed ports, making them smarter. Samuel and Sivadas (2019) had also observed that the technologies improved decision making and the management of different disasters. The participants had also agreed that the technologies would be highly accepted in society; an aspect that indicates that in future, more shipping vessels would adopt ICT technologies. However, other researchers such as Wingrove (2018) and Dimitriadis (2019) argued that reliance on digital solutions led to cyberthreats which culminated in the loss of revenue and information used in unfair competition. As such, it is important for firms to evaluate both the advantages and risks associated with the adoption of ICT.

5.3 Summary

The chapter has discussed the findings obtained in the study. In the first section, it was revealed that currently, the status of oil and gas sector involves the use of modern technology in diverse functions. The second section further revealed that academic technologies, policy initiatives and government support were instrumental in developing technologies utilized in the sector. However, increased regulation, rapid development of alternative fuels and dwindling discoveries of oil wells threatened its growth. The third sector discussed the role of ICT in the oil and gas sector where it was observed that it introduced both benefits and risks.

CHAPTER 6: CONCLUSION

6.1 Study conclusion

In summary, the research concludes that, currently, the oil and gas sector employs a wide variety of modern technologies to run different operations. For instance, in exploration, processing and marketing the oil products. Emerging technologies such as artificial intelligence, IoT and blockchain were identified as pivotal solutions in improving the efficiency of the sector. However, challenges ranging from cyberthreats to the complexity of the ICT solutions hindered their effective adoption and use. In order to tackle such issues, the research observes that there is need for increased investment in research in order to develop appropriate solutions that alleviate such challenges. Companies need to ensure they have the right expertise to handle their digital operations in order to avoid such threats.

6.2 Recommendations

Based on the in-depth evaluation of primary and secondary research regarding the present and future status of the oil and gas sector, this research recommends the adoption of ICT technologies as an important strategy to both enhance productivity and competitiveness of the sector. Secondly, the study also recommends the adoption of sustainable practices in the maritime sector owing to the increased threats of climate change from high pollution levels. The research observes that using technology can enhance sustainability by reducing the levels of emissions produced. Thirdly, aside from adopting digital technologies, the study recommends the implementation of effective security policies in order to guarantee safety of the companies.

6.3 Limitations and future research

Several limitations were associated with the study. First, the data collection process using questionnaires was tedious as most companies restricted the use of web surveys and as a result, required hard copies to be delivered to the companies. As a result, it was tedious to transfer the data into E-views analytical software. Second, the sample size for each firm was also limited to 40 participants due to the extra work involved in data collection.

Subsequently, in future research, the study recommends the utilization of larger sample sizes as well as the collection of data using qualitative interviews. Similarly, it is also recommended that in future studies, researchers conduct follow up studies to identify the challenges that inhibit the adoption of technology in oil and gas industries.

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APPENDIX

A. 4.3 Results from transport and mobility questionnaire

The first questionnaire collected data from oil and gas companies in the transport and mobility field that employed three kinds of technologies hybrid propulsions and vessel energy efficiency systems, coastal-based intelligent transport systems, and smart port solutions. A total of 40 participants were selected to participate in the survey. Therefore, this section is divided into three sub-sections in order to present the findings

4.3.1 Hybrid propulsions and vessel energy efficiency systems

The first question sought to identify the level of technological expertise of the individuals in the different companies. Figure 4.1 shows the results obtained.

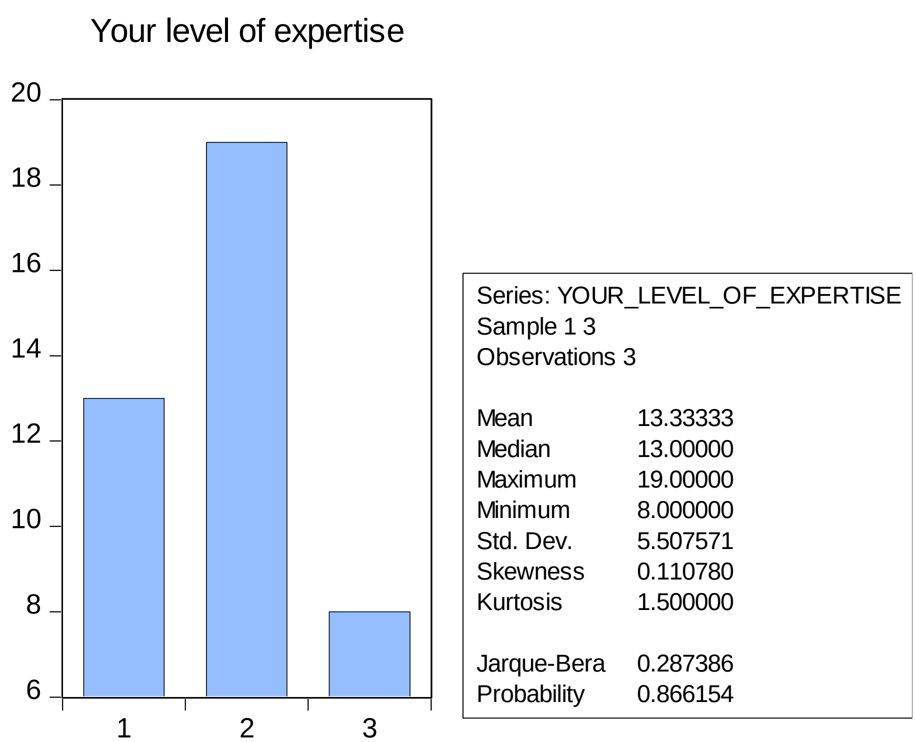


Figure 4.1 Level of expertise for the hybrid propulsions technology

The findings showed that 32.5% of the respondents had maximum expertise in the field while 47.5% had medium expertise. About 20% had minimum expertise. Hypothesis test was also conducted for the expertise level as shown in table 4.1 below.

Hypothesis Testing for YOUR_LEVEL_OF_EXPERTISE

Date: 10/27/19 Time: 03:42

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 5.507571

Method	Value	Probability
t-statistic	0.010483	0.9926

Table 4.1 Hypothesis test for level of expertise in hybrid propulsions technology

The respondents were further asked to highlight the present level of innovation in their specific technological field. Results obtained are shown in figure 4.2 below.

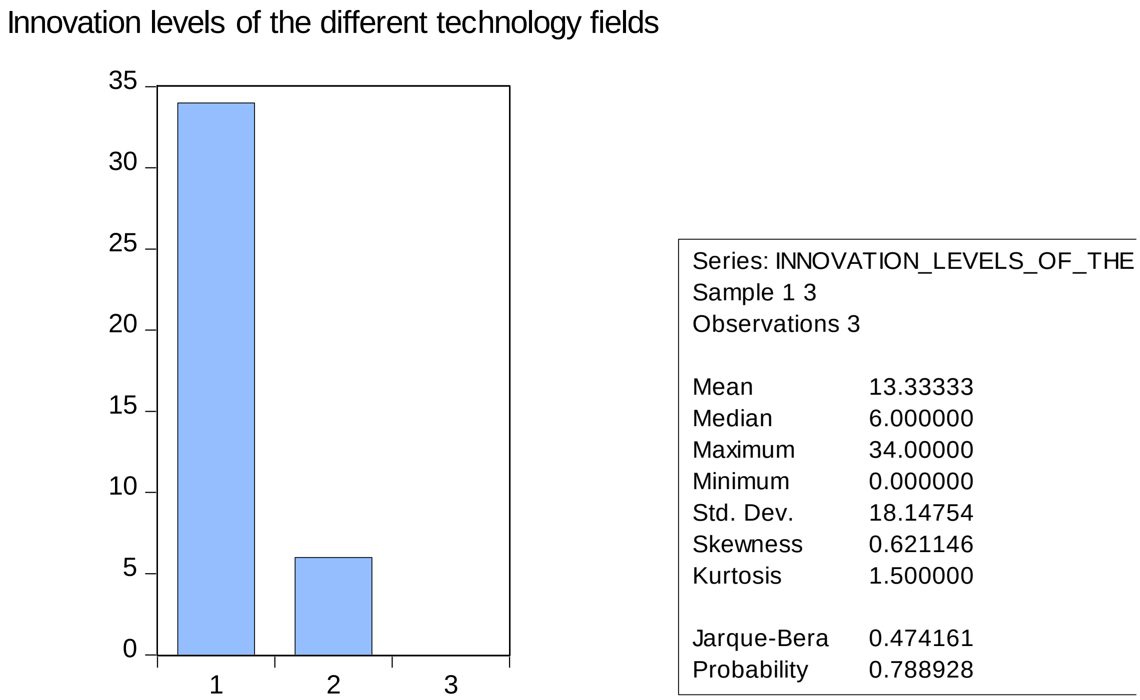


Figure 4.2 Present innovation level in hybrid propulsions technology

The results obtained showed that 85% of the respondents identified that the innovation level was maximum while 15% identified it as medium. None of the respondents classified the innovation level as minimum. The hypothesis test for the present innovation levels is presented in table 4.2 below.

Hypothesis Testing for INNOVATION_LEVELS_OF_THE_DIFFERENT

_TECHNOLOGY_FIELDS

Date: 10/27/19 Time: 03:43

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

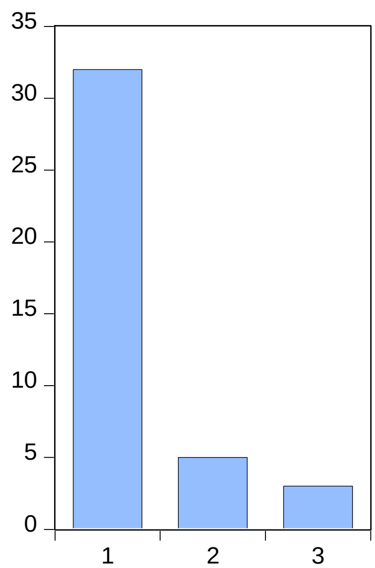
Sample Std. Dev. = 18.14754

Method	Value	Probability
t-statistic	0.003181	0.9978

Table 4.2 Hypothesis test for present innovation level in hybrid technology

The importance of development in the specified technology field was also investigated where results obtained are summarized in figure 4.3 below.

Importance of the development of the different technology fields



Series: IMPORTANCE_OF_THE_DEVELO
Sample 1 3
Observations 3

Mean	13.33333
Median	5.000000
Maximum	32.00000
Minimum	3.000000
Std. Dev.	16.19671
Skewness	0.694997
Kurtosis	1.500000
Jarque-Bera	0.522760
Probability	0.769988

Figure 4.3 Importance of development for hybrid propulsions technology

The results obtained showed that 80% of the participants identified the importance of development was maximum while 12.5% ranked it as medium. A further 7.5% ranked it as minimum. The hypothesis test for the factor was also undertaken as shown in table 4.3 below.

Hypothesis Testing for IMPORTANCE_OF_THE_DEVELOPMENT_OF_

THE_DIFFERENT_TECHNOLOGY_FIELDS

Date: 10/27/19 Time: 03:44

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 16.19671

Method	Value	Probability
t-statistic	0.003565	0.9975

Table 4.3 Hypothesis test for importance of development in hybrid technology

The respondents were also asked to rank the probability of industry wide implementation over the next ten-year period. Figure 4.4 below represents the findings obtained.

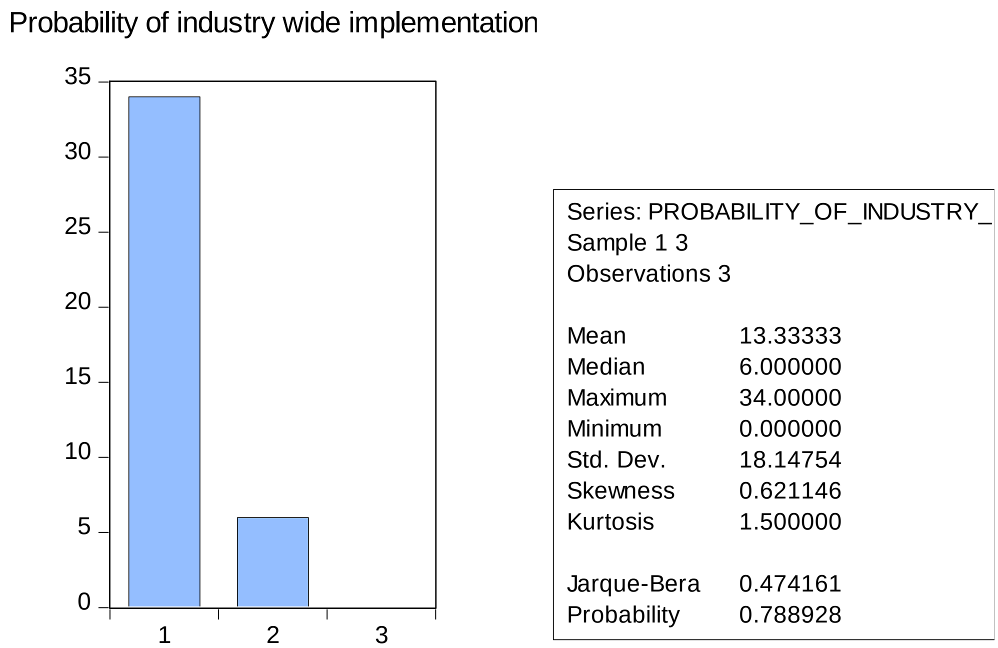


Figure 4.4 Probability of industry-wide implementation in hybrid propulsions technology

Findings obtained showed that 85% of the participants ranked the probability as maximum while 15% of them ranked it as medium. The hypothesis test obtained was summarized in table 4.4 below.

Hypothesis Testing for PROBABILITY_OF_INDUSTRY_WIDE_IMPLEM

ENTATION

Date: 10/27/19 Time: 03:45

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.14754

Method	Value	Probability
t-statistic	0.003181	0.9978

Table 4.4 Hypothesis test for probability of industry-wide implementation in hybrid propulsions technology

With the third question, participants were required to rank the probability of their regions becoming leaders in research and development capabilities. Results obtained are shown in figure 4.5 below.

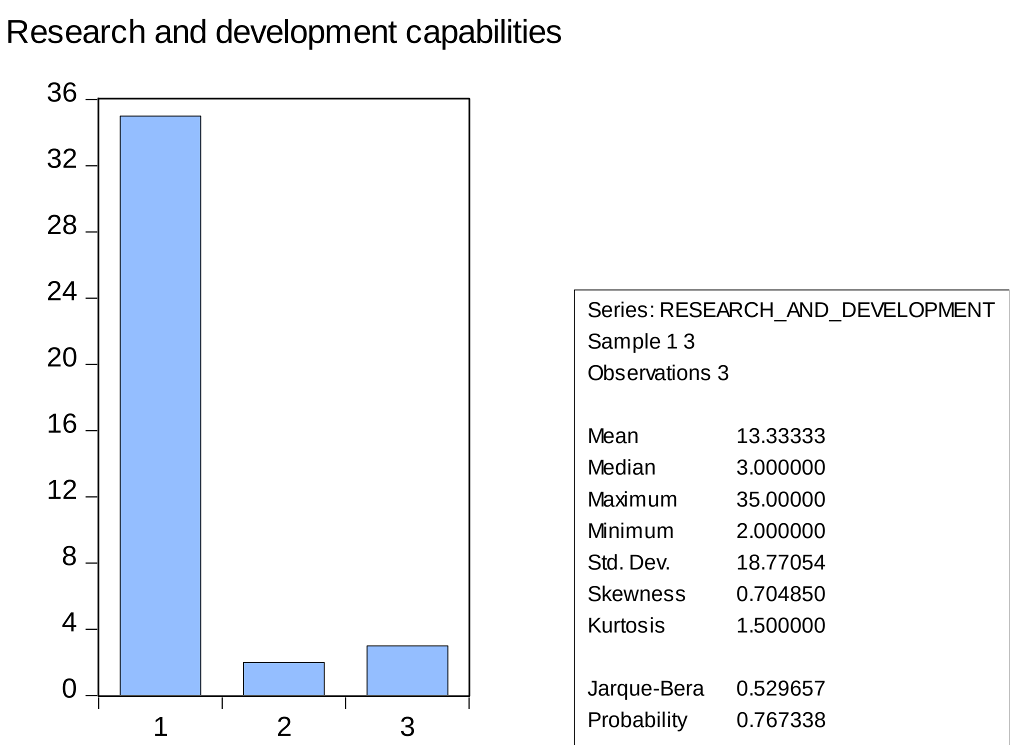


Figure 4.5 Chances of leadership in research & development in hybrid propulsions technology

Findings showed that 87.5% ranked the probability of being leaders in research and development at maximum. 5% ranked it as medium while 7.5% ranked it as minimum. The hypothesis test results obtained are shown in table 4.5 below.

Hypothesis Testing for RESEARCH_AND_DEVELOPMENT_CAPABILI

TIES

Date: 10/27/19   Time: 03:48

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.003076	0.9978

Table 4.5 Hypothesis test for chances of leadership in research & development in hybrid propulsions technology

The third question also sought to identify the societal acceptability of the region being a leader in technology. Figure 4.6 below displays the results obtained.

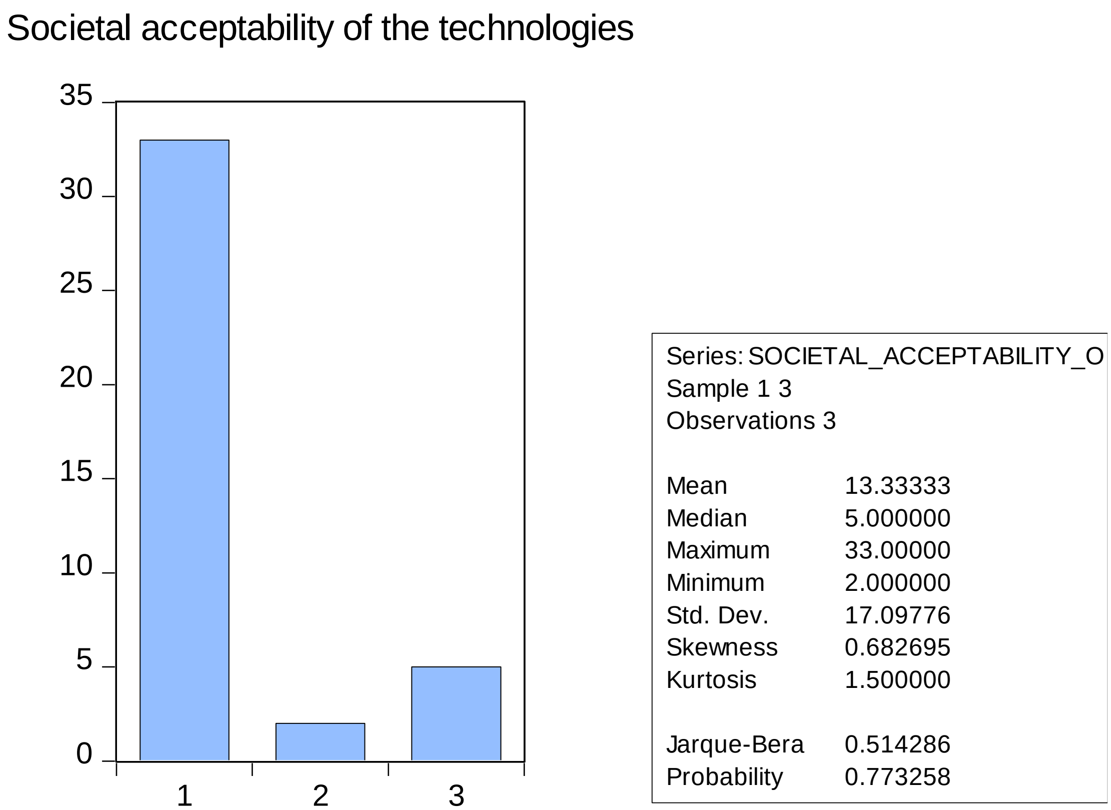


Figure 4.6 Societal acceptability of technologies in hybrid propulsions technology

The findings showed that 82.5% of the respondents ranked the societal acceptability at maximum while 5% ranked it at medium. 12.5% ranked it at minimum. Table 4.6 below further shows the results of the hypothesis test.

Hypothesis Testing for SOCIETAL_ACCEPTABILITY_OF_THE_TECHN

OLOGIES

Date: 10/27/19 Time: 03:50

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.09776

Method	Value	Probability
t-statistic	0.003377	0.9976

Table 4.6 Hypothesis test for societal acceptability of technologies in hybrid propulsions technology

The fourth question investigated how the respondents ranked research and academic institutions as key success players in the given technology field. Figure 4.7 below presents the results obtained.

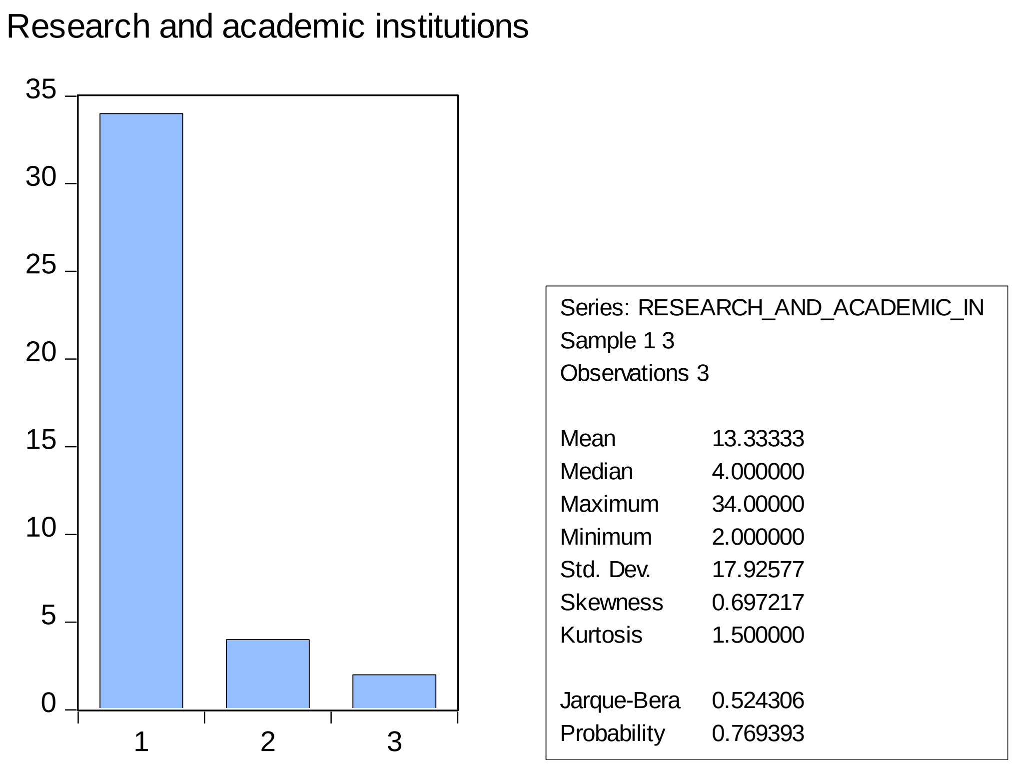


Figure 4.7 Research and academic technologies as key success factors in hybrid propulsions technology

Findings showed that 85% of the respondents ranked them at maximum while 10% ranked them as medium. An additional 5% ranked them at minimum. The hypothesis test for the factor was also undertaken as shown in table 4.7 below.

Hypothesis Testing for RESEARCH_AND_ACADEMIC_INSTITUTIONS

Date: 10/27/19 Time: 03:51

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.92577

Method	Value	Probability
t-statistic	0.003221	0.9977

Table 4.7 Hypothesis test for research and academic technologies as key success factors in hybrid propulsions technology

Similarly, respondents were asked to rank the government as a key success factor in the technology field. Results obtained were summarized in figure 4.8 below.

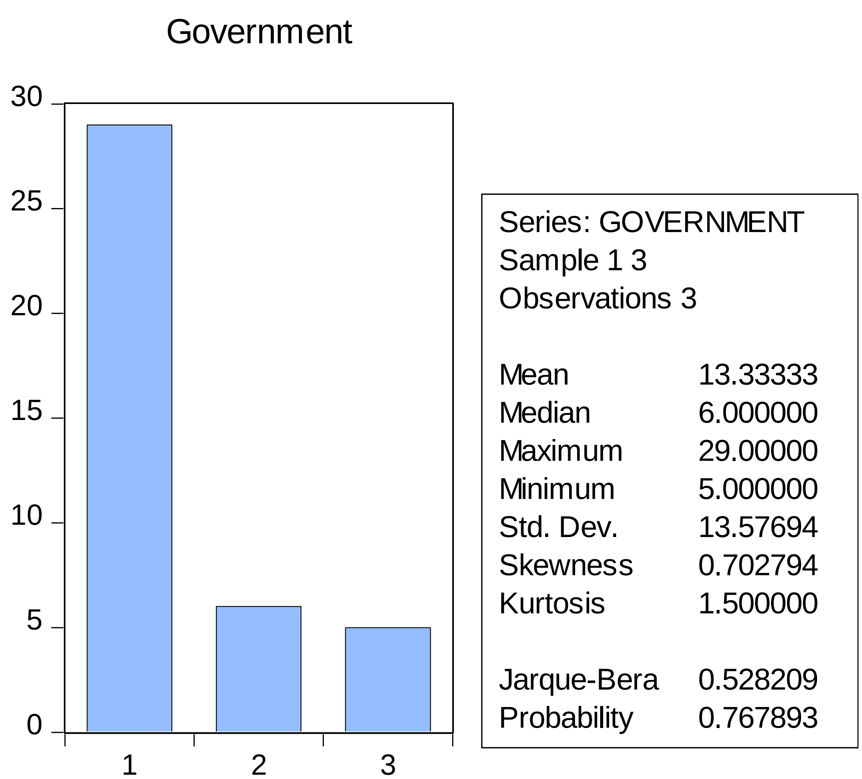


Figure 4.8 Government as a key success factor in hybrid propulsions technology

The results obtained showed that 72.5% of the respondents ranked the government as a key success factor at maximum while 15% ranked it at medium. 12.5% ranked the government at minimum. The hypothesis test was also undertaken as illustrated in table 4.8 below.

Hypothesis Testing for GOVERNMENT

Date: 10/27/19   Time: 03:52

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 13.57694

Method	Value	Probability

t-statistic	0.004252	0.9970

Table 4.8 Hypothesis test for government as a key success factor in hybrid propulsions technology

When asked about the role of policy incentives as a key success factor, the results were obtained as shown in figure 4.9 below.

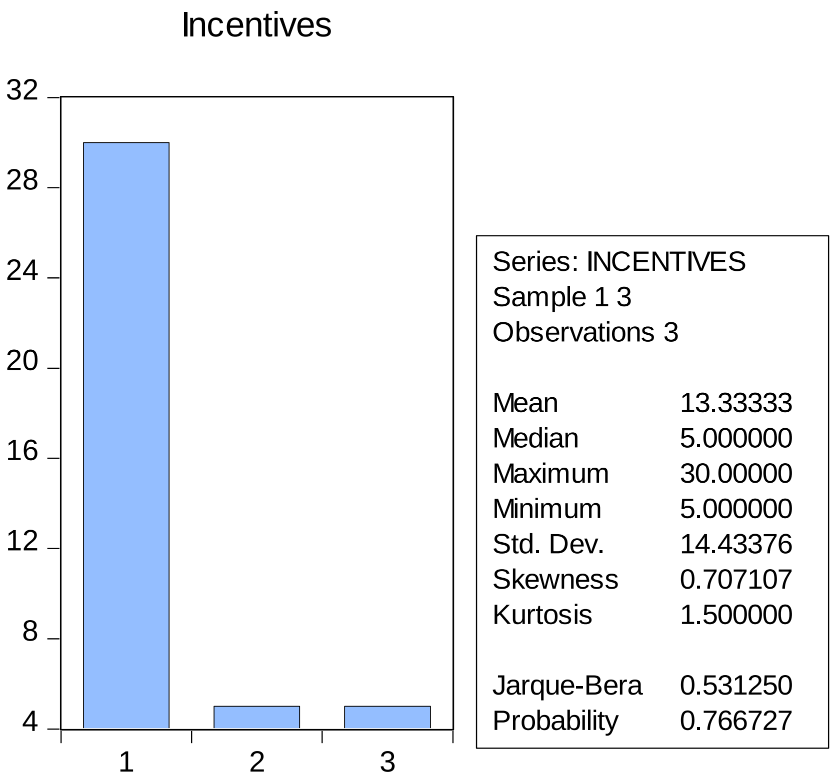


Figure 4.9 Policy incentives as a key success factor in hybrid propulsions technology

The findings obtained showed that 75% of the participants ranked policy incentives at maximum while 12.5% ranked them at medium. An additional 12.5% ranked them at minimum. The hypothesis test was carried out as shown in table 4.9 below.

Hypothesis Testing for INCENTIVES

Date: 10/27/19 Time: 03:53

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 14.43376

Method	Value	Probability
t-statistic	0.004000	0.9972

Table 4.9 Hypothesis test for policy incentives as a key success factor in hybrid propulsions technology

In the fifth question, respondents were asked to rank the importance of legal regulations and standards as a supportive policy measure to promote the field. Results were obtained as shown in figure 4.10 below.

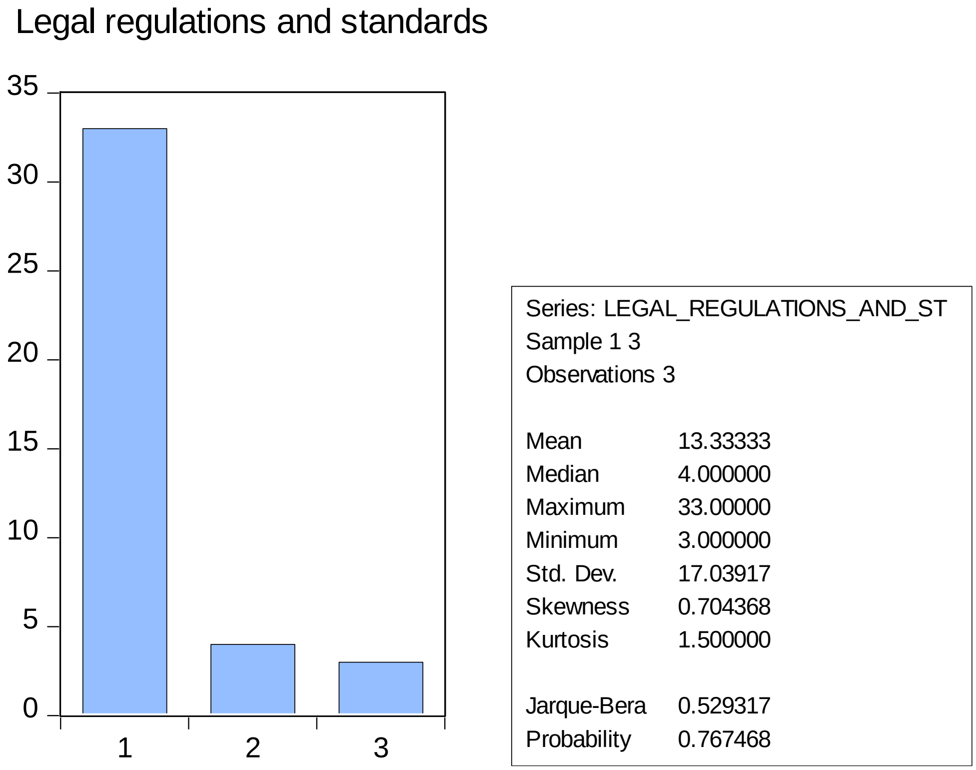


Figure 4.10 Importance of legal regulations and standards in promoting the hybrid propulsions technology

Results obtained showed that 82.5% of the respondents ranked legal regulations and standards at maximum while 10% ranked them medium. 7.5% of the participants ranked regulations and standards at minimum. The hypothesis test was also undertaken as shown in table 4.10 below.

Hypothesis Testing for LEGAL_REGULATIONS_AND_STANDARDS

Date: 10/27/19 Time: 03:55

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.03917

Method	Value	Probability
t-statistic	0.003388	0.9976

Table 4.10 Hypothesis test for importance of legal regulations and standards in promoting hybrid propulsions technology

Likewise, the importance of raising public awareness in promoting hybrid propulsions technology was also investigated with results being displayed in figure 4.11 below.

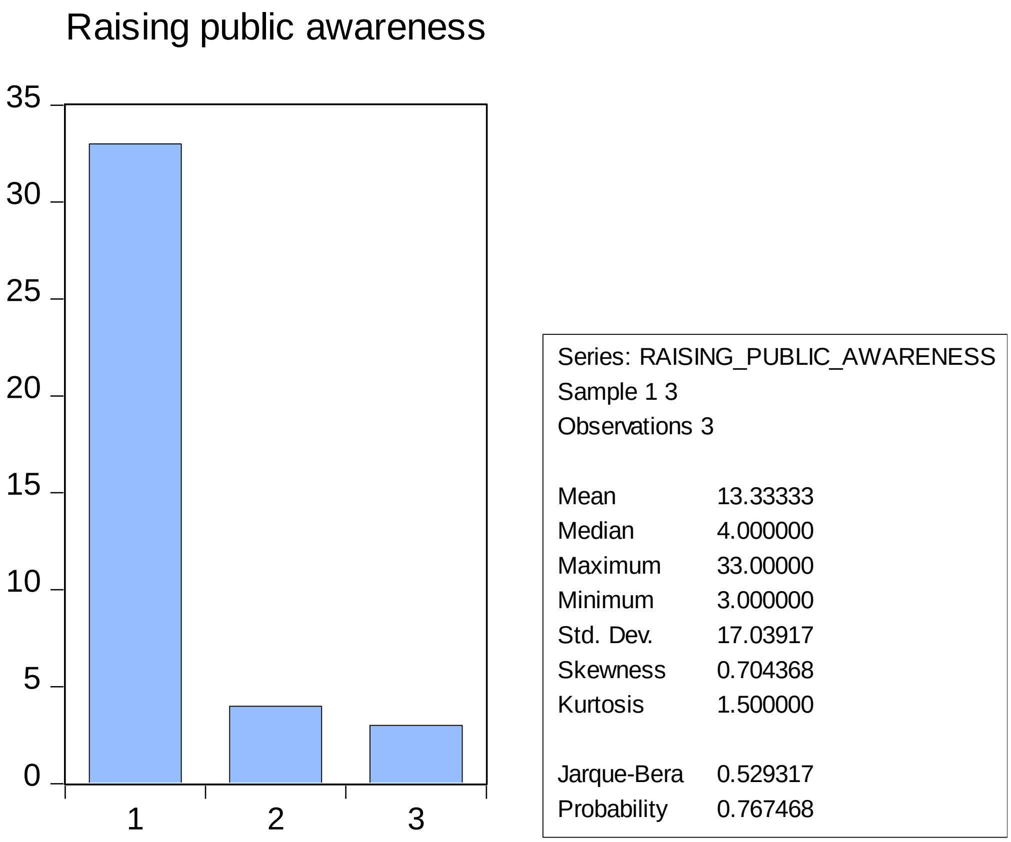


Figure 4.11 Importance of raising public awareness in promoting the hybrid propulsions technology

The results obtained showed that 82.5% of the respondents ranked raising public awareness at maximum. 10% of them ranked it at medium while an additional 7.5% ranked it at minimum. The hypothesis test was also undertaken for the factor as shown in table 4.11 below.

Hypothesis Testing for RAISING_PUBLIC_AWARENESS

Date: 10/27/19 Time: 03:56

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.03917

Method	Value	Probability
t-statistic	0.003388	0.9976

Table 4.11 Hypothesis test for importance of raising public awareness in promoting the hybrid propulsions technology

In the last question, the participants were asked to identify the most important region in regards to present research and development. Figure 4.12 below illustrates the results obtained.

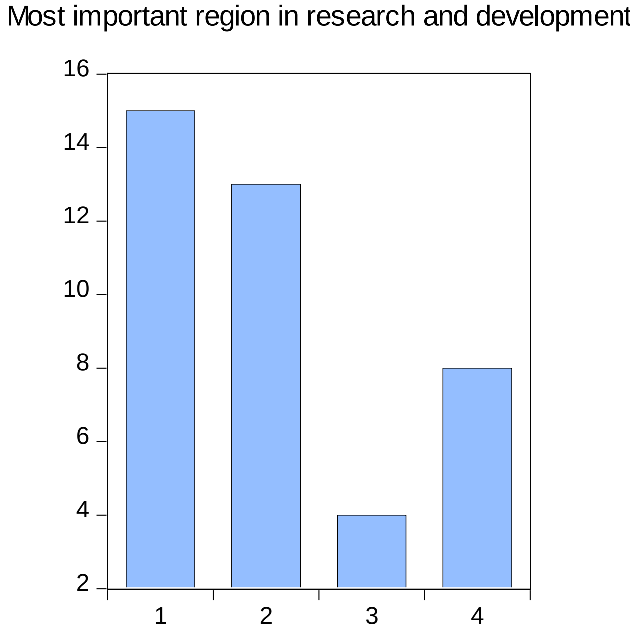


Figure 4.12 Most important research and development region in the hybrid propulsions technology

The findings showed that China was ranked highest by 37.5% of the respondents while Asia followed closely at 32.5%. The USA was ranked third at 20% while Middle East was ranked at 10%.

Finally, the respondents were also asked to identify the most important region in regards to market potential. Figure 4.13 below demonstrated the results obtained.

Region with the highest market potential

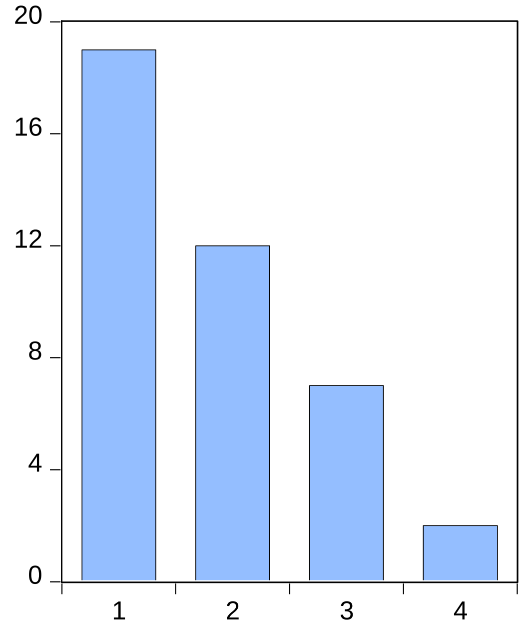
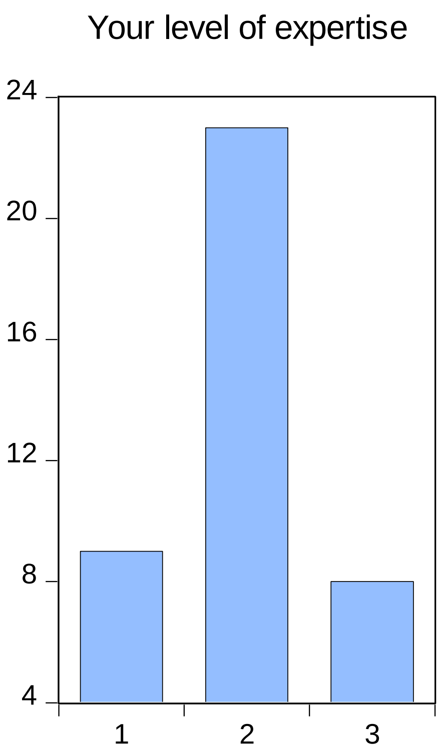


Figure 4.13 Region with the highest market potential for the hybrid propulsions technology

The results obtained showed that China was ranked highest by 47.5% of the respondents while Asia was ranked second by 30% of the respondents. The Middle East was ranked third by 17.5% of the participants while the USA was ranked last by 5% of the participants.

4.3.2 Coastal-based intelligent transport systems

With the coastal-based intelligent transport systems questionnaire, participants were also asked to indicate their level of expertise. Figure 4.14 below displays the results obtained.



Series: YOUR_LEVEL_OF_EXPERTISE	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	9.000000
Maximum	23.00000
Minimum	8.000000
Std. Dev.	8.386497
Skewness	0.695813
Kurtosis	1.500000
Jarque-Bera	0.523328
Probability	0.769770

Figure 4.14 Level of expertise for coastal-based transport systems

The findings obtained showed that 57.5% of the participants ranked their expertise as medium while 22.5% ranked it maximum. About 20% ranked it minimum. The hypothesis test was also carried out as shown in table 4.12 below.

Hypothesis Testing for YOUR_LEVEL_OF_EXPERTISE

Date: 10/27/19 Time: 04:05

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 8.386497

Method	Value	Probability
t-statistic	0.006884	0.9951

Table 4.12 Hypothesis test for level of expertise in coastal-based transport systems

The second question investigated the present level of innovation in their specific technological field. Results were obtained as shown in figure 4.15 below.

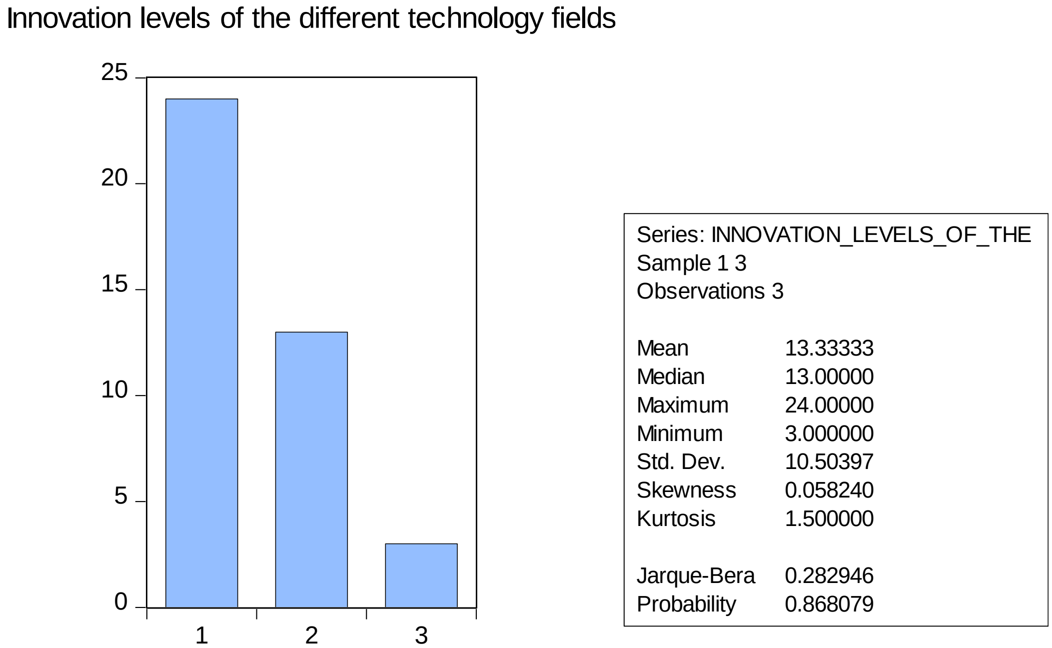


Figure 4.15 Present innovation level in coastal-based transport systems

The results obtained showed that 60% of the respondents ranked the innovation level as maximum while 32.5% identified it as medium. 7.5% of the respondents ranked the innovation level as minimum. The hypothesis test for the present innovation levels is presented in table 4.13 below.

Hypothesis Testing for INNOVATION_LEVELS_OF_THE_DIFFERENT

_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 04:06

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

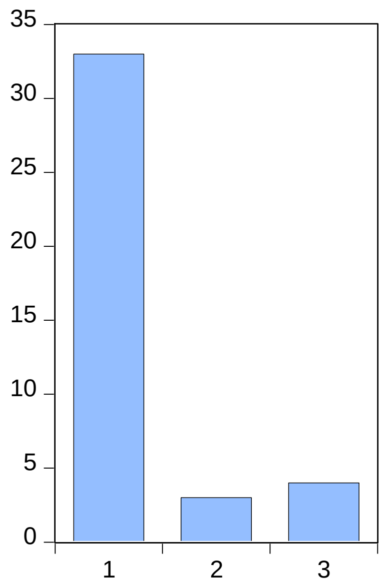
Sample Std. Dev. = 10.50397

Method	Value	Probability
t-statistic	0.005496	0.9961

Table 4.13 Hypothesis test for present innovation level for coastal-based transport systems

Respondents were also asked to rank the importance of development in their specified technology field as summarized in figure 4.16 below.

Importance of the development of the different technology fields



Series: IMPORTANCE_OF_THE_DEVELO
Sample 1 3
Observations 3

Mean	13.33333
Median	4.000000
Maximum	33.00000
Minimum	3.000000
Std. Dev.	17.03917
Skewness	0.704368
Kurtosis	1.500000
Jarque-Bera	0.529317
Probability	0.767468

Figure 4.16 Importance of development for coastal-based transport systems

The results obtained showed that 82.5% of the participants identified the importance of development was maximum while 7.5% ranked it as medium. A further 10% ranked it as minimum. The hypothesis test for the factor was also undertaken as shown in table 4.14 below.

Hypothesis Testing for IMPORTANCE_OF_THE_DEVELOPMENT_OF_
THE_DIFFERENT_TECHNOLOGY_FIELDS

Date: 10/27/19 Time: 04:07

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.03917

Method	Value	Probability
t-statistic	0.003388	0.9976

Table 4.14 Hypothesis test for importance of development in coastal-based transport systems

The next question investigated the probability of industry wide implementation over the next ten-year period. Figure 4.17 below represents the findings obtained.

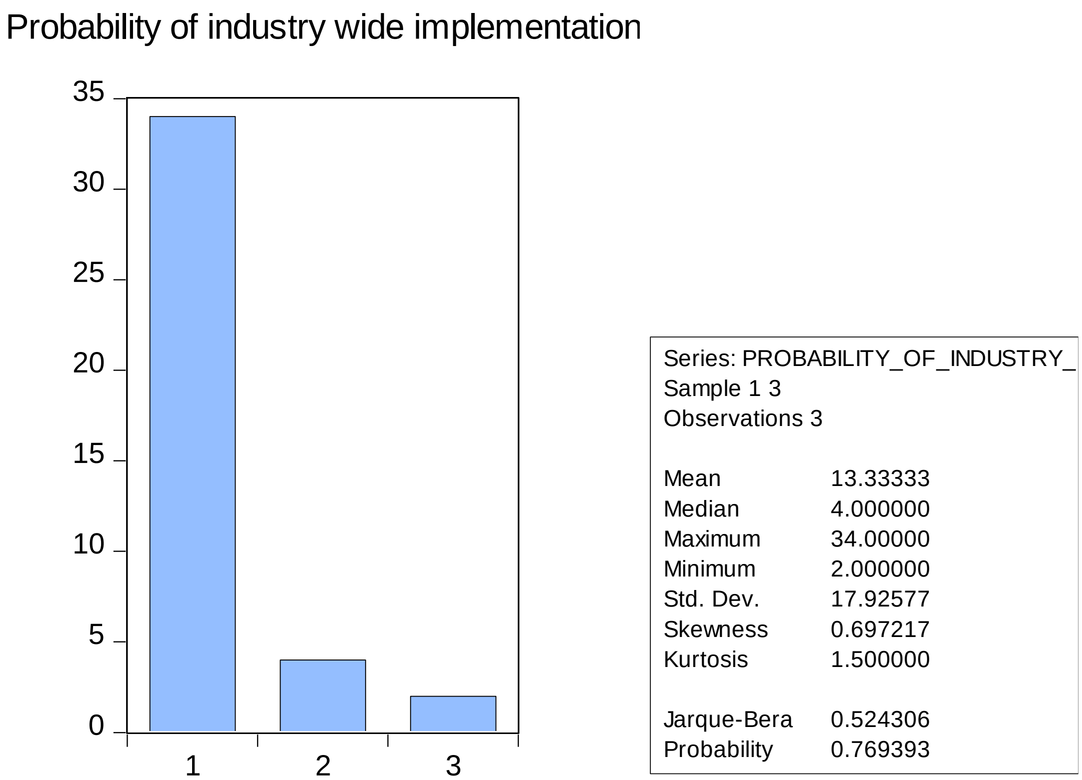


Figure 4.17 Probability of industry-wide implementation in coastal-based transport systems

Findings obtained showed that 85% of the participants ranked the probability as maximum while 10% of them ranked it as medium. 5% ranked it as minimum. The hypothesis test obtained was summarized in table 4.15 below.

Hypothesis Testing for PROBABILITY_OF_INDUSTRY_WIDE_IMPLEM

ENTATION

Date: 10/27/19 Time: 04:09

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

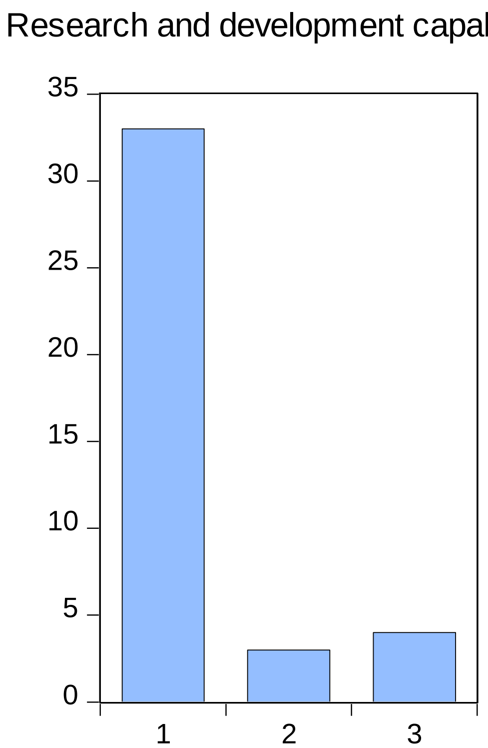
Sample Mean = 13.33333

Sample Std. Dev. = 17.92577

Method	Value	Probability
t-statistic	0.003221	0.9977

Table 4.15 Hypothesis test for probability of industry-wide implementation in coastal-based transport systems

In the next question, participants were required to rank the probability of their regions becoming leaders in research and development capabilities. Results obtained are shown in figure 4.18 below.



Series: RESEARCH_AND_DEVELOPMENT	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	4.000000
Maximum	33.00000
Minimum	3.000000
Std. Dev.	17.03917
Skewness	0.704368
Kurtosis	1.500000
Jarque-Bera	0.529317
Probability	0.767468

Figure 4.18 Chances of leadership in research & development in coastal-based transport systems

Findings showed that 82.5% ranked the probability of being leaders in research and development at maximum. 7.5% ranked it as medium while 10% ranked it as minimum. The hypothesis test results obtained are shown in table 4.16 below.

Hypothesis Testing for RESEARCH_AND_DEVELOPMENT_CAPABILI

TIES

Date: 10/27/19 Time: 04:10

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.03917

Method	Value	Probability
t-statistic	0.003388	0.9976

Table 4.16 Hypothesis test for chances of leadership in coastal-based transport systems

The next question investigated the societal acceptability of the region being a leader in technology. Figure 4.19 below displays the results obtained.

Societal acceptability of the technologies

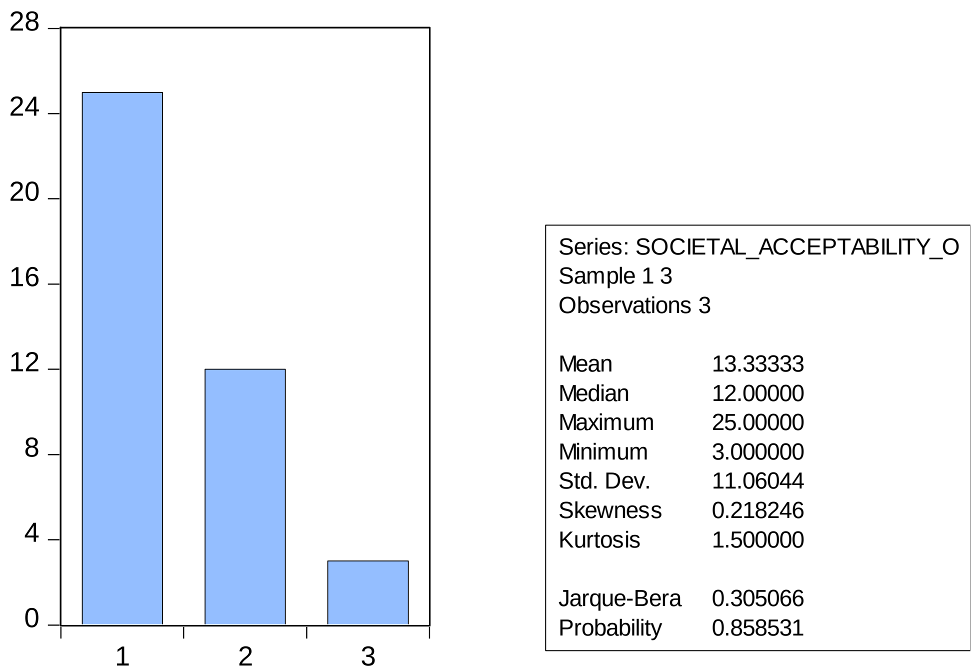


Figure 4.19 Societal acceptability of technologies in coastal-based transport systems

The findings showed that 62.5% of the respondents ranked the societal acceptability at maximum while 30% ranked it at medium. 7.5% ranked it at minimum. Table 4.17 below further shows the results of the hypothesis test.

Hypothesis Testing for SOCIETAL_ACCEPTABILITY_OF_THE_TECHNOLOGIES

Date: 10/27/19 Time: 04:11

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 11.06044

Method	Value	Probability
t-statistic	0.005220	0.9963

Table 4.17 Hypothesis test for societal acceptability of technologies in coastal-based transport systems

The next question investigated how the respondents ranked research and academic institutions as key success players in the given technology field. Figure 4.20 below presents the results obtained.

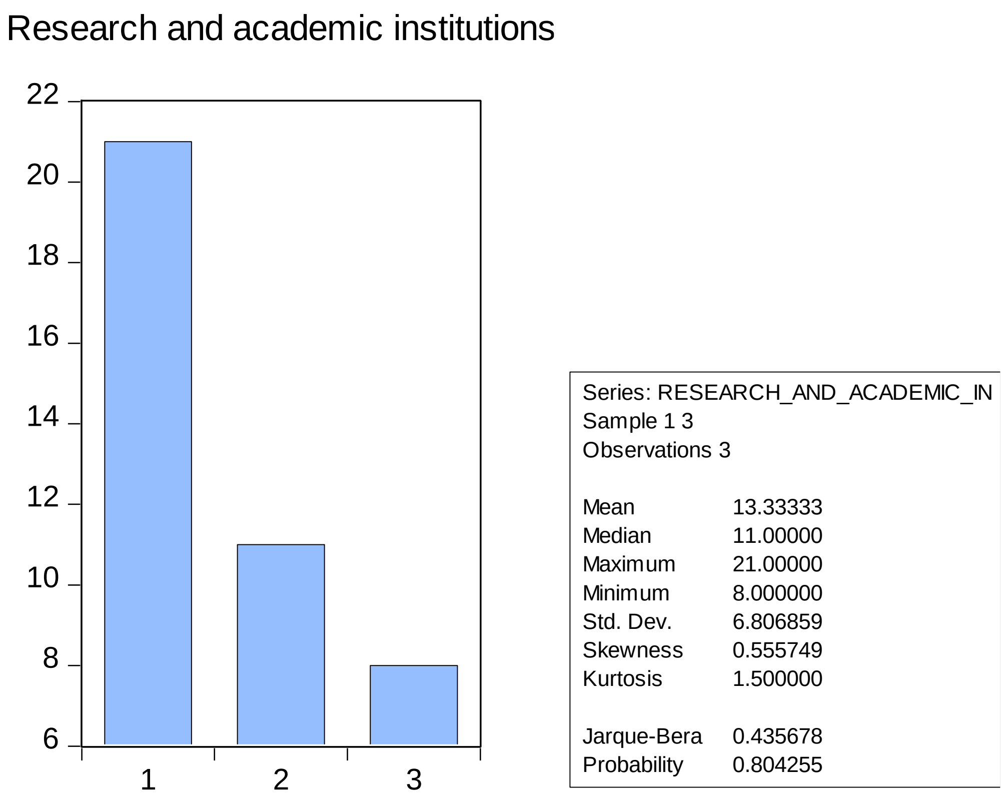


Figure 4.20 Research and academic technologies as key success factors in coastal-based transport systems

Findings showed that 52.5% of the respondents ranked them at maximum while 10% ranked them as medium. An additional 27.5% ranked them medium while 20% ranked them minimum. The hypothesis test for the factor was also undertaken as shown in table 4.18 below.

Hypothesis Testing for RESEARCH_AND_ACADEMIC_INSTITUTIONS

Date: 10/27/19 Time: 04:13

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 6.806859

Method	Value	Probability
t-statistic	0.008482	0.9940

Table 4.18 Hypothesis test for research and academic technologies as key success factors in coastal-based transport systems

The next question required respondents to rank the government as a key success factor in the technology field. Results obtained were summarized in figure 4.21 below.

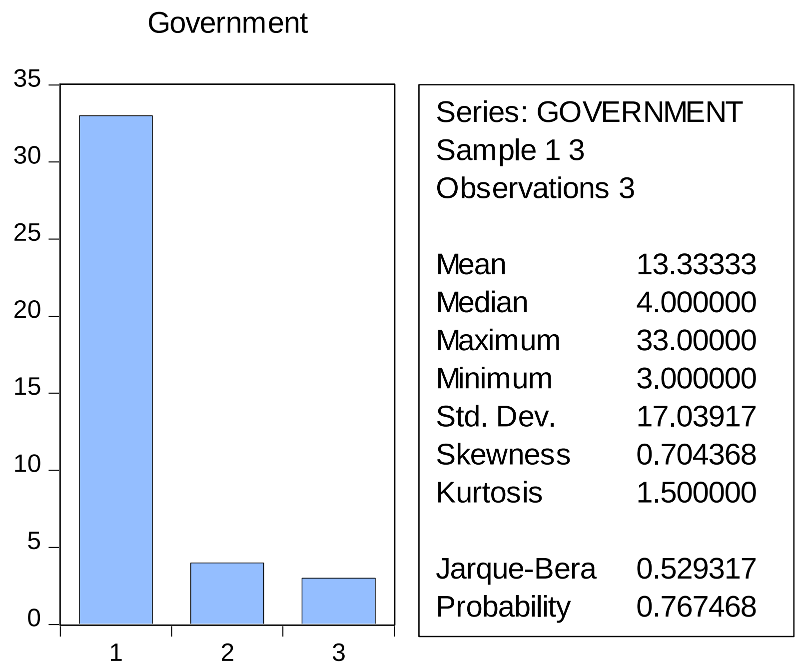


Figure 4.21 Government as a key success factor in coastal-based transport systems

The results obtained showed that 82.5% of the respondents ranked the government as a key success factor at maximum while 10% ranked it at medium. 7.5% ranked the government at minimum. The hypothesis test was also undertaken as illustrated in table 4.19 below.

Hypothesis Testing for GOVERNMENT

Date: 10/27/19 Time: 04:14

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.03917

Method	Value	Probability
t-statistic	0.003388	0.9976

Table 4.19 Hypothesis test for government as a key success factor in coastal-based transport systems

The next question investigated the role of policy incentives as a key success factor, the results were obtained as shown in figure 4.22 below.

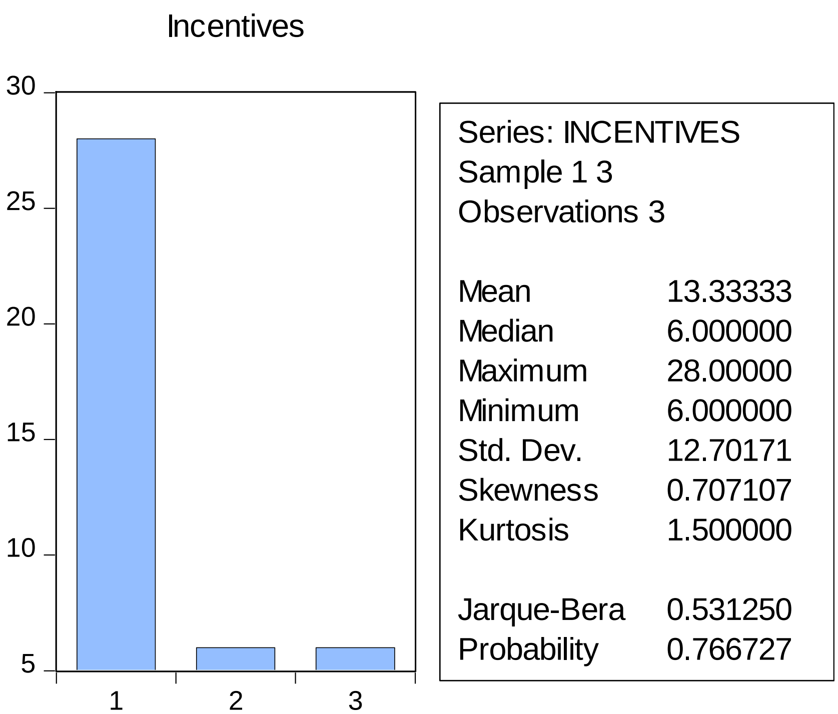


Figure 4.22 Policy incentives as a key success factor in coastal-based transport systems

The findings obtained showed that 70% of the participants ranked policy incentives at maximum while 15% ranked them at medium. An additional 15% ranked them at minimum. The hypothesis test was carried out as shown in table 4.20 below.

Hypothesis Testing for INCENTIVES

Date: 10/27/19 Time: 04:15

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 12.70171

Method	Value	Probability
t-statistic	0.004545	0.9968

Table 4.20 Hypothesis test for policy incentives as a key success factor in coastal-based transport systems

In the fifth question, respondents were asked to rank the importance of legal regulations and standards as a supportive policy measure to promote the field. Results were obtained as shown in figure 4.23 below.

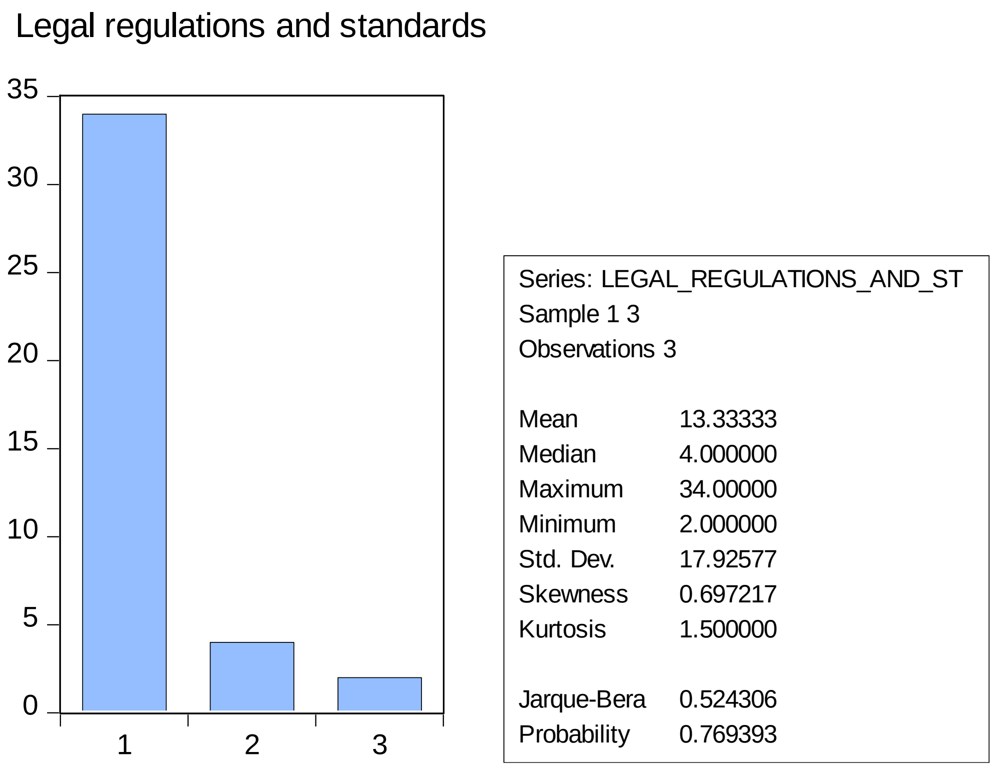


Figure 4.23 Importance of legal regulations and standards in promoting the coastal-based transport systems

Results obtained showed that 85% of the respondents ranked legal regulations and standards at maximum while 10% ranked them medium. 5% of the participants ranked regulations and standards at minimum. The hypothesis test was also undertaken as shown in table 4.21 below.

Hypothesis Testing for LEGAL_REGULATIONS_AND_STANDARDS

Date: 10/27/19 Time: 04:16

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

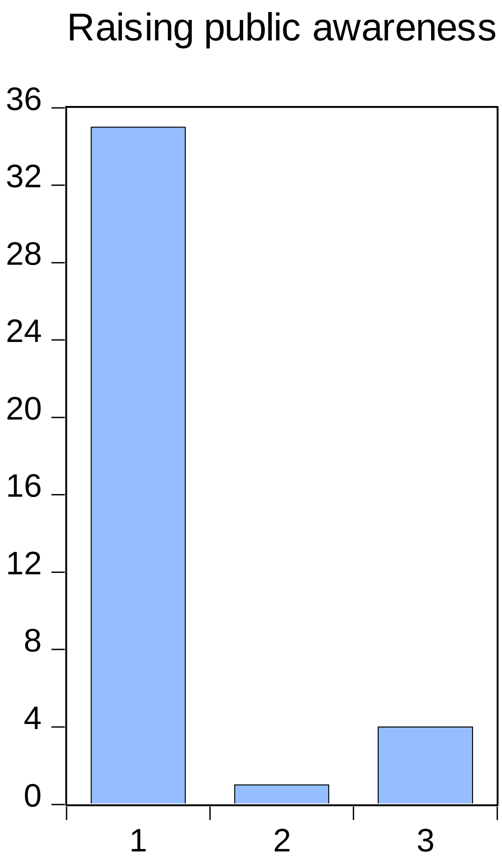
Sample Mean = 13.33333

Sample Std. Dev. = 17.92577

Method	Value	Probability
t-statistic	0.003221	0.9977

Table 4.21 Hypothesis test for importance of legal regulations and standards in promoting coastal-based transport systems

The next question investigated the importance of raising public awareness in promoting hybrid propulsions technology was also investigated with results being displayed in figure 4.24 below.



Series: RAISING_PUBLIC_AWARENESS	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	4.000000
Maximum	35.00000
Minimum	1.000000
Std. Dev.	18.82374
Skewness	0.686955
Kurtosis	1.500000
Jarque-Bera	0.517204
Probability	0.772130

Figure 4.24 Importance of raising public awareness in promoting coastal-based transport systems

The results obtained showed that 87.5% of the respondents ranked raising public awareness at maximum. 2.5% of them ranked it at medium while an additional 10% ranked it at minimum. The hypothesis test was also undertaken for the factor as shown in table 4.22 below.

Hypothesis Testing for RAISING_PUBLIC_AWARENESS

Date: 10/27/19 Time: 04:19

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.82374

Method	Value	Probability
t-statistic	0.003067	0.9978

Table 4.22 Hypothesis test for importance of raising public awareness in promoting the coastal-based transport systems

In the last question, the participants were asked to identify the most important region in regards to present research and development. Figure 4.25 below illustrates the results obtained.

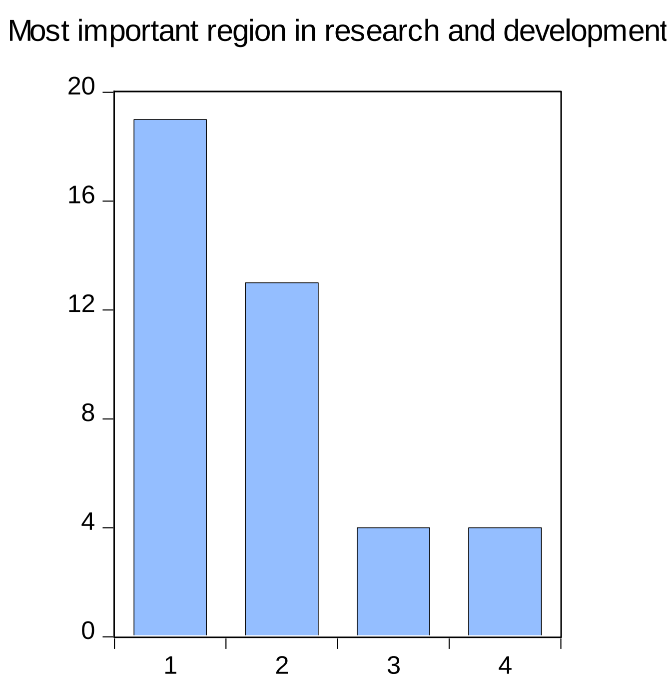


Figure 4.25 Most important research and development region in coastal-based transport systems

The findings showed that China was ranked highest by 47.5% of the respondents while Asia followed closely at 32.5%. The USA and the Middle East were each ranked at 20%.

The respondents were also asked to identify the most important region in regards to market potential. Figure 4.26 below demonstrated the results obtained.

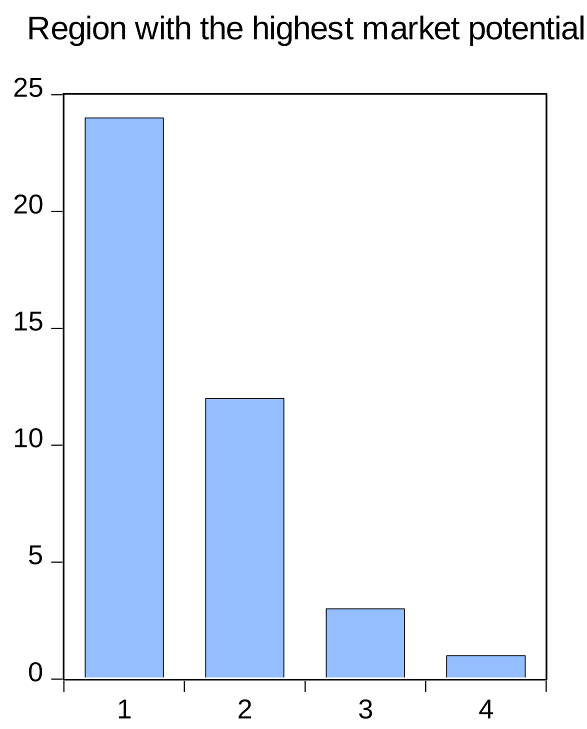


Figure 4.26 Region with the highest market potential for the coastal-based transport systems

The results obtained showed that China was ranked highest by 60% of the respondents while Asia was ranked second by 30% of the respondents. The Middle East was ranked third by 7.5% of the participants while the USA was ranked last by 2.5% of them.

4.3.3 Smart port solutions

In the first question, respondents were asked to indicate their level of expertise. Figure 4.27 below summarized the findings obtained.

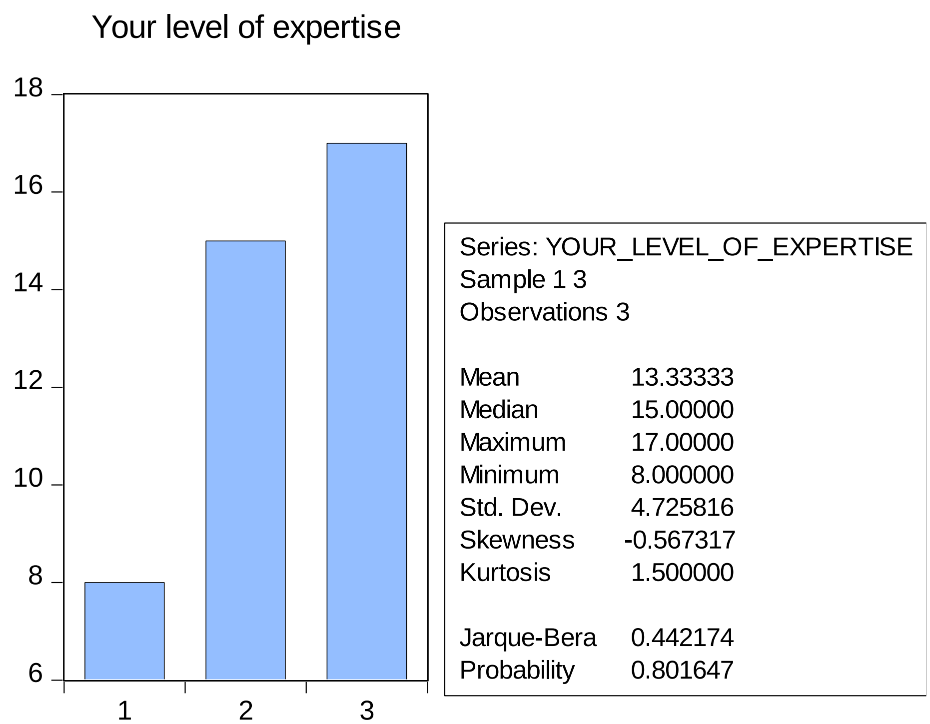


Figure 4.27 Level of expertise in smart port solutions

Results showed that only 20% of the respondents ranked their expertise at maximum while 37.5% ranked it medium. 42.5% ranked it minimum. The hypothesis test was also undertaken as shown in table 4.23 below.

Hypothesis Testing for YOUR_LEVEL_OF_EXPERTISE

Date: 10/27/19 Time: 04:40

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

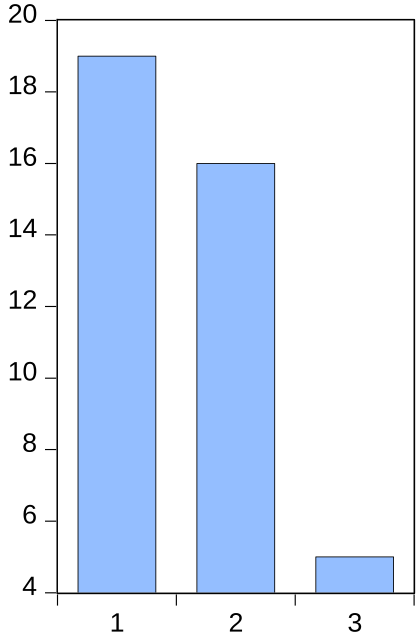
Sample Std. Dev. = 4.725816

Method	Value	Probability
t-statistic	0.012217	0.9914

Table 4.23 Hypothesis test for level of expertise in smart port solutions

The next question required respondents to highlight the present level of innovation in their specific technological field. Results obtained are shown in figure 4.28 below.

Innovation levels of the different technology fields



Series: INNOVATION_LEVELS_OF_THE
Sample 1 3
Observations 3

Mean	13.33333
Median	16.00000
Maximum	19.00000
Minimum	5.000000
Std. Dev.	7.371115
Skewness	-0.577634
Kurtosis	1.500000
Jarque-Bera	0.448080
Probability	0.799283

Figure 4.28 Present innovation level in smart port solutions

The results obtained showed that 47.5% of the respondents identified that the innovation level was maximum while 40% identified it as medium. 12.5% of the respondents ranked the innovation level as minimum. The hypothesis test for the present innovation levels is presented in table 4.24 below.

Hypothesis Testing for INNOVATION_LEVELS_OF_THE_DIFFERENT

_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 04:42

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

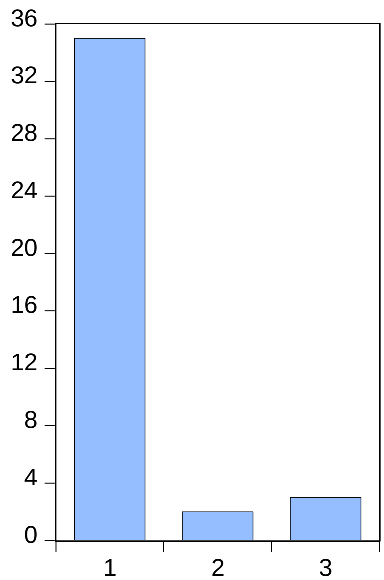
Sample Std. Dev. = 7.371115

Method	Value	Probability
t-statistic	0.007833	0.9945

Table 4.24 Hypothesis test for present innovation level in smart port solutions

The importance of development in the specified technology field was also investigated where results obtained were summarized in figure 4.29 below.

Importance of the development of the different technology fields



Series: IMPORTANCE_OF_THE_DEVELO
Sample 1 3
Observations 3

Mean	13.33333
Median	3.000000
Maximum	35.00000
Minimum	2.000000
Std. Dev.	18.77054
Skewness	0.704850
Kurtosis	1.500000
Jarque-Bera	0.529657
Probability	0.767338

Figure 4.29 Importance of development in smart port solutions

The results obtained showed that 87.5% of the participants ranked the importance of development was maximum while 5% ranked it as medium. A further 7.5% ranked it as minimum. The hypothesis test for the factor was also undertaken as shown in table 4.25 below.

Hypothesis Testing for IMPORTANCE_OF_THE_DEVELOPMENT_OF_
THE_DIFFERENT_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 04:43

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.003076	0.9978

Table 4.25 Hypothesis test for importance of development in smart port solutions

The respondents were also asked to rank the probability of industry wide implementation over the next ten-year period. Figure 4.30 below represents the findings obtained.

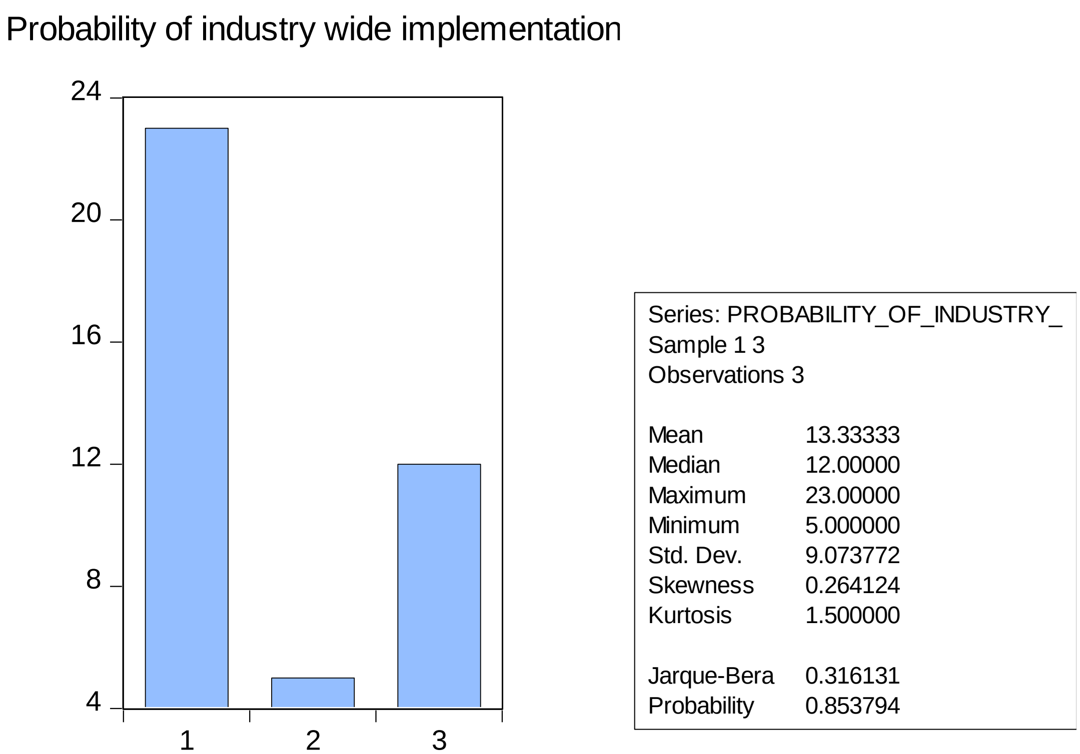


Figure 4.30 Probability of industry-wide implementation in smart port solutions

Findings obtained showed that 57.5% of the participants ranked the probability as maximum while 12.5% of them ranked it as medium. 30% ranked it minimum. The hypothesis test obtained was summarized in table 4.26 below.

Hypothesis Testing for PROBABILITY_OF_INDUSTRY_WIDE_IMPLEM

ENTATION

Date: 10/27/19 Time: 04:44

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 9.073772

Method	Value	Probability
t-statistic	0.006363	0.9955

Table 4.26 Hypothesis test for probability of industry-wide implementation in smart port solutions

With the third question, participants were required to rank the probability of their regions becoming leaders in research and development capabilities. Results obtained are shown in figure 4.31 below.

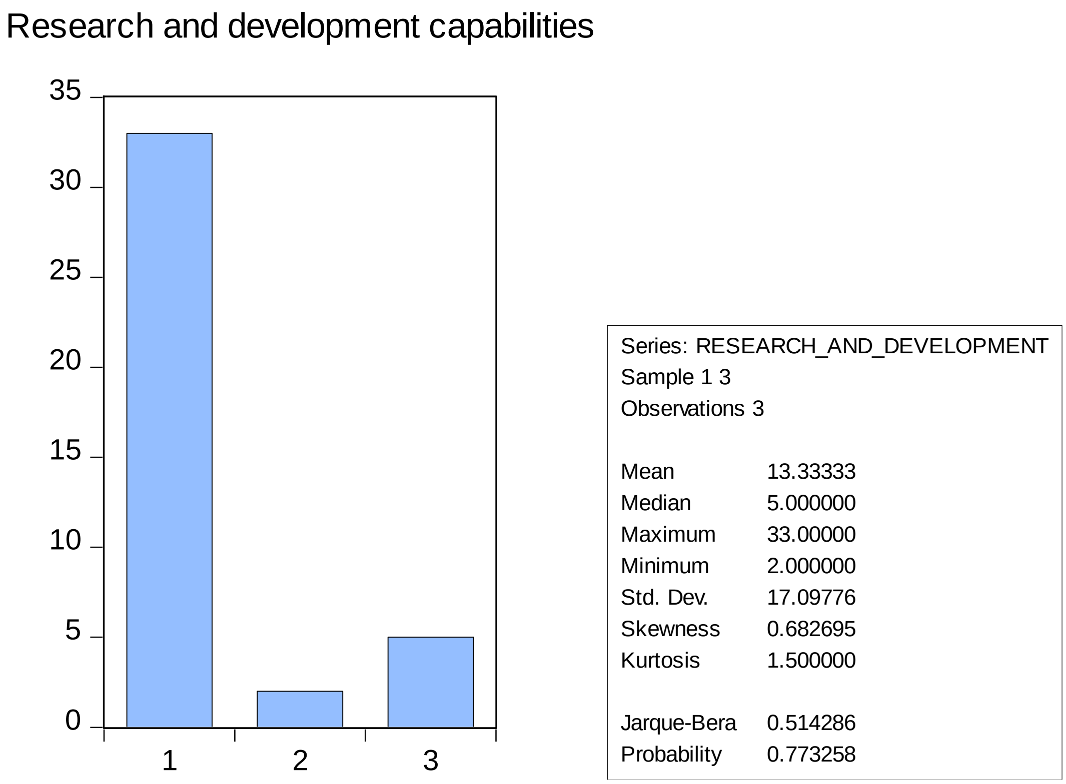


Figure 4.31 Chances of leadership in research & development in smart port solutions

Findings showed that 82.5% ranked the probability of being leaders in research and development at maximum. 5% ranked it as medium while 12.5% ranked it as minimum. The hypothesis test results obtained are shown in table 4.27 below.

Hypothesis Testing for RESEARCH_AND_DEVELOPMENT_CAPABILI

TIES

Date: 10/27/19 Time: 04:46

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.09776

Method	Value	Probability
t-statistic	0.003377	0.9976

Table 4.27 Hypothesis test for chances of leadership in research & development in smart port solutions

The third question further sought to identify the societal acceptability of the region being a leader in technology. Figure 4.32 below displayed the results obtained.

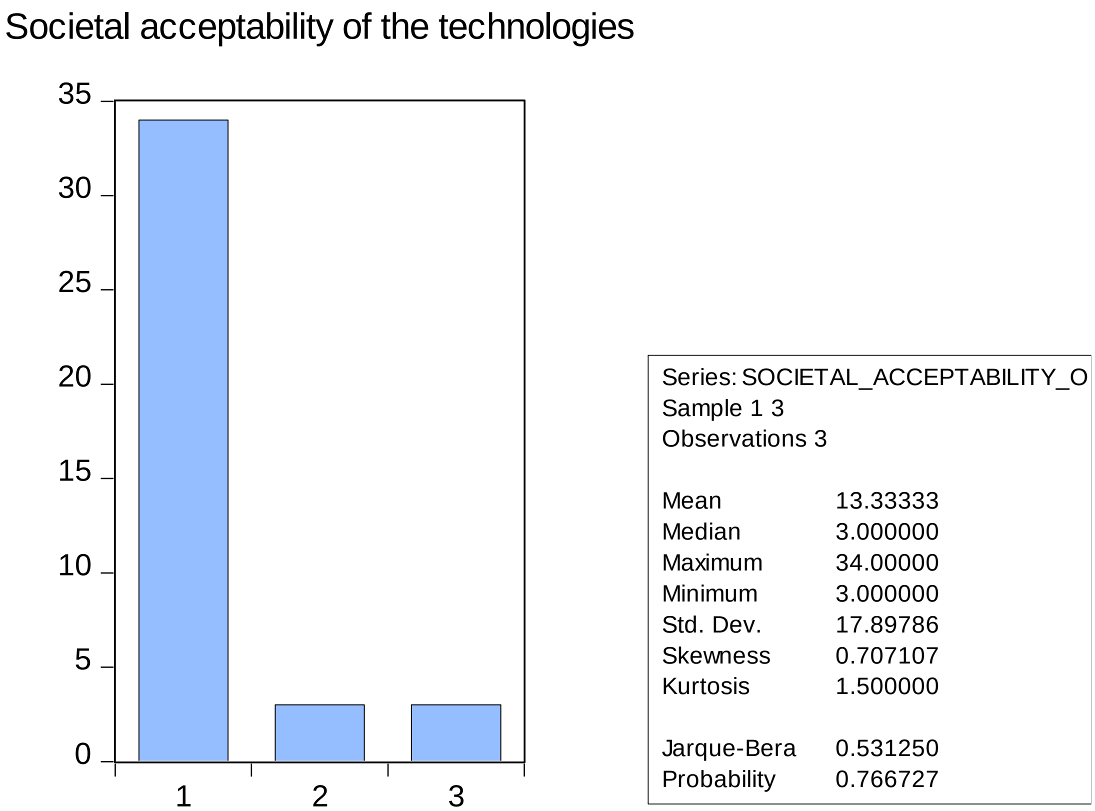


Figure 4.32 Societal acceptability of technologies in smart port solutions

The findings showed that 85% of the respondents ranked the societal acceptability at maximum while 7.5% ranked it at medium. An additional 7.5% ranked it at minimum. Table 4.28 below further shows the results of the hypothesis test.

Hypothesis Testing for SOCIETAL_ACCEPTABILITY_OF_THE_TECHN

OLOGIES

Date: 10/27/19 Time: 04:47

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

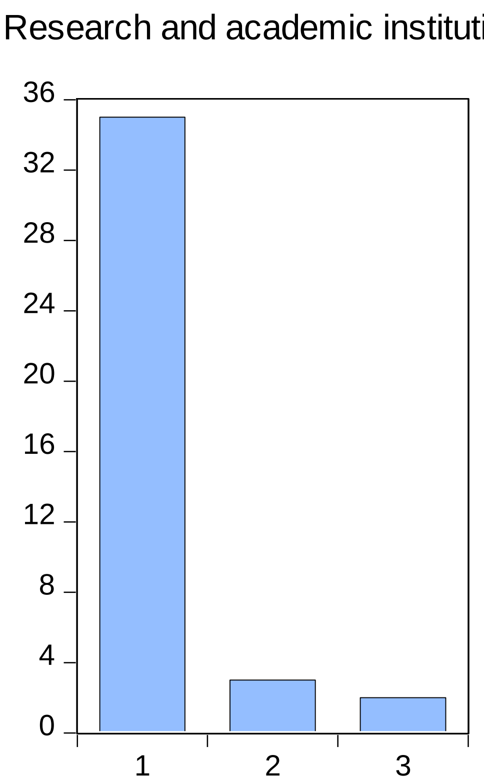
Sample Mean = 13.33333

Sample Std. Dev. = 17.89786

Method	Value	Probability
t-statistic	0.003226	0.9977

Table 4.28 Hypothesis test for societal acceptability of technologies in smart port solutions

The fourth question investigated how the respondents ranked research and academic institutions as key success players in the given technology field. Figure 4.33 below presents the results obtained.



Series: RESEARCH_AND_ACADEMIC_IN	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	3.000000
Maximum	35.00000
Minimum	2.000000
Std. Dev.	18.77054
Skewness	0.704850
Kurtosis	1.500000
Jarque-Bera	0.529657
Probability	0.767338

Figure 4.33 Research and academic technologies as key success factors in smart port solutions

Findings showed that 87.5% of the respondents ranked them at maximum while 7.5% ranked them as medium. An additional 5% ranked them at minimum. The hypothesis test for the factor was also undertaken as shown in table 4.29 below.

Hypothesis Testing for RESEARCH_AND_ACADEMIC_INSTITUTIONS

Date: 10/27/19 Time: 04:48

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.33000

Sample Mean = 13.33333

Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.000308	0.9998

Table 4.29 Hypothesis test for research and academic technologies as key success factors in smart port solutions

Similarly, respondents were asked to rank the government as a key success factor in the technology field. Results obtained were summarized in figure 4.34 below.

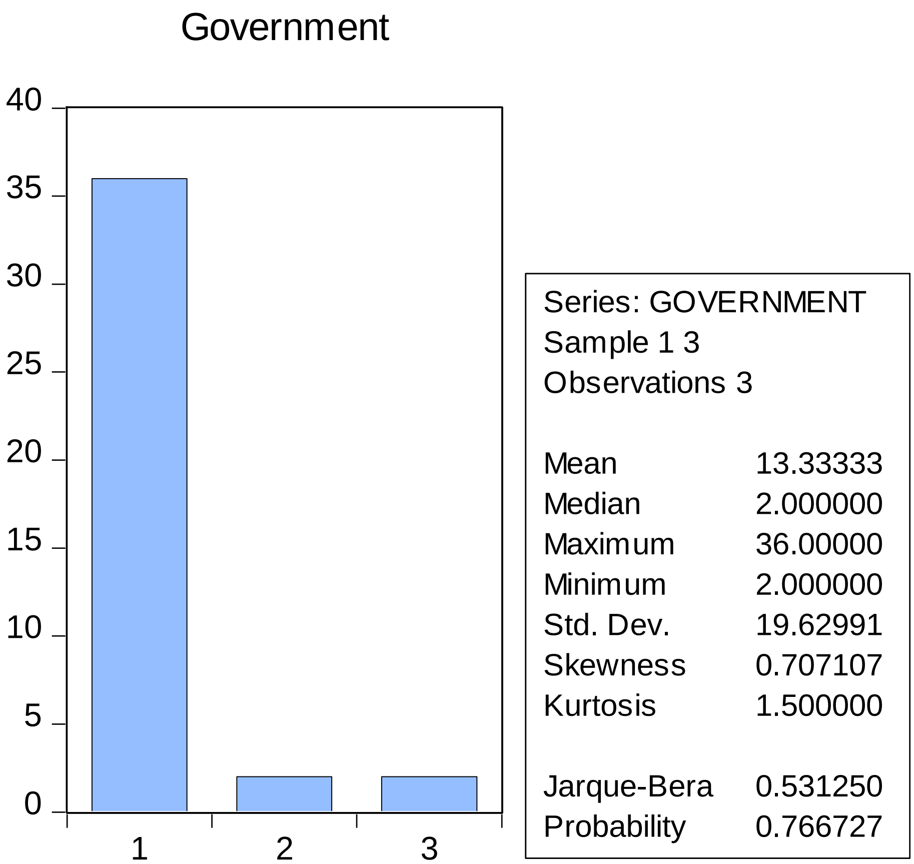


Figure 4.34 Government as a key success factor in smart port solutions

The results obtained showed that 90% of the respondents ranked the government as a key success factor at maximum while 5% ranked it at medium. An additional 5% also ranked the government at minimum. The hypothesis test was also undertaken as illustrated in table 4.30 below.

Hypothesis Testing for GOVERNMENT

Date: 10/27/19 Time: 04:50

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 19.62991

Method	Value	Probability
t-statistic	0.002941	0.9979

Table 4.30 Hypothesis test for government as a key success factor in smart port solutions

When asked about the role of policy incentives as a key success factor, the results were obtained as shown in figure 4.35 below.

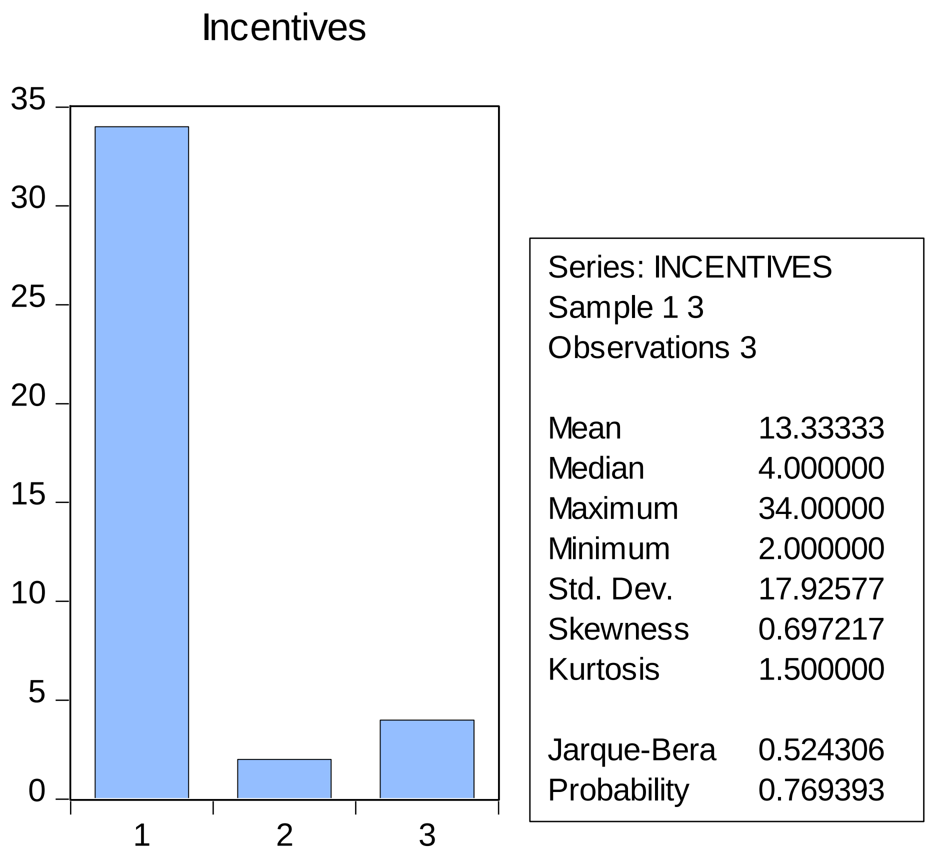


Figure 4.35 Policy incentives as a key success factor in smart port solutions

The findings obtained showed that 85% of the participants ranked policy incentives at maximum while 5% ranked them at medium. An additional 10% ranked them at minimum. The hypothesis test was carried out as shown in table 4.31 below.

Hypothesis Testing for INCENTIVES

Date: 10/27/19 Time: 04:51

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.92577

Method	Value	Probability
t-statistic	0.003221	0.9977

Table 4.31 Hypothesis test for policy incentives as a key success factor in smart port solutions

In the fifth question, respondents were asked to rank the importance of legal regulations and standards as a supportive policy measure to promote the field. Results were obtained as shown in figure 4.36 below.

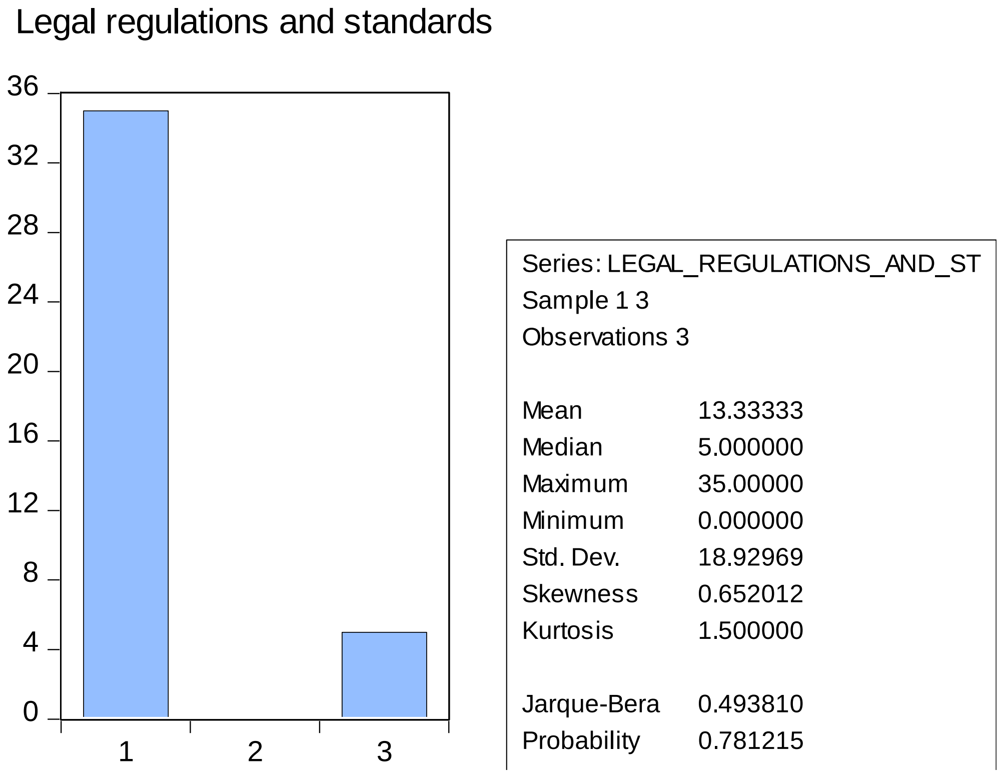


Figure 4.36 Importance of legal regulations and standards in promoting smart port solutions

Results obtained showed that 87.5% of the respondents ranked legal regulations and standards at maximum while 12.5% of the participants ranked regulations and standards at minimum. None ranked them at medium. The hypothesis test was also undertaken as shown in table 4.32 below.

Hypothesis Testing for LEGAL_REGULATIONS_AND_STANDARDS

Date: 10/27/19   Time: 04:53

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.92969

Method	Value	Probability
t-statistic	0.003050	0.9978

Table 4.32 Hypothesis test for importance of legal regulations and standards in promoting smart port solutions

Likewise, the importance of raising public awareness in promoting smart ports technology was also investigated with results being displayed in figure 4.37 below.

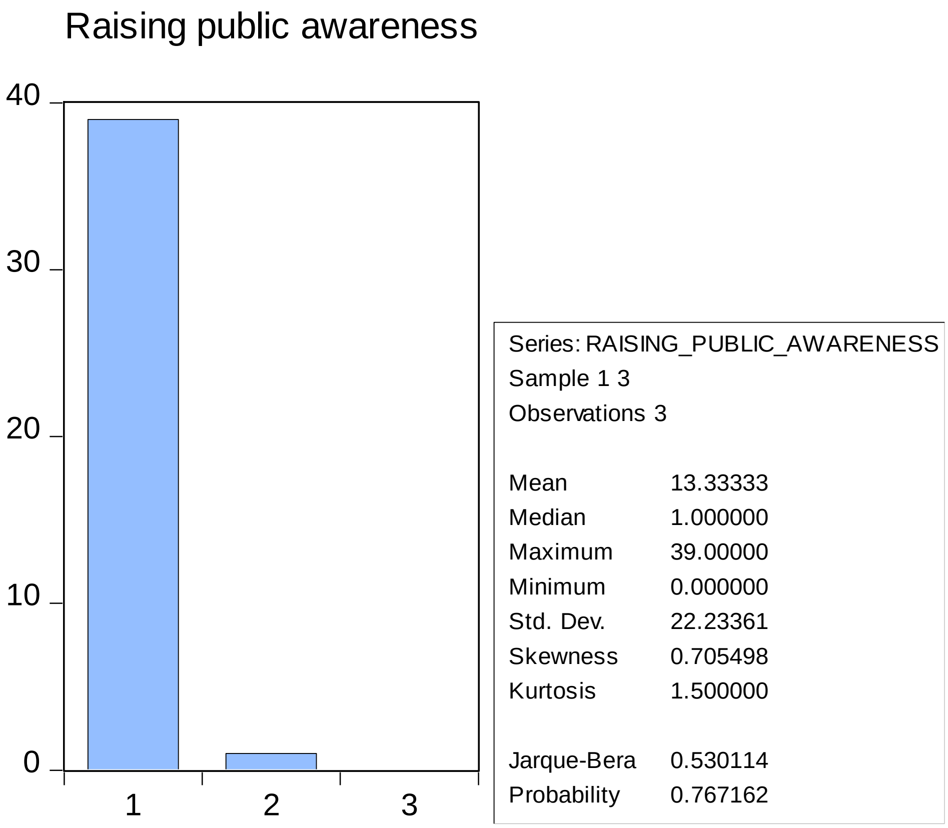


Figure 4.37 Importance of raising public awareness in promoting smart port solutions

The results obtained showed that 97.5% of the respondents ranked raising public awareness at maximum. none of them ranked it at medium while 2.5% ranked it at minimum. The hypothesis test was also undertaken for the factor as shown in table 4.33 below.

Hypothesis Testing for RAISING_PUBLIC_AWARENESS

Date: 10/27/19 Time: 04:54

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 22.23361

Method	Value	Probability
t-statistic	0.002597	0.9982

Table 4.33 Hypothesis test for importance of raising public awareness in promoting smart port solutions

In the last question, the participants were asked to identify the most important region in regards to present research and development. Figure 4.38 below illustrates the results obtained.

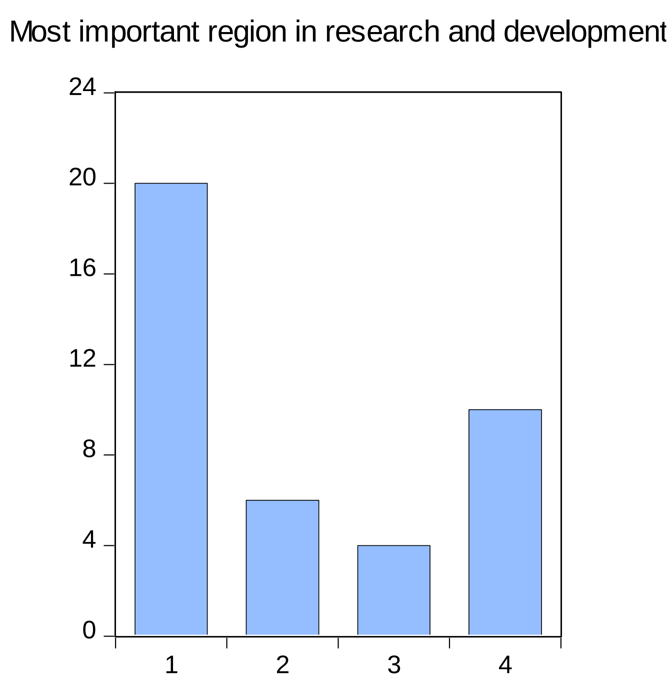


Figure 4.38 Most important research and development region in smart port solutions

The findings showed that China was ranked highest by 50% of the respondents while the USA followed closely at 25%. Asia followed third at 15% and the Middle East was ranked last at 10%.

Finally, the respondents were also asked to identify the most important region in regards to market potential. Figure 4.39 below demonstrated the results obtained.

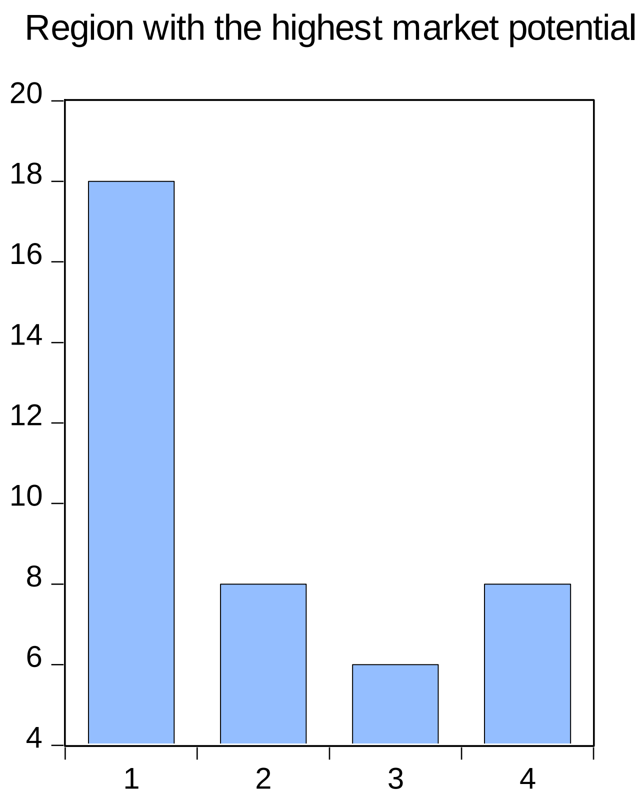


Figure 4.39 Region with the highest market potential for the smart port solutions

The results obtained showed that China was ranked highest by 45% of the respondents while Asia and the USA were ranked second by 20% of the respondents. The Middle East was ranked last by 5% of the participants.

B. 4.4 Results from energy and environment questionnaire

4.4.1 Integration of renewable energy

The first question investigated the level of expertise of the participants where results were summarized in figure 4.40 below.

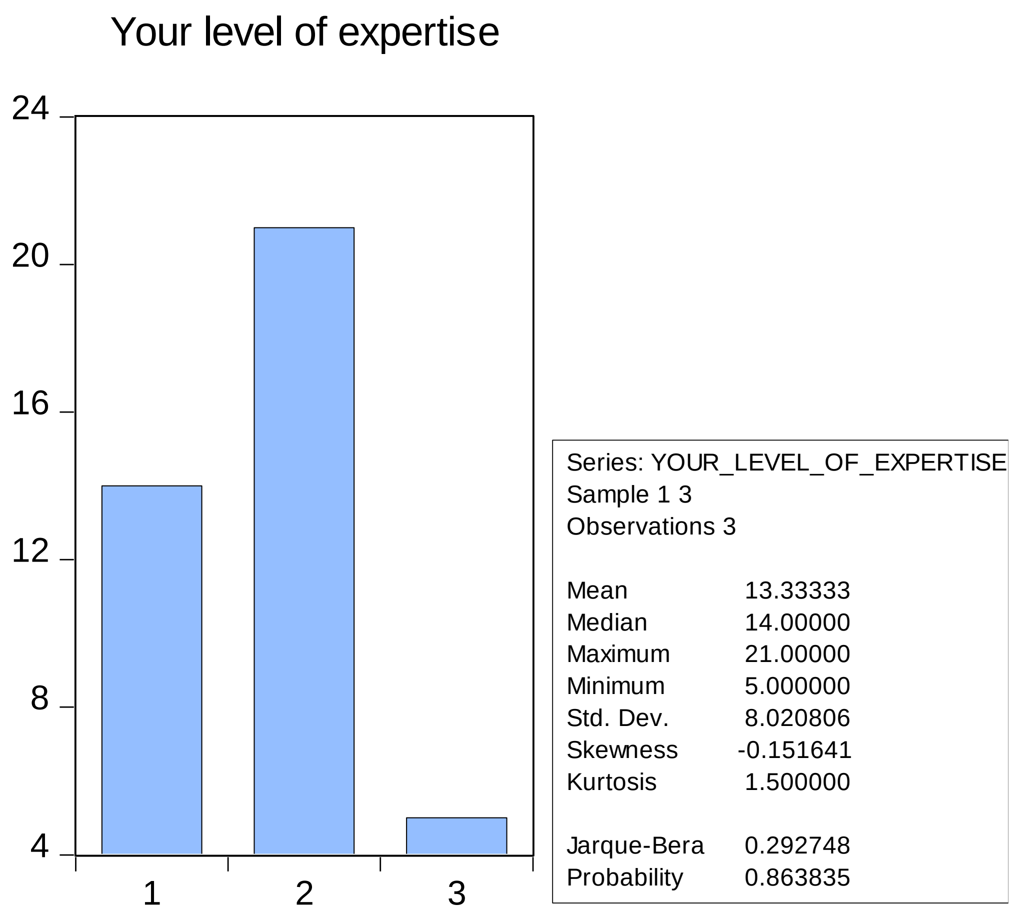


Figure 4.40 Level of expertise in renewable energy

The results obtained showed that 35% of the respondents ranked their expertise at maximum whereas 52.5% ranked it at medium. About 12.5% ranked it at minimum. The hypothesis test was also undertaken as shown in table 4.34 below.

Hypothesis Testing for YOUR_LEVEL_OF_EXPERTISE

Date: 10/27/19   Time: 02:08

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.33000

Assuming Std. Dev. = 8.020000

Sample Mean = 13.33333

Sample Std. Dev. = 8.020806

Method	Value	Probability
Z-statistic	0.000720	0.9994
t-statistic	0.000720	0.9995

Table 4.34 Hypothesis test for level of expertise in renewable energy

The respondents were then required to rank the present level of innovation in their specific technological field. Results obtained are shown in figure 4.41 below.

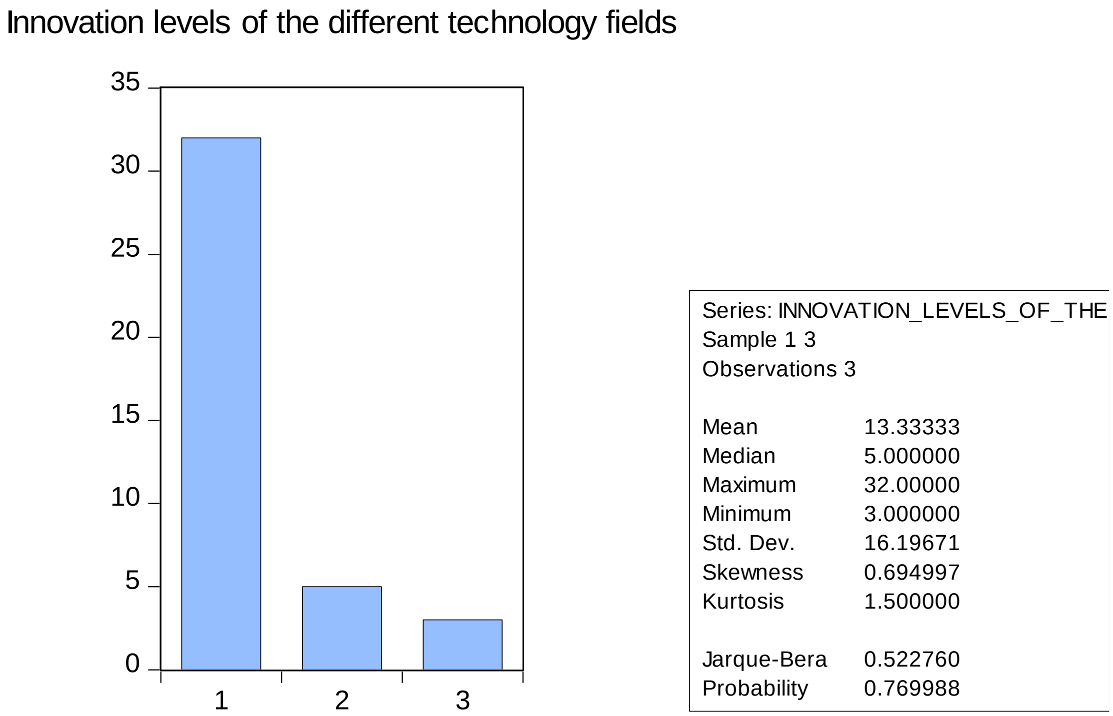


Figure 4.41 Present innovation level in renewable energy

The results obtained showed that 80% of the respondents identified that the innovation level was maximum while 12.5% identified it as medium. 7.5%of the respondents classified the innovation level as minimum. The hypothesis test for the present innovation levels is presented in table 4.34 below.

Hypothesis Testing for INNOVATION_LEVELS_OF_THE_DIFFERENT

_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 02:17

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

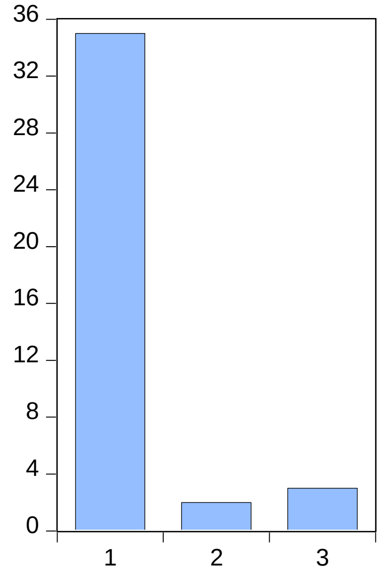
Sample Std. Dev. = 16.19671

Method	Value	Probability
t-statistic	0.003565	0.9975

Table 4.35 Hypothesis test for present innovation level in renewable energy

The importance of development in the specified technology field was also investigated with results obtained being shown in figure 4.42 below.

Importance of the development of the different technology fields



Series: IMPORTANCE_OF_THE_DEVELO	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	3.000000
Maximum	35.00000
Minimum	2.000000
Std. Dev.	18.77054
Skewness	0.704850
Kurtosis	1.500000
Jarque-Bera	0.529657
Probability	0.767338

Figure 4.42 Importance of development in renewable energy

The results obtained showed that 87.5% of the participants identified the importance of development was maximum while 5% ranked it as medium. A further 7.5% ranked it as minimum. The hypothesis test for the factor was also undertaken as shown in table 4.36 below.

Hypothesis Testing for IMPORTANCE_OF_THE_DEVELOPMENT_OF_

THE_DIFFERENT_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 02:24

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.003076	0.9978

Table 4.36 Hypothesis test for importance of development in renewable energy

The respondents were also asked to rank the probability of industry wide implementation over the next ten years. Figure 4.43 below represents the findings obtained.

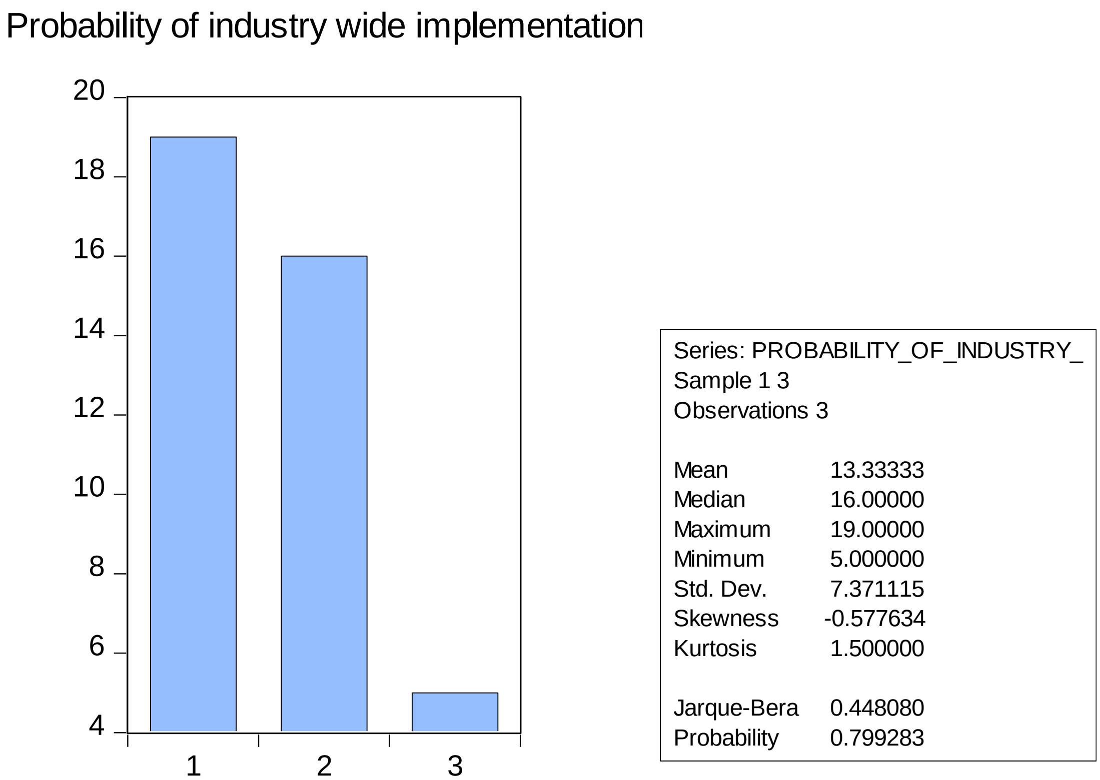


Figure 4.43 Probability of industry-wide implementation in renewable energy

Findings obtained showed that 47.5% of the participants ranked the probability as maximum while 40% of them ranked it as medium. 12.5% ranked it as minimum. The hypothesis test obtained was further summarized in table 4.37 below.

Hypothesis Testing for PROBABILITY_OF_INDUSTRY_WIDE_IMPLEM

ENTATION

Date: 10/27/19   Time: 02:26

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 7.371115

Method	Value	Probability
t-statistic	0.007833	0.9945

Table 4.37 Hypothesis test for probability of industry-wide implementation in renewable energy

The next question required participants to rank the probability of their regions becoming leaders in research and development capabilities. Results obtained are shown in figure 4.44 below.

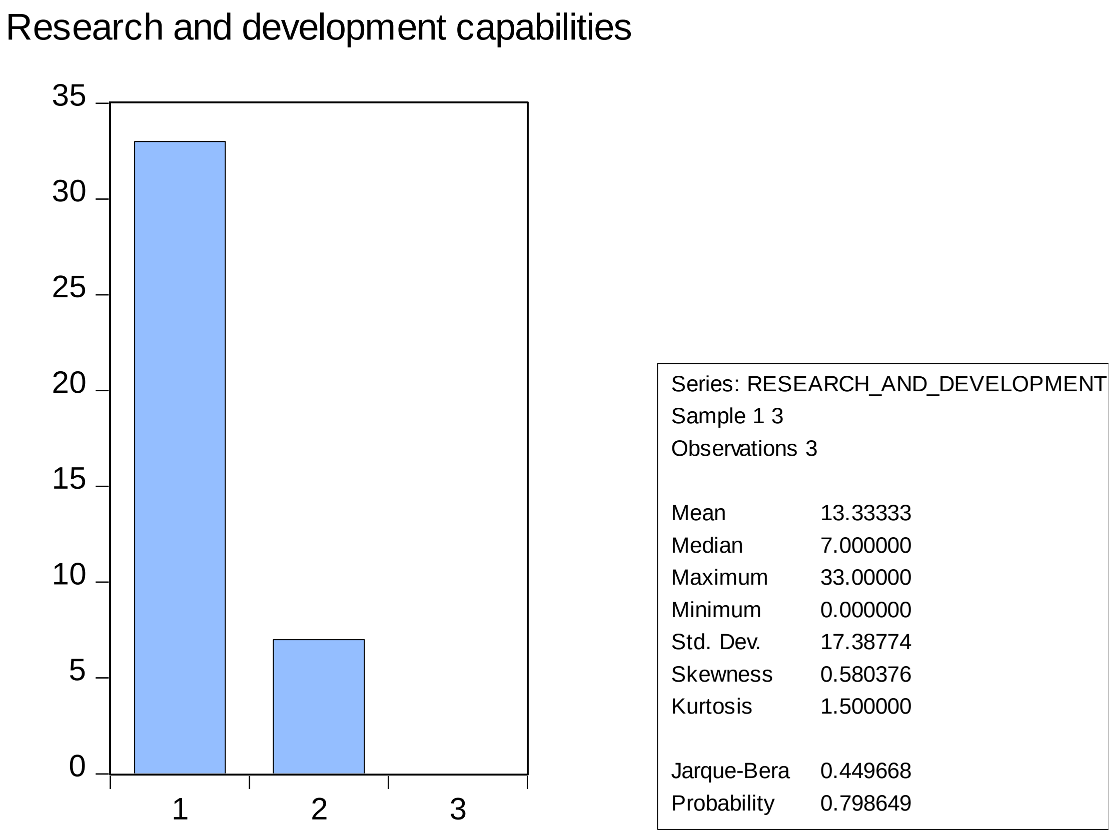


Figure 4.44 Chances of leadership in research & development in renewable energy

Findings showed that 82.5% ranked the probability of being leaders in research and development at maximum. 17.5% ranked it as medium while none of the participants ranked it as minimum. The hypothesis test results obtained are shown in table 4.38 below.

Hypothesis Testing for RESEARCH_AND_DEVELOPMENT_CAPABILI

TIES

Date: 10/27/19   Time: 02:28

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.38774

Method	Value	Probability
t-statistic	0.003320	0.9977

Table 4.38 Hypothesis test for chances of leadership in research & development in renewable energy

The third question investigated the societal acceptability of the region being a leader in technology. Figure 4.45 below displays the results obtained.

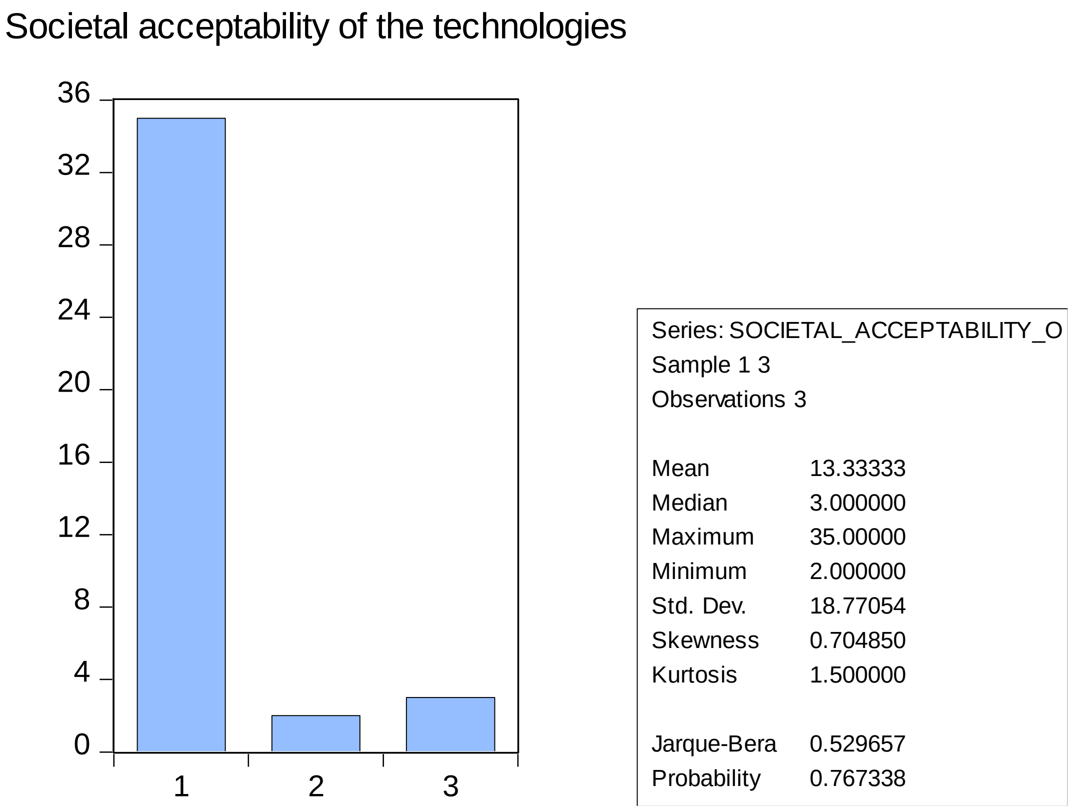


Figure 4.45 Societal acceptability of technologies in renewable energy

The findings showed that 87.5% of the respondents ranked the societal acceptability at maximum while 5% ranked it at medium. 7.5% ranked it at minimum. Table 4.39 below further shows the results of the hypothesis test.

Hypothesis Testing for SOCIETAL_ACCEPTABILITY_OF_THE_TECHN

OLOGIES

Date: 10/27/19   Time: 02:29

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.003076	0.9978

Table 4.39 Hypothesis test for societal acceptability of technologies in renewable energy

The fourth question required respondents to rank research and academic institutions as key success players in the given technology field. Figure 4.46 below presents the results obtained.

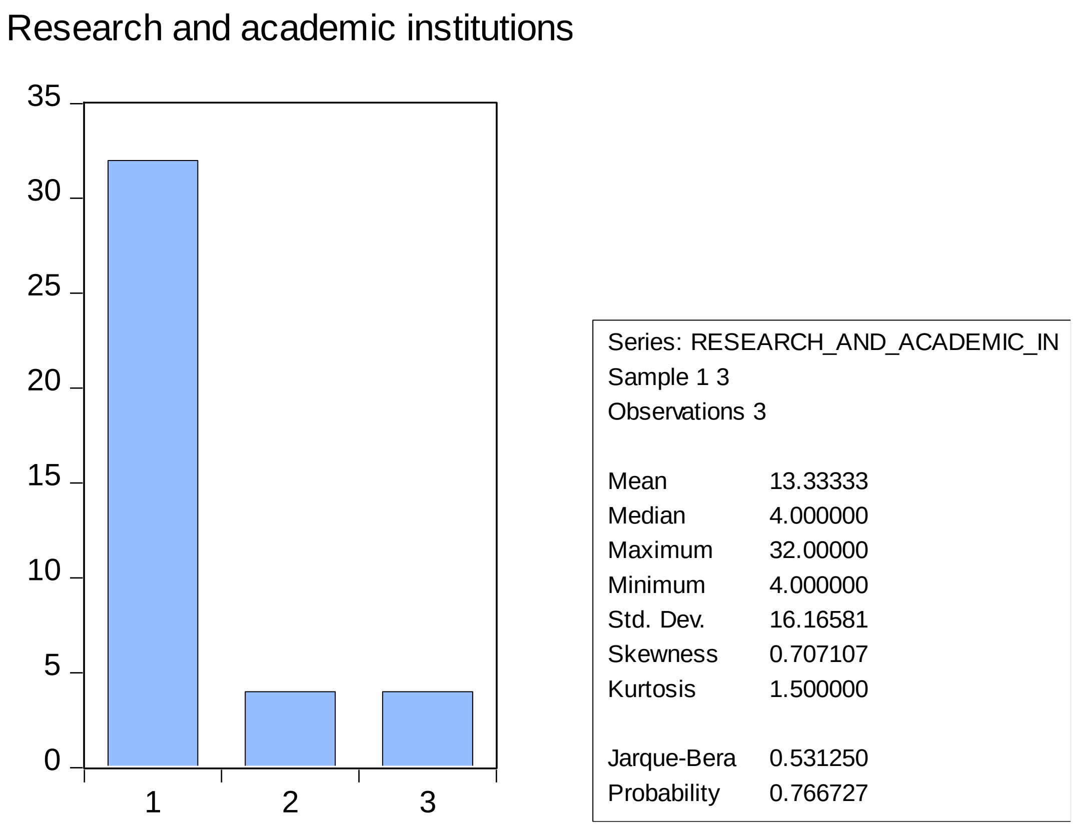


Figure 4.46 Research and academic technologies as key success factors in renewable energy

Findings showed that 80% of the respondents ranked them at maximum while 10% ranked them as medium. An additional 10% ranked them at minimum. The hypothesis test for the factor was also undertaken as shown in table 4.40 below.

Hypothesis Testing for RESEARCH_AND_ACADEMIC_INSTITUTIONS

Date: 10/27/19 Time: 02:34

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 16.16581

Method	Value	Probability
t-statistic	0.003571	0.9975

Table 4.40 Hypothesis test for research and academic technologies as key success factors in renewable energy

Similarly, respondents were asked to rank the government as a key success factor in the technology field. Results obtained are displayed in figure 4.47 below.

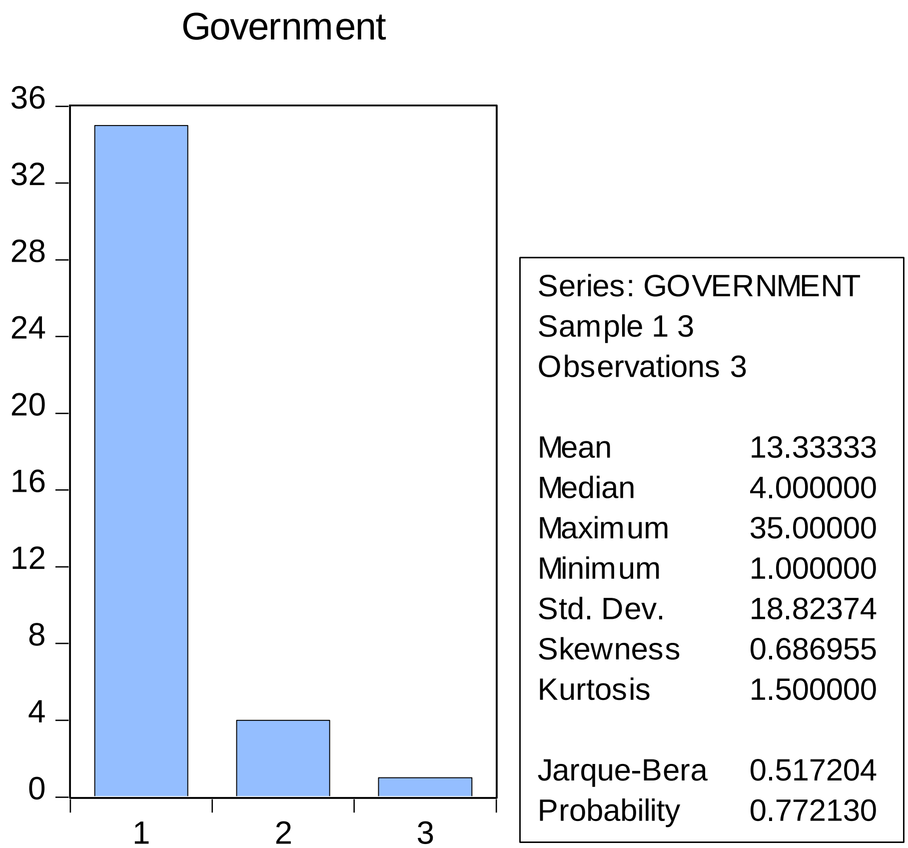


Figure 4.47 Government as a key success factor in renewable energy

The results obtained showed that 87.5% of the respondents ranked the government as a key success factor at maximum while 10% ranked it at medium. 2.5% ranked the government at minimum. The hypothesis test was also undertaken as illustrated in table 4.41 below.

Hypothesis Testing for GOVERNMENT

Date: 10/27/19 Time: 02:35

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.82374

Method	Value	Probability
t-statistic	0.003067	0.9978

Table 4 41 Hypothesis test for government as a key success factor in renewable energy

When asked about the role of policy incentives as a key success factor, the results were obtained as shown in figure 4.48 below.

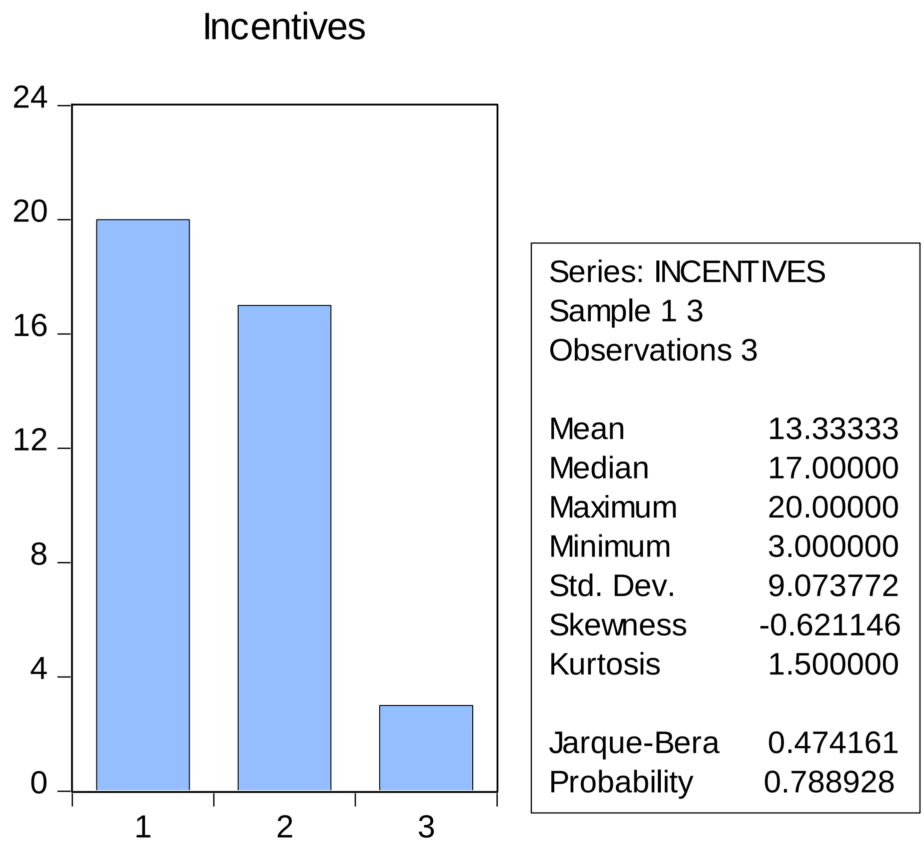


Figure 4.48 Policy incentives as a key success factor in renewable energy

The findings obtained showed that 50% of the participants ranked policy incentives at maximum while 42.5% ranked them at medium. An additional 7.5% ranked them at minimum. The hypothesis test was carried out as shown in table 4.42 below.

Hypothesis Testing for INCENTIVES

Date: 10/27/19 Time: 02:37

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 9.073772

Method	Value	Probability
t-statistic	0.006363	0.9955

Table 4.42 Hypothesis test for policy incentives as a key success factor in renewable energy

With the fifth question, respondents were asked to rank the importance of legal regulations and standards as a supportive policy measure to promote the field. Results were obtained as shown in figure 4.49 below.

Figure 4.49 Importance of legal regulations and standards in promoting renewable energy

Results obtained showed that 62.5% of the respondents ranked legal regulations and standards at maximum while 27.5% ranked them medium. 10% of the participants ranked regulations and standards at minimum. The hypothesis test was also undertaken as shown in table 4.43 below.

Hypothesis Testing for LEGAL_REGULATIONS_AND_STANDARDS

Date: 10/27/19   Time: 02:38

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 10.69268

Method	Value	Probability
t-statistic	0.005399	0.9962

Table 4.43 Hypothesis test for importance of legal regulations and standards in promoting renewable energy

Likewise, the importance of raising public awareness in promoting renewable energy technology was also investigated with results being displayed in figure 4.50 below.

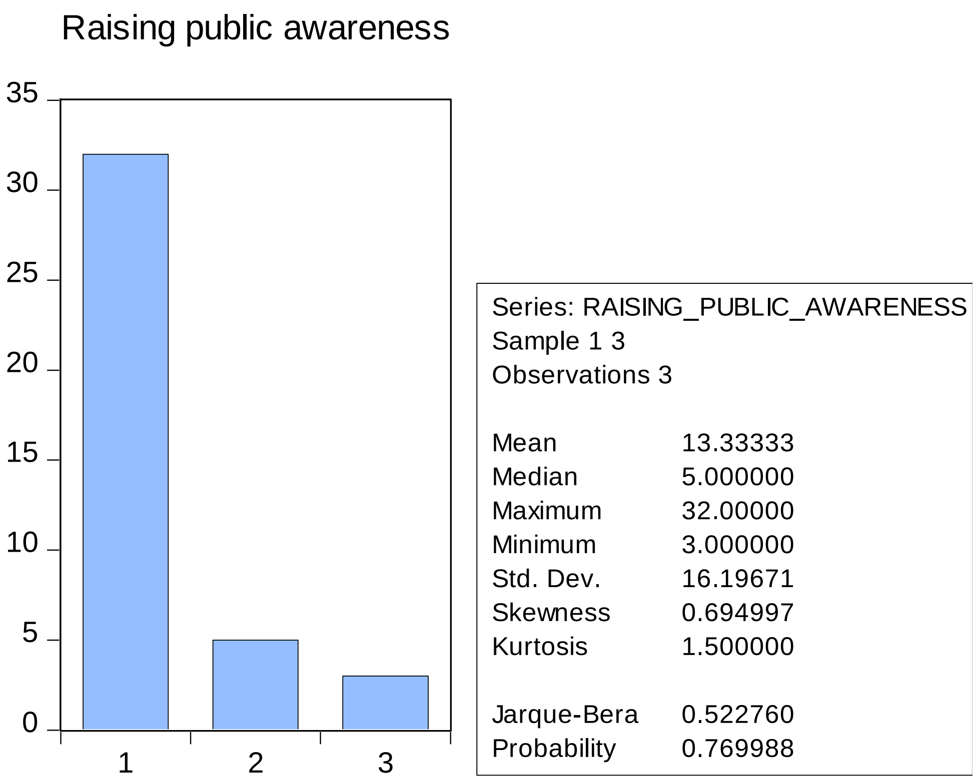


Figure 4.50 Importance of raising public awareness in promoting renewable energy

The results obtained showed that 80% of the respondents ranked raising public awareness at maximum. 12.5% of them ranked it at medium while an additional 7.5% ranked it at minimum. The hypothesis test was also undertaken for the factor as shown in table 4.44 below.

Hypothesis Testing for RAISING_PUBLIC_AWARENESS

Date: 10/27/19 Time: 02:40

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 16.19671

Method	Value	Probability
t-statistic	0.003565	0.9975

Table 4.44 Hypothesis test for importance of raising public awareness in promoting renewable energy

In the last question, the participants were asked to identify the most important region in regards to present research and development. Figure 4.51 below illustrates the results obtained.

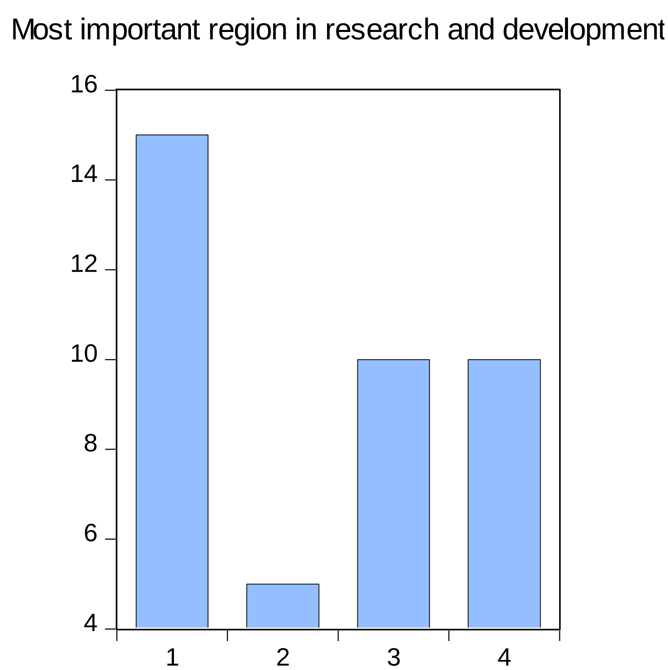


Figure 4.51 Most important research and development region in renewable energy

The findings showed that China was ranked highest by 37.5% of the respondents while the USA and the Middle East were ranked third at 25%. Asia was ranked last at 12.5%.

Finally, the respondents were also asked to identify the most important region in regards to market potential. Figure 4.52 below demonstrated the results obtained.

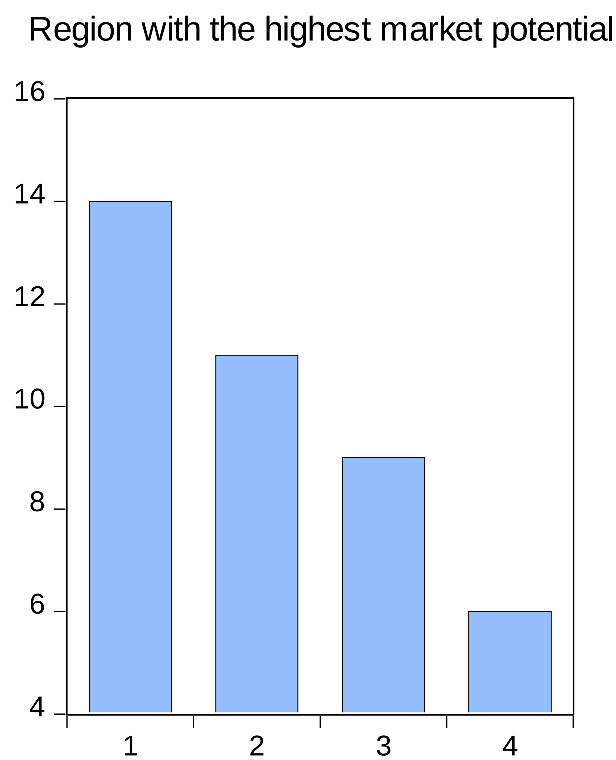
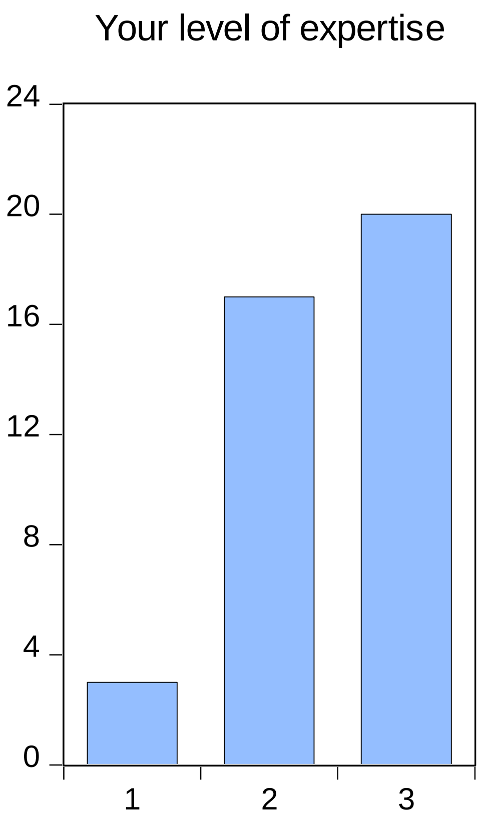


Figure 4.52 Region with the highest market potential for renewable energy

The results obtained showed that China was ranked highest by 35% of the respondents while Asia was ranked second by 27.5% of the respondents. The Middle East was ranked third by 22.5% of the participants while the USA was ranked last by 15% of the participants.

4.4.2 Data based services and solutions

The first question required respondents to rank their expertise in the field. Figure 4.53 below presents the results obtained.



Series: YOUR_LEVEL_OF_EXPERTISE
Sample 1 3
Observations 3

Mean	13.33333
Median	17.00000
Maximum	20.00000
Minimum	3.000000
Std. Dev.	9.073772
Skewness	-0.621146
Kurtosis	1.500000
Jarque-Bera	0.474161
Probability	0.788928

Figure 4.53 Level of expertise in data-based solutions

Results obtained showed that only 7.5% of the respondents ranked their expertise as maximum while 42.5% ranked it medium. An additional 50% ranked it minimum. The hypothesis test was also undertaken as shown in table 4.45 below.

Hypothesis Testing for YOUR_LEVEL_OF_EXPERTISE

Date: 10/27/19   Time: 03:17

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 9.073772

Method	Value	Probability
t-statistic	0.006363	0.9955

Table 4.45 Hypothesis for the level of expertise in data-based solutions

The respondents were also required to rank the present level of innovation in their specific technological field. Results obtained are shown in figure 4.54 below.

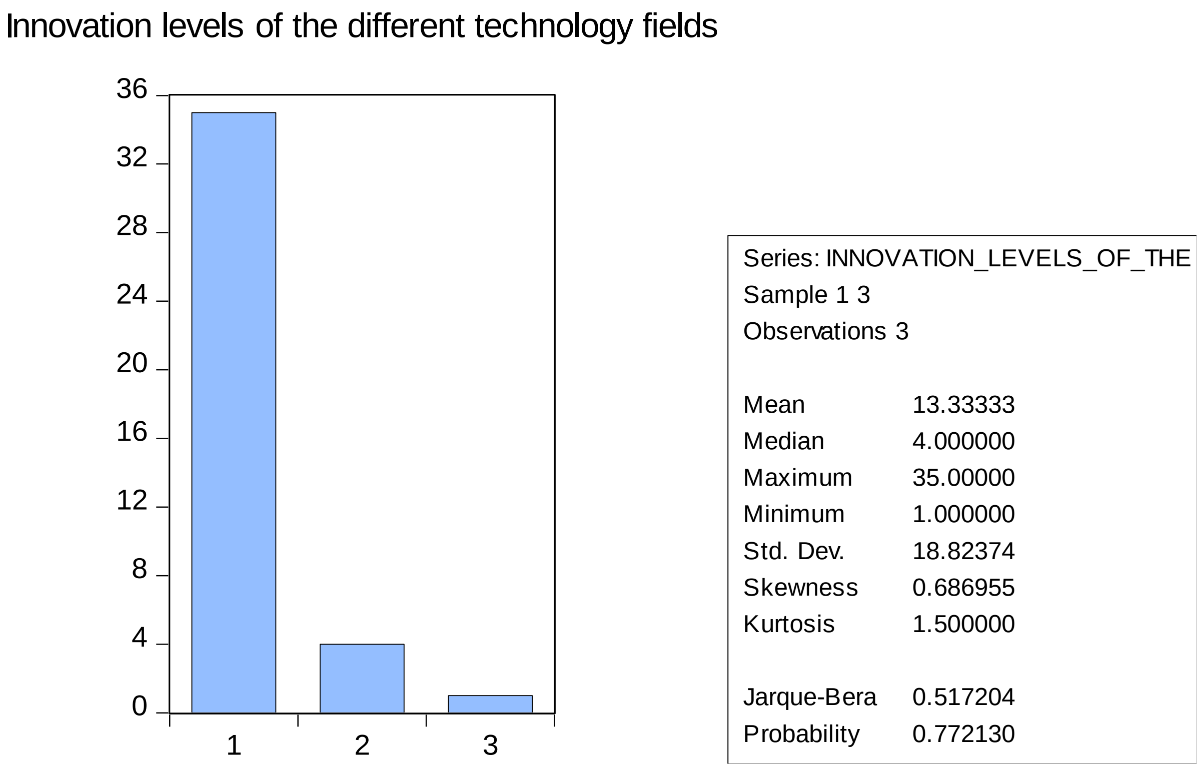


Figure 4.54 Present innovation level in data-based solutions

The results obtained showed that 87.5% of the respondents identified that the innovation level was maximum while 10% identified it as medium. 2.5% of the respondents ranked the innovation level as minimum. The hypothesis test for the present innovation levels is presented in table 4.46 below.

Hypothesis Testing for INNOVATION_LEVELS_OF_THE_DIFFERENT _TECHNOLOGY_FIELDS

Date: 10/27/19 Time: 03:19

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

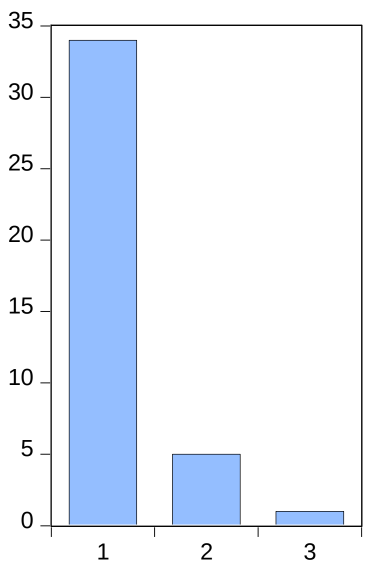
Sample Std. Dev. = 18.82374

Method	Value	Probability
t-statistic	0.003067	0.9978

Table 4.46 Hypothesis test for present innovation level in data-based solutions

The importance of development in the specified technology field was also investigated where results obtained are summarized in figure 4.55 below.

Importance of the development of the different technology fields



Series: IMPORTANCE_OF_THE_DEVELO
Sample 1 3
Observations 3

Mean	13.33333
Median	5.000000
Maximum	34.00000
Minimum	1.000000
Std. Dev.	18.00926
Skewness	0.668066
Kurtosis	1.500000
Jarque-Bera	0.504406
Probability	0.777087

Figure 4.55 Importance of development for data-based solutions

The results obtained showed that 85% of the participants identified the importance of development was maximum while 12.5% ranked it as medium. Only 2.5% ranked it as minimum. The hypothesis test for the factor was also undertaken as shown in table 4.47 below.

Hypothesis Testing for IMPORTANCE_OF_THE_DEVELOPMENT_OF_
THE_DIFFERENT_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 03:20

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.00926

Method	Value	Probability
t-statistic	0.003206	0.9977

Table 4.47 Hypothesis test for importance of development in data-based solutions

The respondents were also asked to rank the probability of industry wide implementation over the next ten-year period. Figure 4.56 below represents the findings obtained.

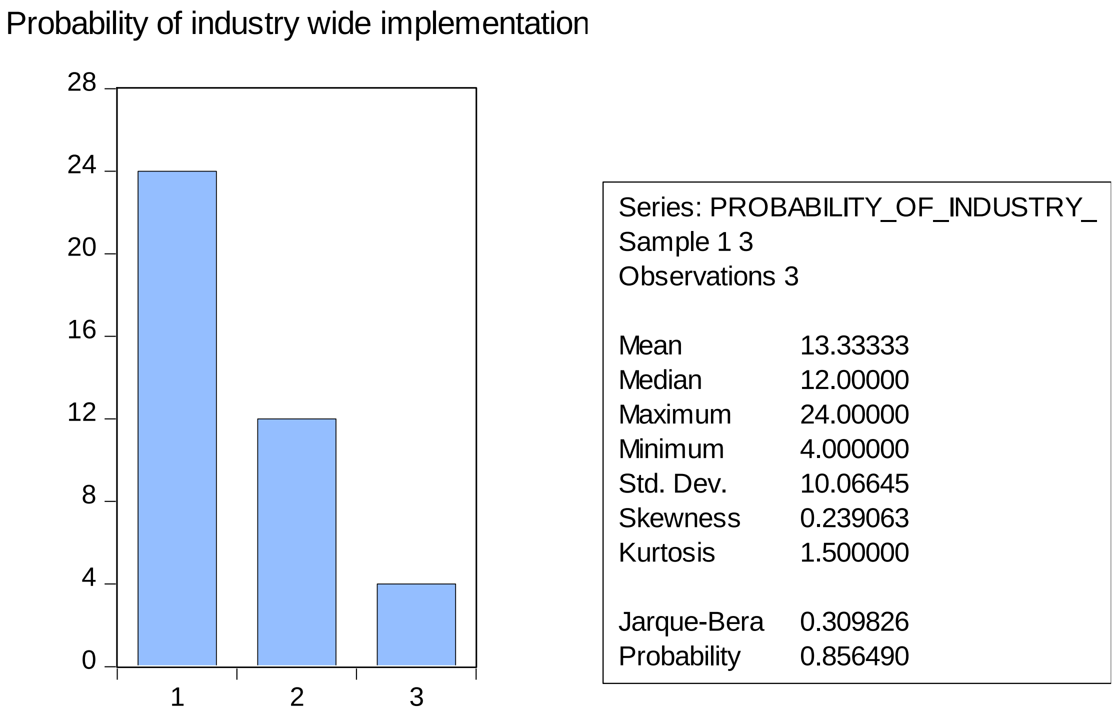


Figure 4.56 Probability of industry-wide implementation in data-based solutions

Findings obtained showed that 60% of the participants ranked the probability as maximum while 30% of them ranked it as medium. 10% ranked it as minimum. The hypothesis test obtained was summarized in table 4.48 below.

Hypothesis Testing for PROBABILITY_OF_INDUSTRY_WIDE_IMPLEM

ENTATION

Date: 10/27/19   Time: 03:21

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

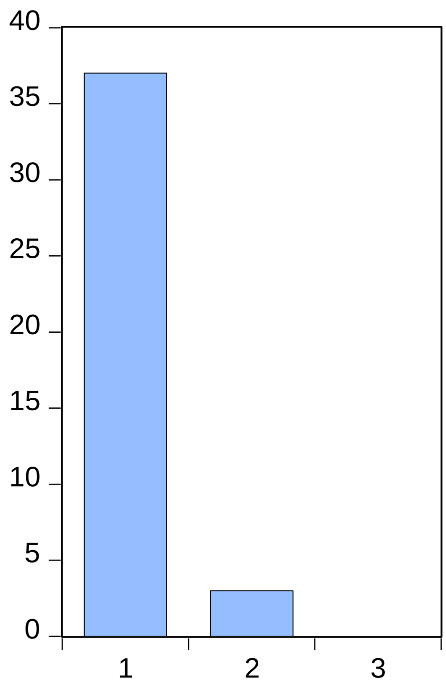
Sample Std. Dev. = 10.06645

Method	Value	Probability
t-statistic	0.005735	0.9959

Table 4.48 Hypothesis test for probability of industry-wide implementation in data-based solutions

In the third question, participants were required to rank the probability of their regions becoming leaders in research and development capabilities. Results obtained are shown in figure 4.57 below.

Research and development capabilities



Series: RESEARCH_AND_DEVELOPMENT	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	3.000000
Maximum	37.00000
Minimum	0.000000
Std. Dev.	20.55075
Skewness	0.690192
Kurtosis	1.500000
Jarque-Bera	0.519433
Probability	0.771270

Figure 4.57 Chances of leadership in research & development in data-based solutions

Findings showed that 92.5% ranked the probability of being leaders in research and development at maximum while 7.5% ranked it as medium. None of the participants ranked it as minimum. The hypothesis test results obtained are shown in table 4.49 below.

Hypothesis Testing for RESEARCH_AND_DEVELOPMENT_CAPABILI

TIES

Date: 10/27/19 Time: 03:22

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 20.55075

Method	Value	Probability
t-statistic	0.002809	0.9980

Table 4.49 Hypothesis test for chances of leadership in research & development in data-based solutions

The third question also sought to investigate the societal acceptability of the region being a leader in technology. Figure 4.58 below displays the results obtained.

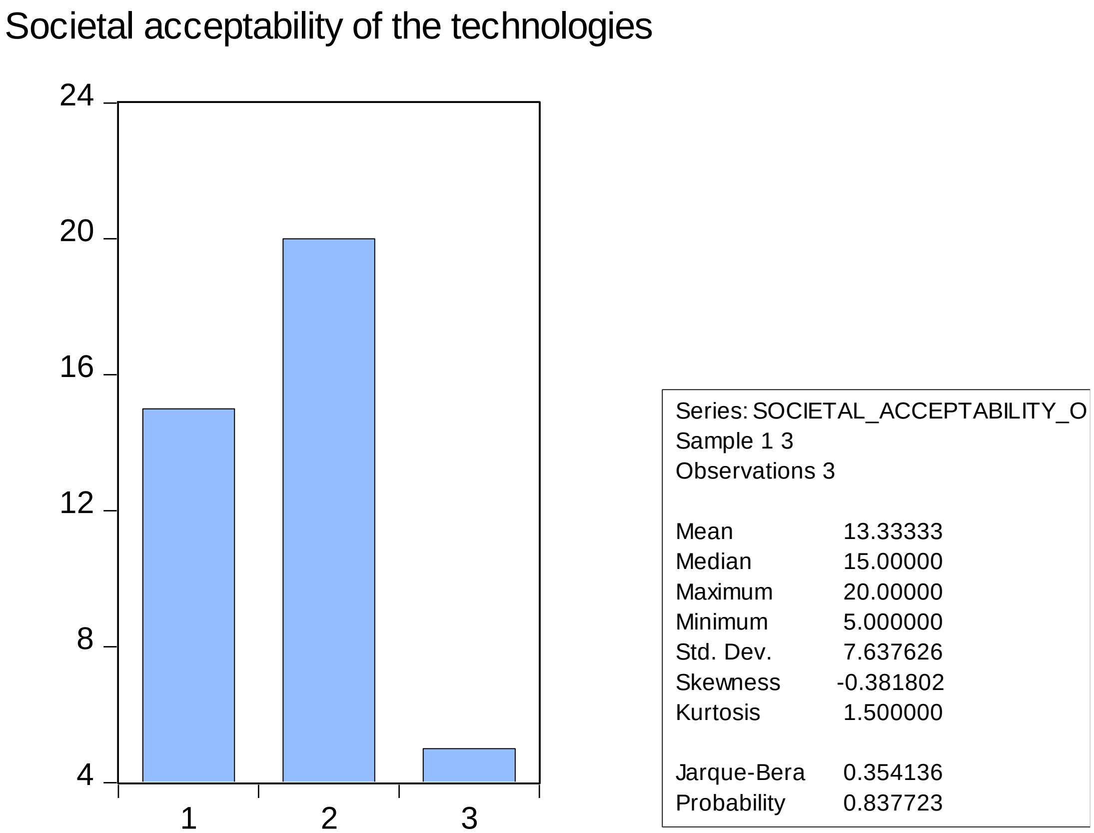


Figure 4.58 Societal acceptability of technologies in data-based solutions

The findings showed that 37.5% of the respondents ranked the societal acceptability at maximum while 50% ranked it at medium. Only 12.5% ranked it at minimum. Table 4.50 below further shows the results of the hypothesis test.

Hypothesis Testing for SOCIETAL_ACCEPTABILITY_OF_THE_TECHN

Date: 10/27/19   Time: 03:23

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

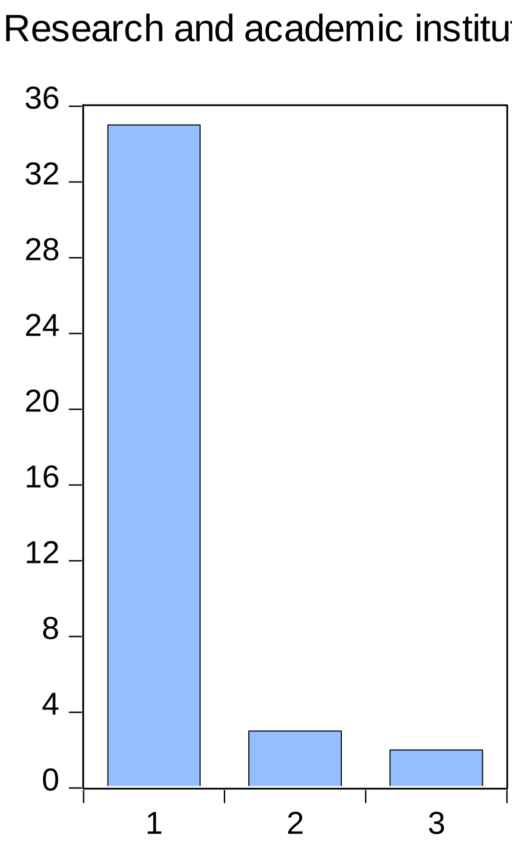
Sample Mean = 13.33333

Sample Std. Dev. = 7.637626

Method	Value	Probability
t-statistic	0.007559	0.9947

Table 4.50 Hypothesis test for societal acceptability of technologies in data-based solutions

The next question investigated how the respondents ranked research and academic institutions as key success players in the given technology field. Figure 4.59 below presents the results obtained.



Series: RESEARCH_AND_ACADEMIC_IN
Sample 1 3
Observations 3

Mean	13.33333
Median	3.000000
Maximum	35.00000
Minimum	2.000000
Std. Dev.	18.77054
Skewness	0.704850
Kurtosis	1.500000
Jarque-Bera	0.529657
Probability	0.767338

Figure 4.59 Research and academic technologies as key success factors in data-based solutions

Findings showed that 87.5% of the respondents ranked them at maximum while 7.5% ranked them as medium. An additional 5% ranked them at minimum. The hypothesis test for the factor was also undertaken as shown in table 4.51 below.

Hypothesis Testing for RESEARCH_AND_ACADEMIC_INSTITUTIONS

Date: 10/27/19   Time: 03:26

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.003076	0.9978

Table 4.51 Hypothesis test for research and academic technologies as key success factors in data-based solutions

Similarly, respondents were asked to rank the government as a key success factor in the technology field. Results obtained were summarized in figure 4.60 below.

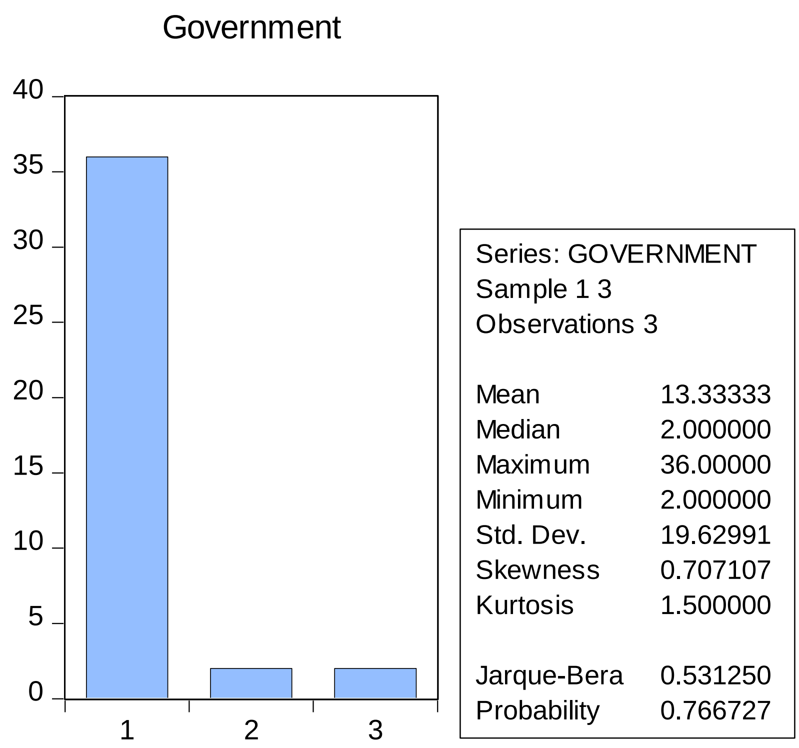


Figure 4.60 Government as a key success factor in data-based solutions

The results obtained showed that 90% of the respondents ranked the government as a key success factor at maximum while 5% ranked it at medium. An additional 5% ranked the government at minimum. The hypothesis test was also undertaken as illustrated in table 4.52 below.

Hypothesis Testing for GOVERNMENT

Date: 10/27/19 Time: 03:27

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 19.62991

Method	Value	Probability
t-statistic	0.002941	0.9979

Table 4.52 Hypothesis test for government as a key success factor in data-based solutions

When asked about the role of policy incentives as a key success factor, the results were obtained as shown in figure 4.61 below.

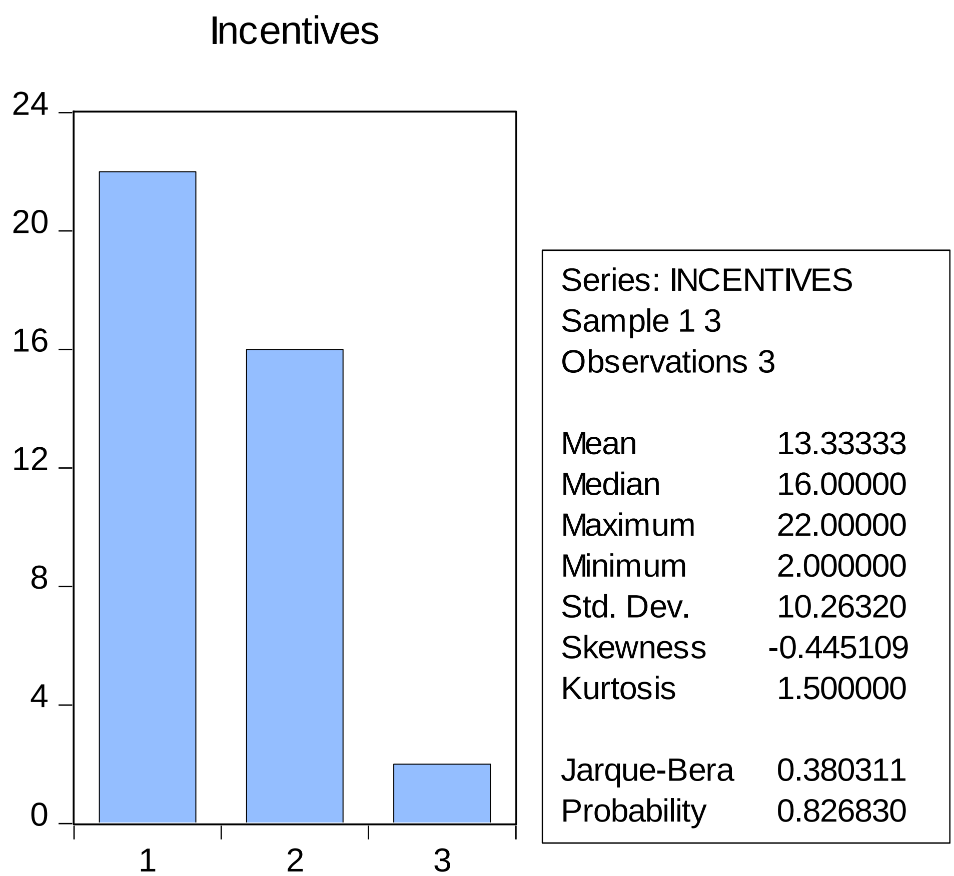


Figure 4.61 Policy incentives as a key success factor in data-based solutions

The findings obtained showed that 55% of the participants ranked policy incentives at maximum while 40% ranked them at medium. An additional 5% ranked them at minimum. The hypothesis test was carried out as shown in table 4.53 below.

Hypothesis Testing for INCENTIVES

Date: 10/27/19 Time: 03:29

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 10.26320

Method	Value	Probability
t-statistic	0.005625	0.9960

Table 4.53 Hypothesis test for policy incentives as a key success factor in data-based solutions

In the fifth question, respondents were asked to rank the importance of legal regulations and standards as a supportive policy measure to promote the field. Results were obtained as shown in figure 4.62 below.

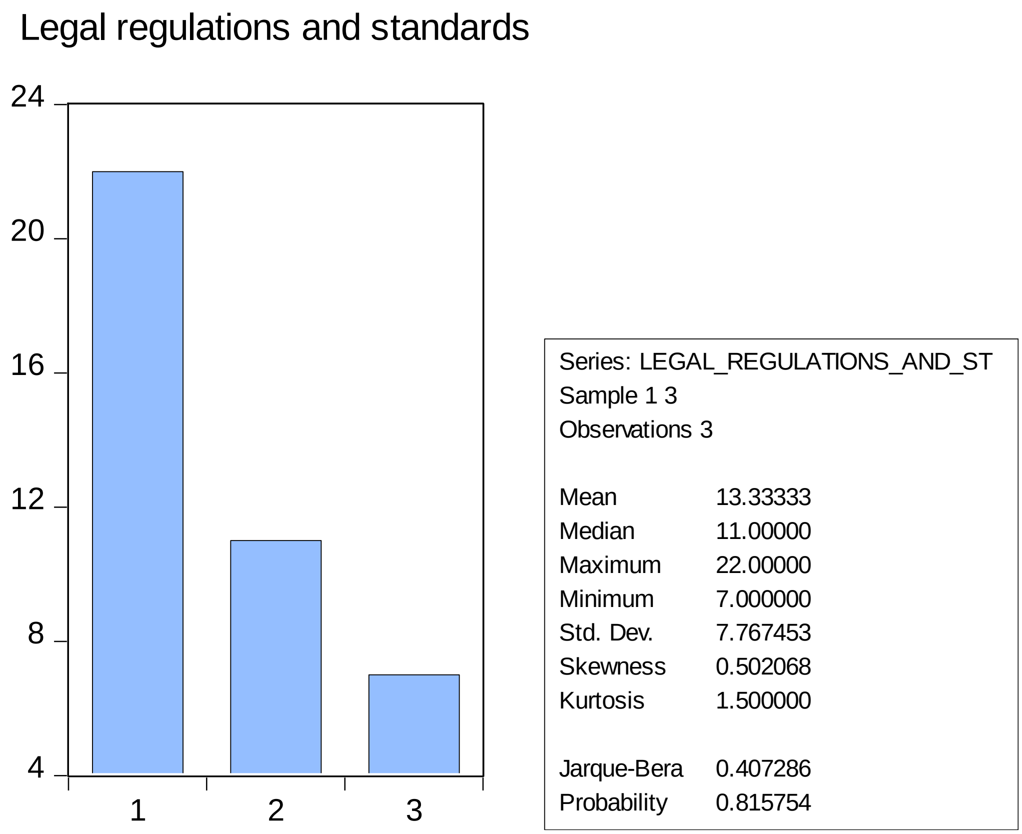


Figure 4.62 Importance of legal regulations and standards in promoting data-based solutions

Results obtained showed that 55% of the respondents ranked legal regulations and standards at maximum while 27.5% ranked them medium. 17.5% of the participants ranked regulations and standards at minimum. The hypothesis test was also undertaken as shown in table 4.54 below.

Hypothesis Testing for LEGAL_REGULATIONS_AND_STANDARDS

Date: 10/27/19 Time: 03:30

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 7.767453

Method	Value	Probability
t-statistic	0.007433	0.9947

Table 4.54 Hypothesis test for importance of legal regulations and standards in promoting data-based solutions

Likewise, the importance of raising public awareness in promoting hybrid propulsions technology was also investigated with results being displayed in figure 4.63 below.

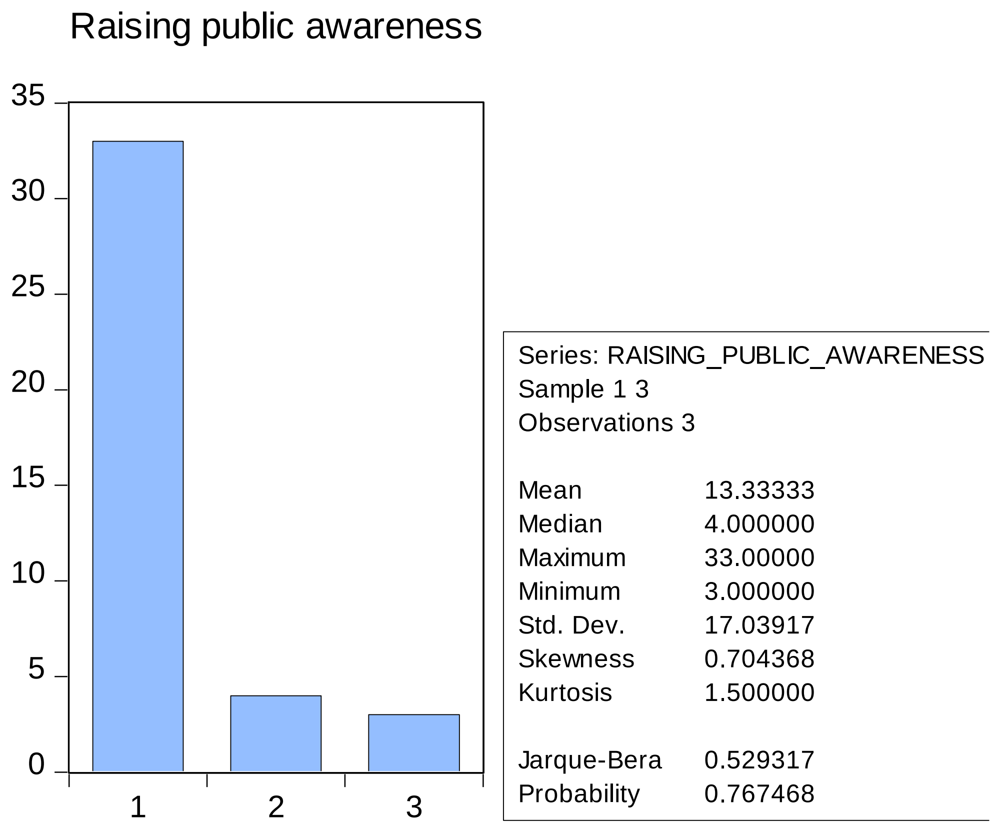


Figure 4.63 Importance of raising public awareness in promoting data-based solutions

The results obtained showed that 82.5% of the respondents ranked raising public awareness at maximum. 10% of them ranked it at medium while an additional 7.5% ranked it at minimum. The hypothesis test was also undertaken for the factor as shown in table 4.55 below.

Hypothesis Testing for RAISING_PUBLIC_AWARENESS

Date: 10/27/19   Time: 03:31

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.03917

Method	Value	Probability
t-statistic	0.003388	0.9976

Table 4.55 Hypothesis test for importance of raising public awareness in promoting data-based solutions

In the last question, the participants were asked to identify the most important region in regards to present research and development. Figure 4.64 below illustrates the results obtained.

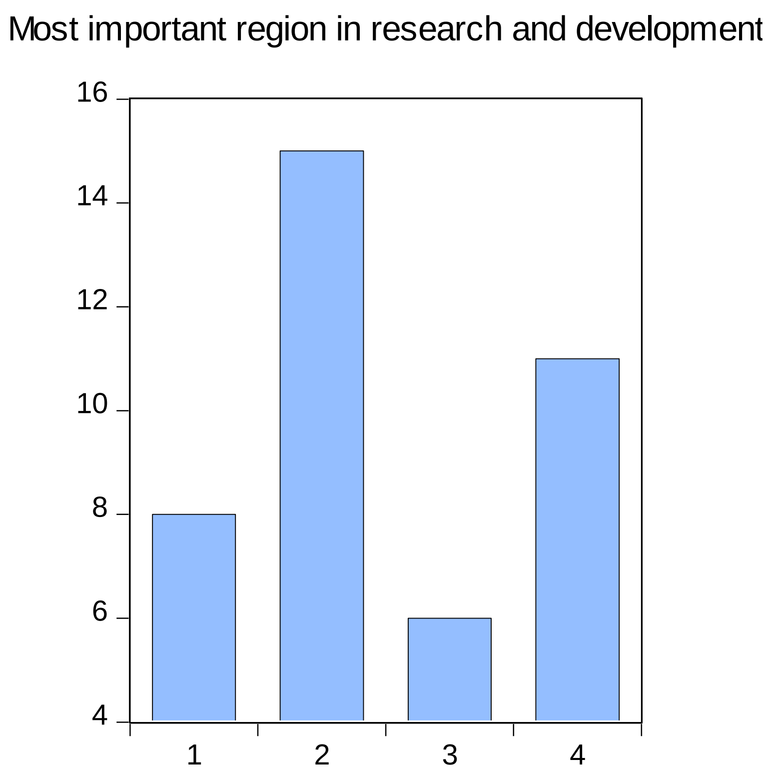


Figure 4.64 Most important research and development region in the data-based solutions

The findings showed that Asia was ranked highest by 37.5% of the respondents while USA followed closely at 27.5%. China was ranked third at 20% while Middle East was ranked last at 15%.

Finally, the respondents were also asked to identify the most important region in regards to market potential. Figure 4.65 below demonstrated the results obtained.

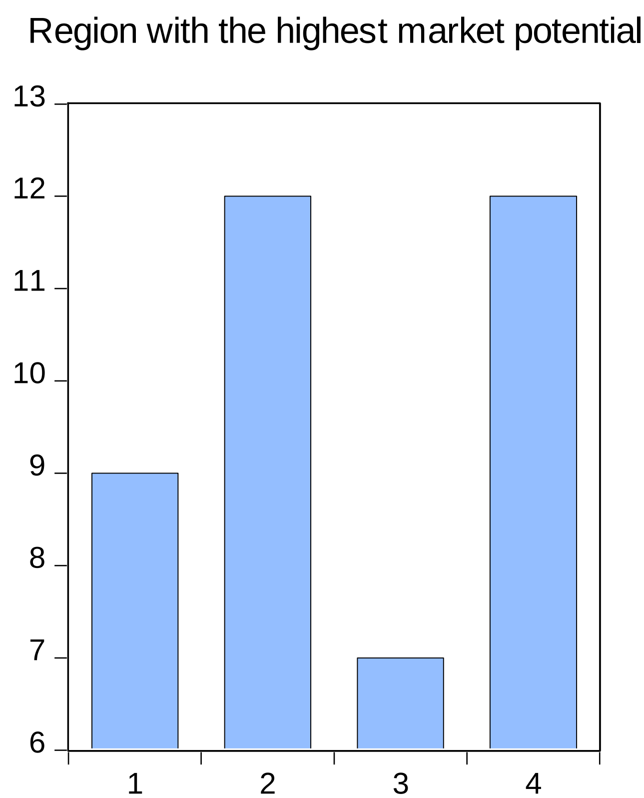


Figure 4.65 Region with the highest market potential for data-based solutions

The results obtained showed that Asia and USA were ranked highest by 30% of the respondents. China was ranked second by 22.5% of the respondents while the Middle East was ranked last by 17.5% of the participants.

4.4.3 Smart grid solutions

The first question investigated the level of expertise of the participants where findings obtained were as shown in figure 4.66 below.

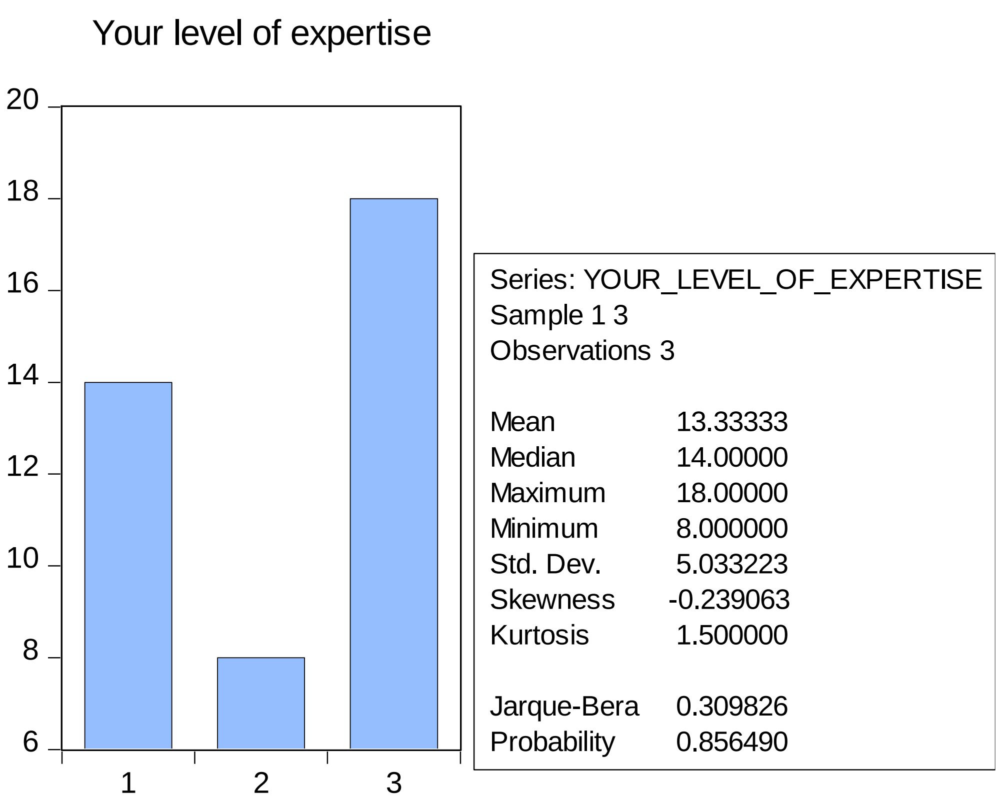


Figure 4.66 Level of expertise in smart grid solutions

Findings obtained showed that 35% of the participants ranked their expertise as maximum while 20% ranked it as medium. 45% ranked it as minimum. The hypothesis test was also carried out as shown in table 4.56 below.

Hypothesis Testing for YOUR_LEVEL_OF_EXPERTISE

Date: 10/27/19   Time: 02:53

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

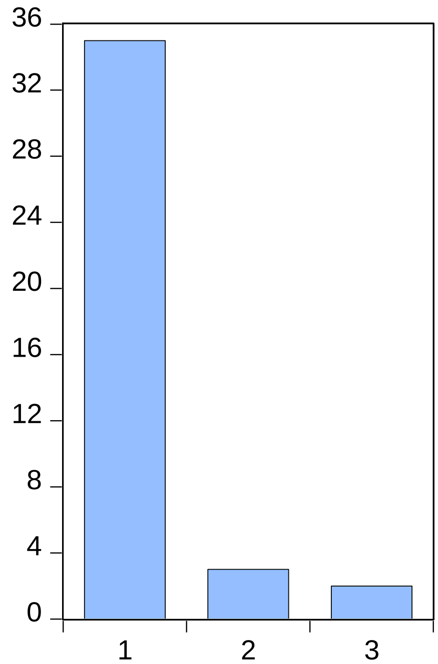
Sample Std. Dev. = 5.033223

Method	Value	Probability
t-statistic	0.011471	0.9919

Table 4.56 Hypothesis test for level of expertise in smart grid solutions

The respondents were further asked to highlight the present level of innovation in their specific technological field. Results obtained are shown in figure 4.67 below.

Innovation levels of the different technology fields



Series: INNOVATION_LEVELS_OF_THE	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	3.000000
Maximum	35.00000
Minimum	2.000000
Std. Dev.	18.77054
Skewness	0.704850
Kurtosis	1.500000
Jarque-Bera	0.529657
Probability	0.767338

Figure 4.67 Present innovation level in smart grid solutions

The results obtained showed that 87.5% of the respondents identified that the innovation level was maximum while 7.5% identified it as medium. 5% of the respondents classified the innovation level as minimum. The hypothesis test for the present innovation levels is presented in table 4.57 below

Hypothesis Testing for INNOVATION_LEVELS_OF_THE_DIFFERENT

_TECHNOLOGY_FIELDS

Date: 10/27/19   Time: 02:54

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

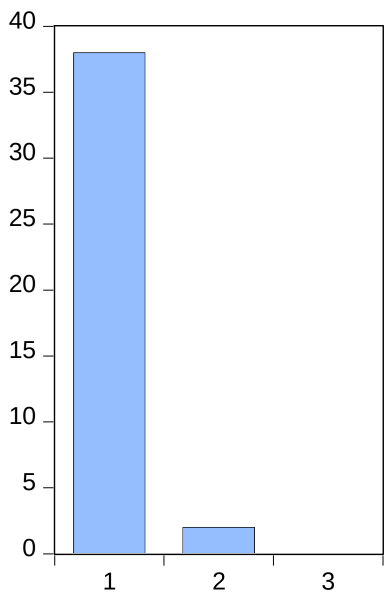
Sample Std. Dev. = 18.77054

Method	Value	Probability
t-statistic	0.003076	0.9978

Table 4.57 Hypothesis test for present innovation level in smart grid solutions

The importance of development in the specified technology field was also investigated where results obtained are summarized in figure 4.68 below.

Importance of the development of the different technology fields



Series: IMPORTANCE_OF_THE_DEVELO	
Sample 1 3	
Observations 3	
Mean	13.33333
Median	2.000000
Maximum	38.00000
Minimum	0.000000
Std. Dev.	21.38535
Skewness	0.700155
Kurtosis	1.500000
Jarque-Bera	0.526359
Probability	0.768604

Figure 4.68 Importance of development in smart grid solutions

The results obtained showed that 95% of the participants identified the importance of development was maximum while 5% ranked it as medium. None of the respondents ranked it as minimum. The hypothesis test for the factor was also undertaken as shown in table 4.58 below.

Hypothesis Testing for IMPORTANCE_OF_THE_DEVELOPMENT_OF_

THE_DIFFERENT_TECHNOLOGY_FIELDS

Date: 10/27/19 Time: 02:55

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 21.38535

Method	Value	Probability
t-statistic	0.002700	0.9981

Table 4.58 Hypothesis test for importance of development in smart grid solutions

The respondents were also asked to rank the probability of industry wide implementation over the next ten-year period. Figure 4.69 below represents the findings obtained.

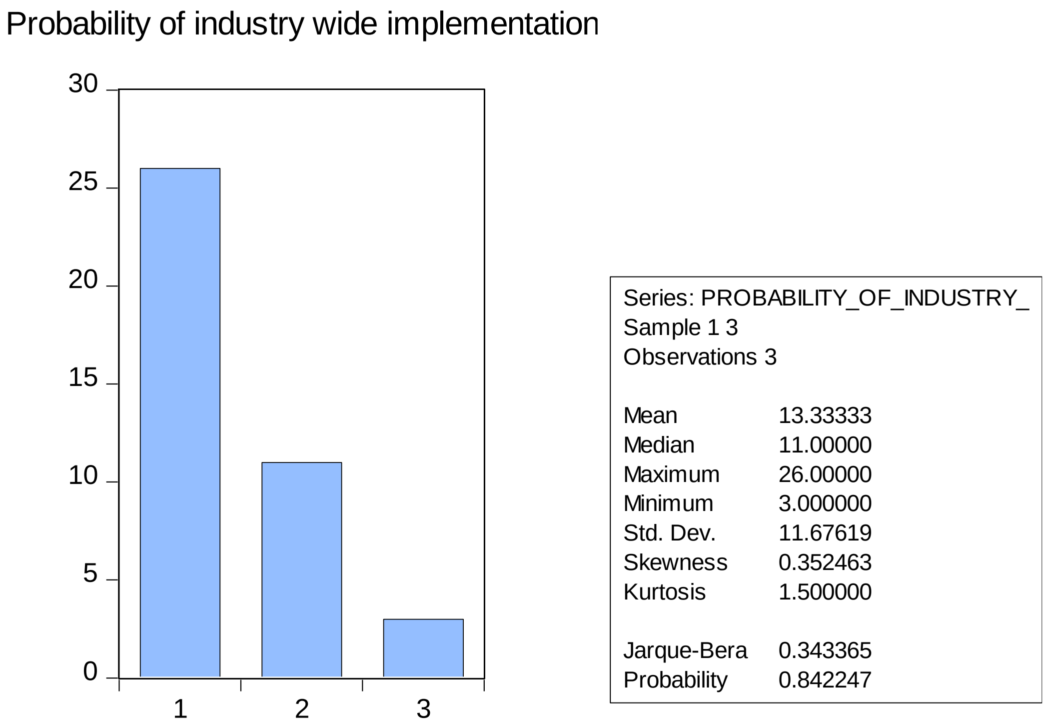


Figure 4.69 Probability of industry-wide implementation in smart grid solutions

Findings obtained showed that 65% of the participants ranked the probability as maximum while 27.5% of them ranked it as medium. 7.5% ranked it as minimum. The hypothesis test obtained was summarized in table 4.59 below.

Hypothesis Testing for PROBABILITY_OF_INDUSTRY_WIDE_IMPLEM

ENTATION

Date: 10/27/19 Time: 02:56

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 11.67619

Method	Value	Probability
t-statistic	0.004945	0.9965

Table 4.59 Hypothesis test for probability of industry-wide implementation in smart grid solutions

With the third question, participants were required to rank the probability of their regions becoming leaders in research and development capabilities. Results obtained are shown in figure 4.70 below.

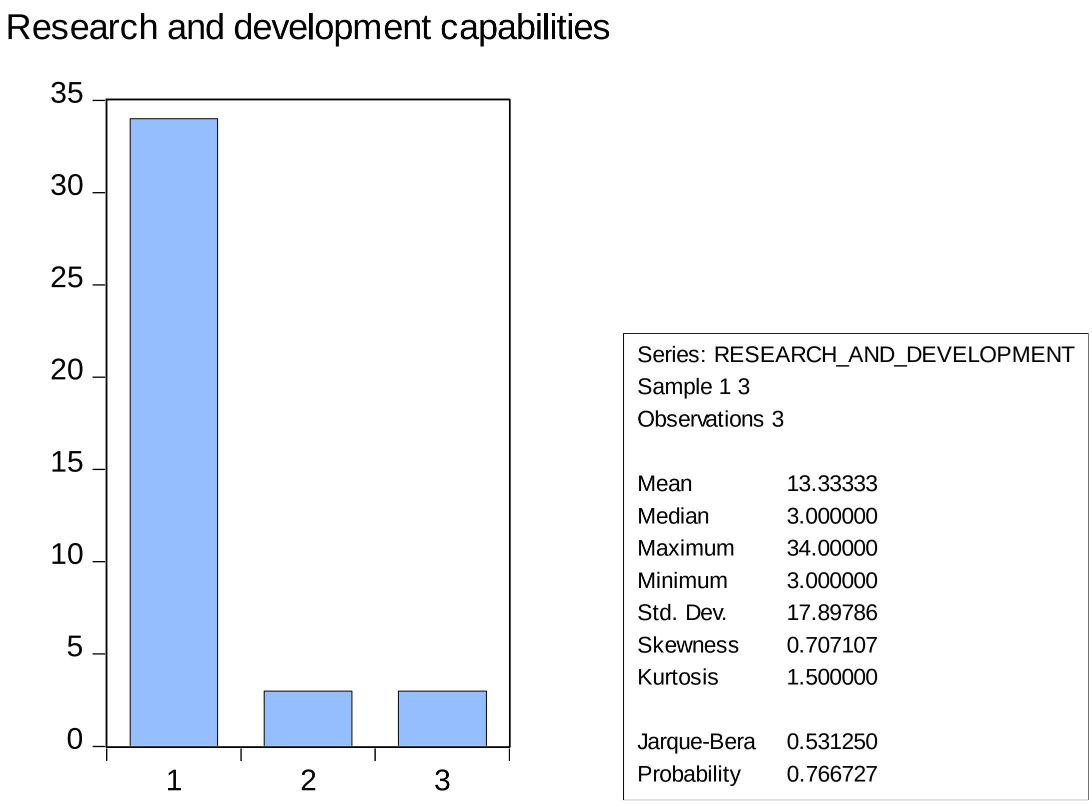


Figure 4.70 Chances of leadership in research & development in smart grid solutions

Findings showed that 85% ranked the probability of being leaders in research and development at maximum. 7.5% ranked it as medium while an additional 7.5% also ranked it as minimum. The hypothesis test results obtained are shown in table 4.60 below.

Hypothesis Testing for RESEARCH_AND_DEVELOPMENT_CAPABILI

TIES

Date: 10/27/19 Time: 02:57

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.89786

Method	Value	Probability
t-statistic	0.003226	0.9977

Table 4.60 Hypothesis test for chances of leadership in research & development in smart grid solutions

The third question further sought to identify the societal acceptability of the region being a leader in technology. Figure 4.71 below displays the results obtained.

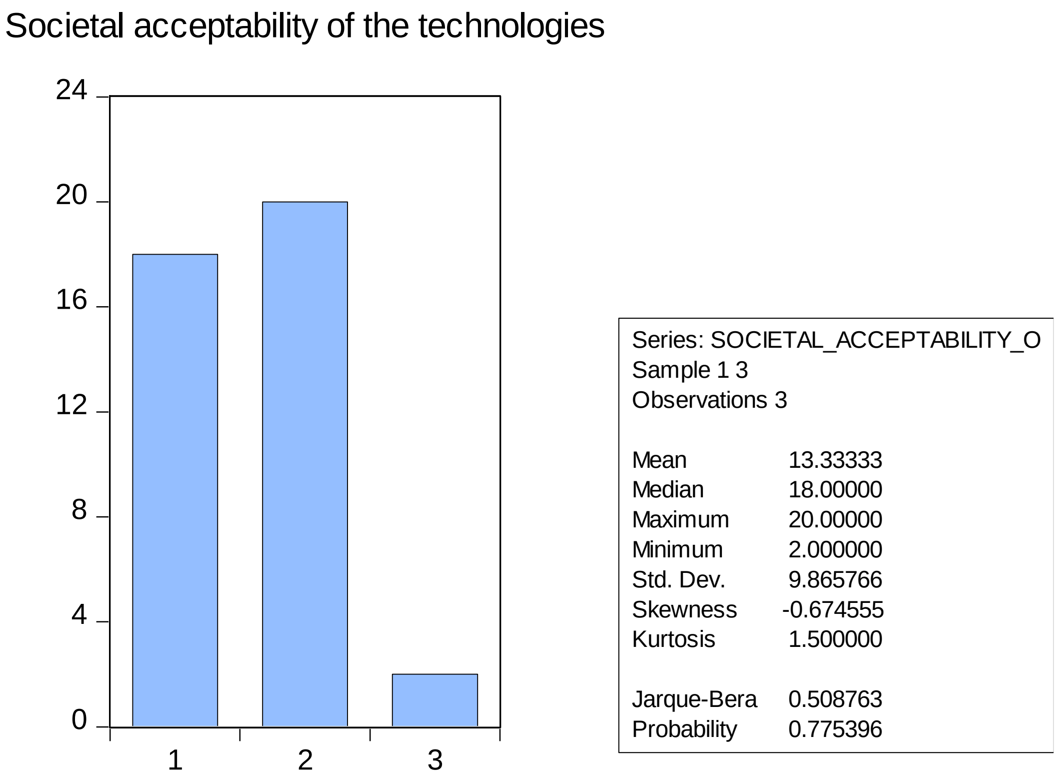


Figure 4.71 Societal acceptability of technologies in smart grid solutions

The findings showed that 45% of the respondents ranked the societal acceptability at maximum while 50% ranked it at medium. Only 5% ranked it at minimum. Table 4.61 below further shows the results of the hypothesis test.

Hypothesis Testing for SOCIETAL_ACCEPTABILITY_OF_THE_TECHN

OLOGIES

Date: 10/27/19   Time: 02:59

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 9.865766

Method	Value	Probability
t-statistic	0.005852	0.9959

Table 4.61 Hypothesis test for societal acceptability of technologies in smart grid solutions

The fourth question investigated how the respondents ranked research and academic institutions as key success players in the given technology field. Figure 4.72 below presents the results obtained.

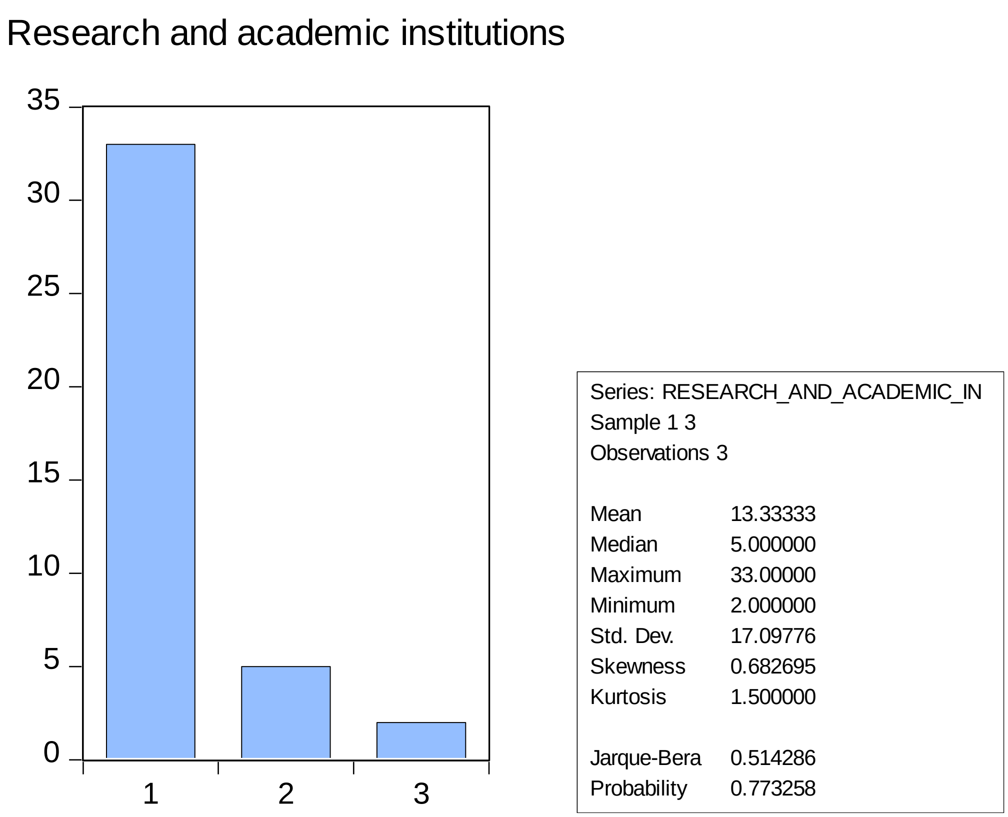


Figure 4.72 Research and academic technologies as key success factors in smart grid solutions

Findings showed that 82.5% of the respondents ranked them at maximum while 12.5% ranked them as medium. An additional 5% ranked them at minimum. The hypothesis test for the factor was also undertaken as shown in table 4.62 below.

Hypothesis Testing for RESEARCH_AND_ACADEMIC_INSTITUTIONS

Date: 10/27/19   Time: 03:00

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.09776

Method	Value	Probability
t-statistic	0.003377	0.9976

Table 4.62 Hypothesis test for research and academic technologies as key success factors in smart grid solutions

Similarly, respondents were asked to rank the government as a key success factor in the technology field. Results obtained were summarized in figure 4.73 below.

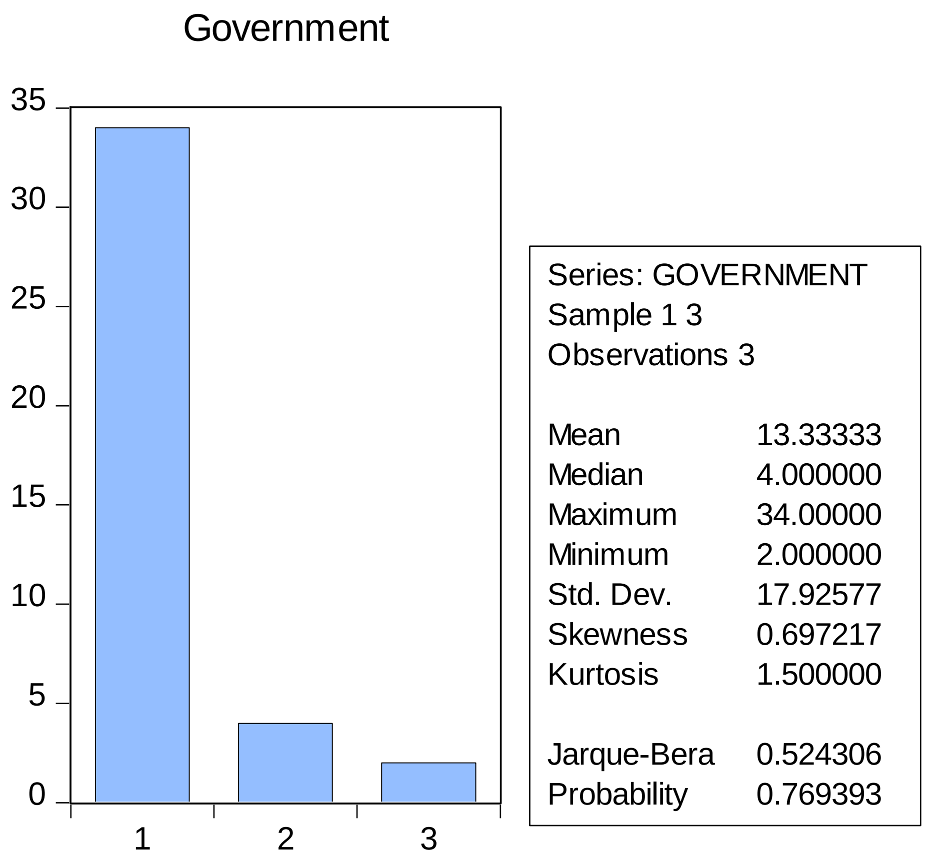


Figure 4.73 Government as a key success factor in smart grid solutions

The results obtained showed that 85% of the respondents ranked the government as a key success factor at maximum while 10% ranked it at medium. Only 5% ranked the government at minimum. The hypothesis test was also undertaken as illustrated in table 4.63 below.

Hypothesis Testing for GOVERNMENT

Date: 10/27/19   Time: 03:01

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.92577

Method	Value	Probability
t-statistic	0.003221	0.9977

Table 4.63 Hypothesis test for government as a key success factor in smart grid solutions

When asked about the role of policy incentives as a key success factor, the results were obtained as shown in figure 4.74 below.

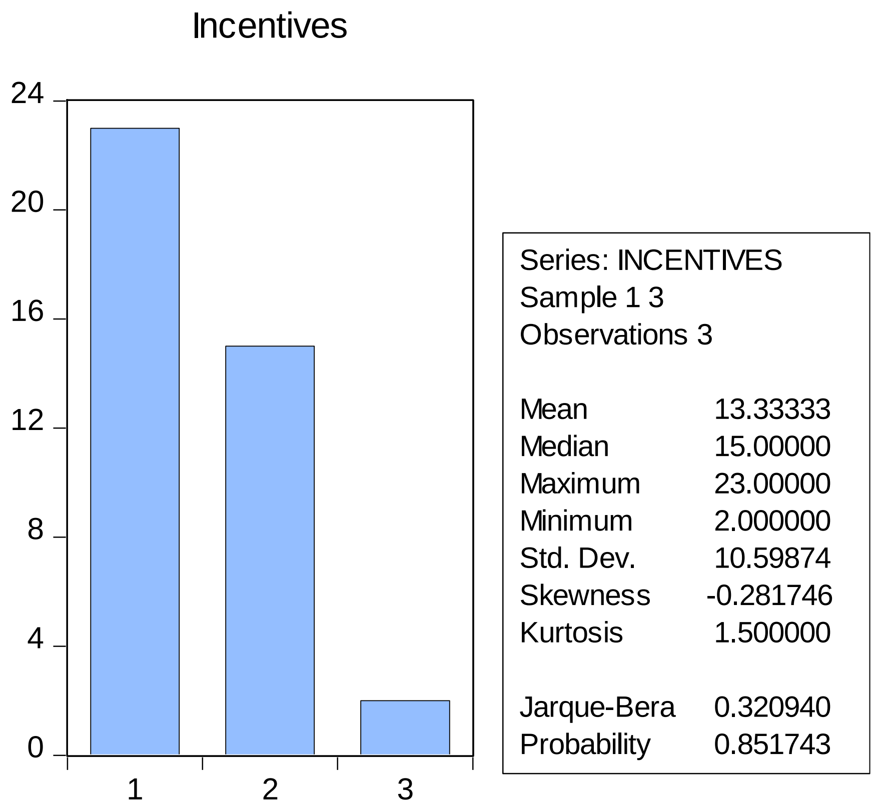


Figure 4.74 Policy incentives as a key success factor in smart grid solutions

The findings obtained showed that 57.5% of the participants ranked policy incentives at maximum while 37.5% ranked them at medium. Only 5% ranked them at minimum. The hypothesis test was carried out as shown in table 4.64 below.

Hypothesis Testing for INCENTIVES

Date: 10/27/19 Time: 03:02

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 10.59874

Method	Value	Probability
t-statistic	0.005447	0.9961

Table 4.64 Hypothesis test for policy incentives as a key success factor in smart grid solutions

In the fifth question, respondents were asked to rank the importance of legal regulations and standards as a supportive policy measure to promote the field. Results were obtained as shown in figure 4.75 below.

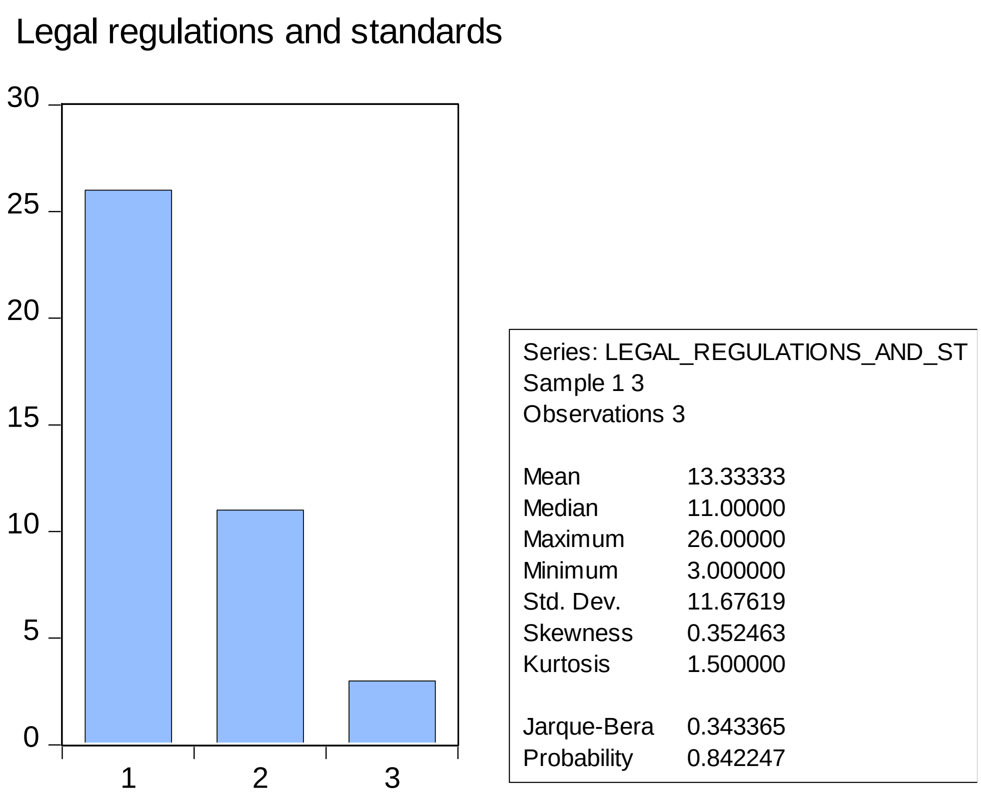


Figure 4.75 Importance of legal regulations and standards in promoting smart grid solutions

Results obtained showed that 65% of the respondents ranked legal regulations and standards at maximum while 27.5% ranked them medium. 7.5% of the participants ranked regulations and standards at minimum. The hypothesis test was also undertaken as shown in table 4.65 below.

Hypothesis Testing for LEGAL_REGULATIONS_AND_STANDARDS

Date: 10/27/19 Time: 03:03

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 11.67619

Method	Value	Probability
t-statistic	0.004945	0.9965

Table 4.65 Hypothesis test for importance of legal regulations and standards in promoting smart grid solutions

The importance of raising public awareness in promoting hybrid propulsions technology was also investigated with results being displayed in figure 4.76 below.

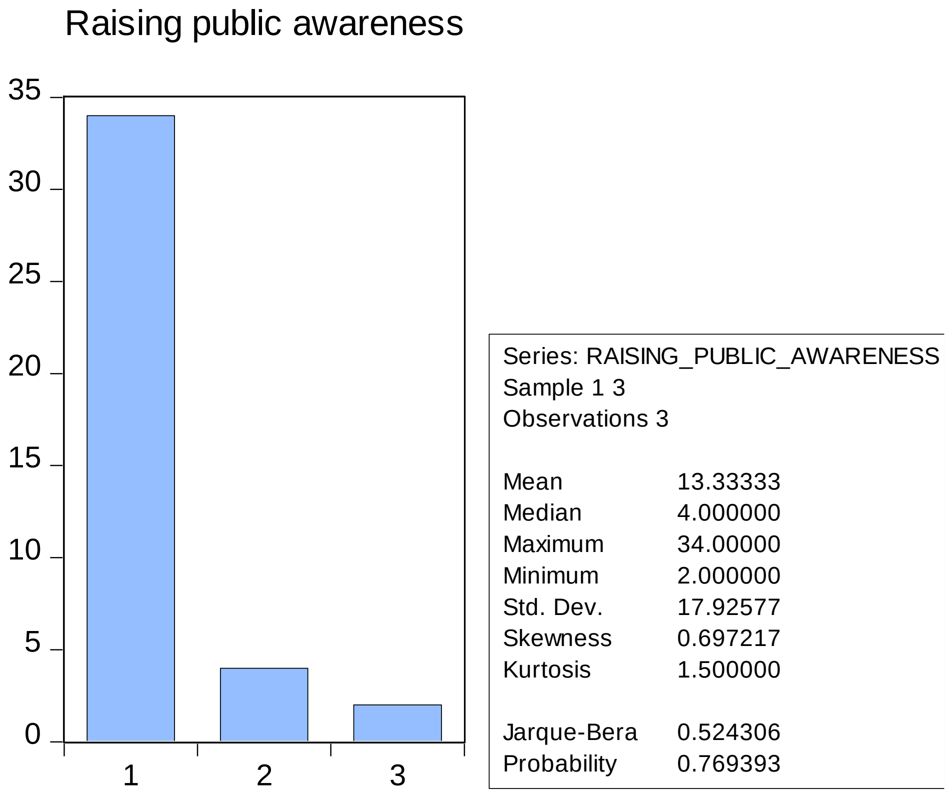


Figure 4.76 Importance of raising public awareness in promoting smart grid solutions

The results obtained showed that 85% of the respondents ranked raising public awareness at maximum. 10% of them ranked it medium while an additional 5% ranked it at minimum. The hypothesis test was also undertaken for the factor as shown in table 4.66 below.

Hypothesis Testing for RAISING_PUBLIC_AWARENESS

Date: 10/27/19   Time: 03:05

Sample: 1 3

Included observations: 3

Test of Hypothesis: Mean = 13.30000

Sample Mean = 13.33333

Sample Std. Dev. = 17.92577

Method	Value	Probability
t-statistic	0.003221	0.9977

Table 4.66 Hypothesis test for importance of raising public awareness in promoting smart grid solutions

In the last question, the participants were asked to identify the most important region in regards to present research and development. Figure 4.77 below illustrates the results obtained.

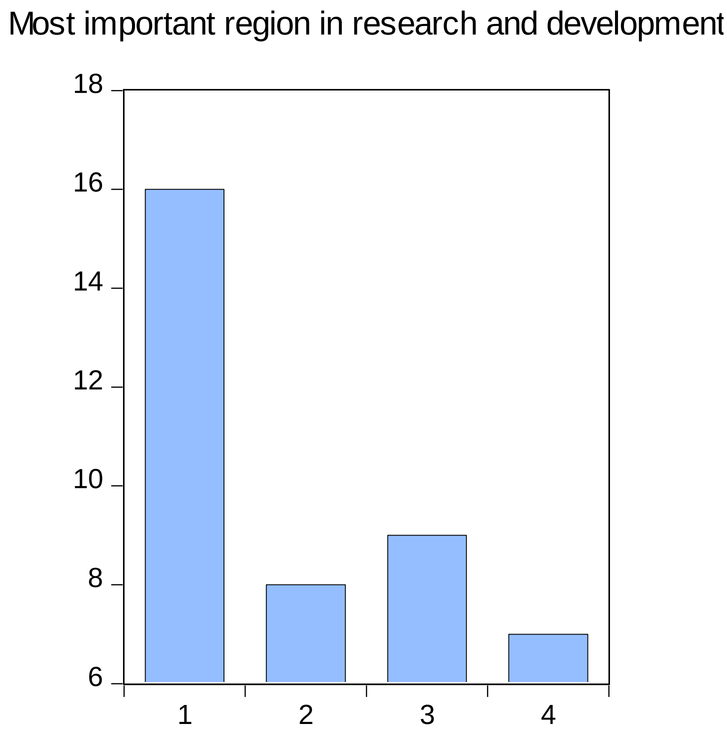


Figure 4.77 Most important research and development region in smart grid solutions

The findings showed that China was ranked highest by 40% of the respondents while the Middle East followed closely at 22.5%. Asia was ranked third at 20% while USA was ranked last at 17.5%.

Finally, the respondents were also asked to identify the most important region in regards to market potential. Figure 4.78 below demonstrated the results obtained.

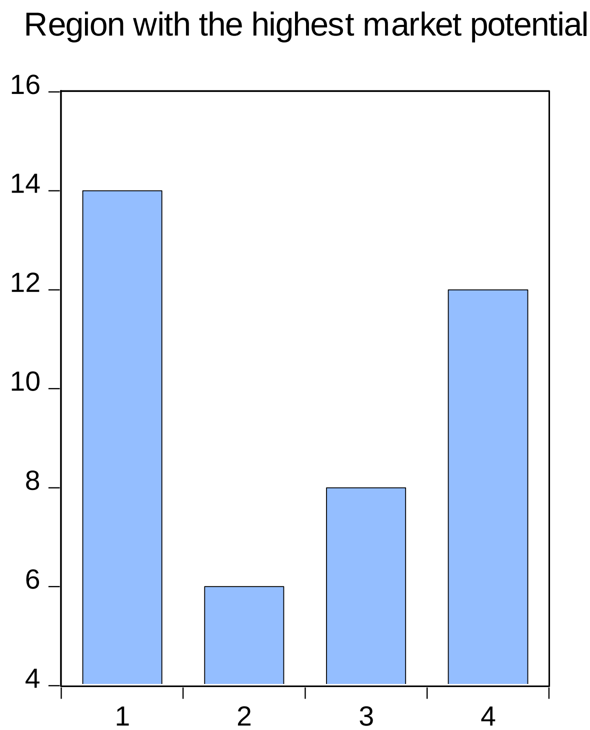


Figure 4.78 Region with the highest market potential for the smart grid solutions

The results obtained showed that China was ranked highest by 35% of the respondents while USA was ranked second by 30% of the respondents. The Middle East was ranked third by 20% of the participants while the Asia was ranked last by 15% of the participants.