Master's Thesis in Economics

An Analysis of Saudi Arabia's Natural Resource

– A Blessing or a Curse? –

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Abstract

As the most significant oil exporter in OPEC with relatively one of the least dense populations among OPEC members, Saudi Arabia' s economy might not show the apparent symptoms of a resource curse as other countries like Venezuela and Algeria. Hence, this assessment of the Saudi economy' s health was needed to see whether it is suffering from the resource curse and whether its innovation attempts in energy can lead to better economic health. Assessing factors included diversification of revenue, sectoral data, measuring innovation, and analyzing institutional quality. These factors show that Saudi Arabia is indeed suffering from the natural resource curse. Amid the reform efforts, this curse can be lifted with shrewd public policy that empowers the public-private partnership in different sectors.

Keywords : oil, sustainable development, Saudi Arabia, resource curse, innovation, public policy

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1. Introduction

1.1. Natural Resource Curse

The economics of resource-rich countries and the best way of managing their resources has been a topic of interest since the discovery of oil. The observations have been that oil richness, natural gas, and related valuable mineral deposits do not necessarily guarantee economic success (Lederman & Maloney, 2008). For instance, resource-rich nations such as Nigeria, India, and the Democratic Republic of Congo are among the top 10 resource-rich countries in the world; their nations show a persistently low GDP per capita considering the purchasing power parity. On the other hand, East Asian economies such as Taiwan, Singapore, and Korea have witnessed a leap in development, overcoming their limited exportable natural resources. Hence, the endowment of a natural resource does not necessarily translate to having a rich society or a prosperous economy.

In the contrary, the abundance of natural resource can have a negative impact if it drains the other sectors of the economy out of resource allocation by the government, investment by the private sector, or a combination of both. The biased focus on a natural resource as the most lucrative sector can cripple the economy's agility to smoothen cyclical effects or price fluctuations of the resource. Hence, the natural resource has the probabiltity to emerge as a curse when mismanaged, having servere consequences, reaching the extent of social inequality and political instability (Addison & Roe, 2018).

1.2. Focusing on Saudi Arabia

While the empirical studies focus has on a success story (namely Norway) versus an inferred relatively slow development (such as Kazakhstan), there has not been a focus on the Saudi Arabian case, as a mediocre case that is neither a profound success nor an agreed-upon stagnant development. Also, Saudi Arabia has always been avoided by academics due to lack of available data in English. The Oil Shock pushed researchers into studying the effect of oil on the world and how to seek another reliable source, with few studies shedding light on the economy of Saudi Arabia and its reliance on petrodollars.

However, the researcher visited offices in the Kingdom and contacted various government agencies to make this research possible. Lack of data made comparative analysis, benchmarking, and interviews an important alternative to reach the goal of this research and to guide policymakers in their decisions.

1.3. Significance of the research

The significance of the research stems from the role the country plays in the international community. Saudi Arabia has been the biggest hub of energy for the world to grow and thrive. It has been a net donor to the international community since the early years of oil discovery. In 1975, it established the Saudi Fund for Development which aims to fund developmental projects in the emerging economies. Assessing the situation of the Saudi economy is a cornerstone to its transformational plan.

The Kingdom is going through its biggest transformation in its history in terms of the capital dedicated to the transformation and the level of transparency in communicating the plan. This intended transformation, coined Saudi Vision 2030, is absorbing intellectual contributions and research from around the globe, and this paper is intended to contribute to the Vision 2030 plan. The role of this paper is to be an input in the plan, by explicitly diagnosing the Saudi economic track record in terms of its status in regard to the natural resource curse, and to observe its previous diversification attempts.

Due to the relatively low coverage regarding the kingdom, this paper has to establish common ground by starting with an elaborate introductory background regarding the country and its status.

2. Saudi Arabia: A Background

This section highlights main aspect of the country geopolitically and economically.

2.1. Geopolitics of Saudi Arabia

In the far southwest of Asia resides the largest peninsula in the world; the Arabian Peninsula, where the Kingdom of Saudi Arabia, shortened as Saudi Arabia or abbreviated as KSA, makes four-fifth of the peninsula. The total area is ~230,000 km^2, making it the fifth-largest country in Asia (after Russia, China, India,

Figure 1: Saudi Arabia is located in the Arabian Peninsula, Southeast of Asia. The Red Sea separates it from the African continent and the Arabian Gulf separates it from Iran. *(BBC).*

and Kazakhstan); about ten times the size of the Korean Peninsula.

Politically, the Kingdom of Saudi Arabia started its unification process in 1902 until it was wholly unified under this name in September 1932. The kingdom uses a monarchy political system, with *Shura council* serving as an advisory parliament. Prior to its establishment, the country was composed of scattered villages and towns across the country, Bedouins who live a weather-influenced nomadic life, and uncharted deserts, mountains, and forests in between.

Unlike the other countries in the Arabian Peninsula, Saudi Arabia has never been occupied or colonized as a whole, which consequentially made its culture develop differently than neighboring countries and in a much less homogenous way[1]. Hence, some of the country's laws were solely inspired by the local culture, without a written constitution. Traveling to work used to be the norm before the discovery of oil. Nowadays, around 70% of its 31 million residents, 33% of whom are foreigners, live in sizable urban areas.

In terms of density, which can translate into the human resources relative to the geographic size, Saudi Arabia can be compared with countries who have similar resource abundance and socioeconomic circumstances, such as Kazakhstan and Norway. Even after Saudi Arabia became the most populous of the three, as in Figure 2, the ratio is still similar, with around 15 people per km^2 in Saudi Arabia, compared to 14 people/ km^2 and seven people/ km^2 in Norway and Kazakhstan respectively in 2017.

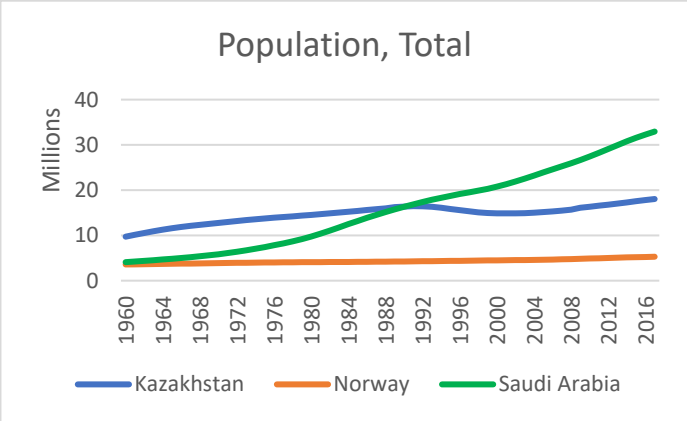

Figure 2: The three countries started with relatively similar geosocial conditions; i.e. in terms of population ratio to the land size, but the population in Saudi Arabia witnessed a sharper increase since the 1990s. Data source: World Bank

[1] The currently Saudi region has not been under one government in the recent history (since the end of the Abbasid Caliphate in 1258; more than 700 years ago).

While the Kazakh nation the least populous of the three, by just reaching the density level as Norway, Saudi Arabia is still considered a low-density country.

2.2. Oil Production and Oil Market

The first decade of the 21st century was the boom of the Chinese economy and its thirst for oil, making Far East Asia the largest exporting destination for Saudi Arabia, with a staggering 65.0% of its total 2,603 million barrels in 2015. This high demand pushed oil prices to a record-high which made alternatives more feasible, like shale oil[2]. However, the technology for extracting shale oil is still under development in order to be less sensitive to crude oil prices. Also, motivated by environmental concerns and pushed by oil prices, renewable energy gained an accumulating focus and still going under extensive R&D. In the second half of 2014, oil prices started waning, but Saudi Arabia's production did not follow, unlike its usual trend, as in *Figure 3*.

The increase in production coincided with a historic increase in the US oil production, which can be seen as a way for OPEC to undercut their new rival[3], and Iran's agreement with the US supported the excess in supply and deepened the fall of oil prices, until the US withdrew from the agreement effectively cutting Iran's supply.

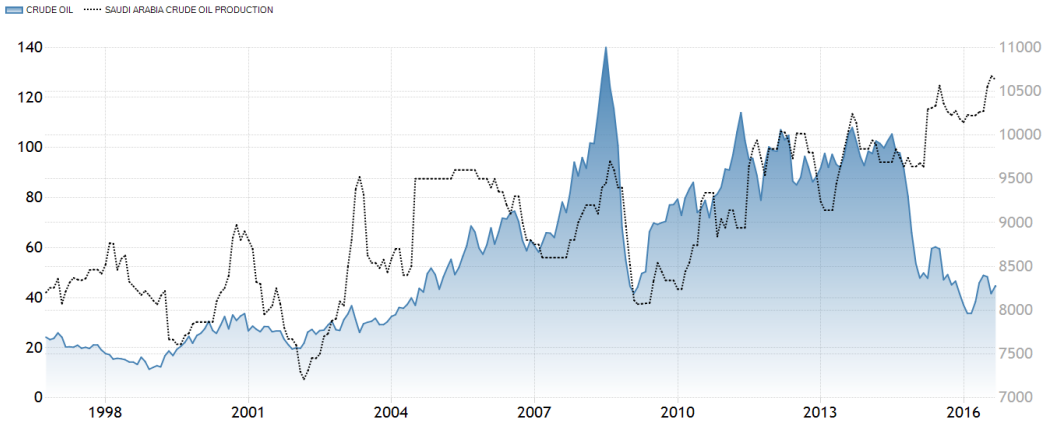

Figure 3: Saudi crude oil production was loosely moving inline with its price until they parted on the second half of 2014, which coincided with the increase in American companies' production of shale oil. *Data Source: Trading Economics, Inc.*

[2] Shale oil is an oil obtained from bituminous shale.
[3] "U.S. oil production growth in 2014 was the largest in more than 100 years." *U.S. Energy Information Administration,* www.eia.gov/todayinenergy/detail.php?id=20572

2.3. Trade

The main five exports for Saudi Arabia, as of 2016[4], are:

1. Minerals (74.4%): 75% raw minerals, 12% semi-manufactured, 13% manufactured. Main producer: Saudi Aramco.
2. Plastics, rubbers, and their products (8.1%): This includes end-user products and manufactured materials for care products, aerospace, tires, and appliances' manufacturing parts.
3. Chemical products (7.3%): mostly as components of industrial products, like materials in the medical industry, vehicles manufacturing, adhesive, and decorative-laminate industries.
4. Transportation equipment and parts (2.3%).
5. Metals (2.1%).

- Other commodities (5.8%)

Trading Partners Main 5 Countries by Value	
Export	Import
China %20.8	U.S.A %29.1
Japan %18.8	China %28.2
U.S.A %17.2	Germany %12.9
India %16.6	U.A.E %10.7
Korea %14.9	Japan %10.4
U.A.E %11.7	Korea %8.7

Table 1: Main trading partners with Saudi Arabia as of 2016.

3. Literature Review

This review of literature aims to reach to the defining factors of a resource curse, in order to use them in analyzing the Saudi case and whether it is suffering from it.

3.1. Defining the Resource Curse

The resource curse was initially conceived to capture the observation that resource-rich countries grow economically slower compared to the resource-poor countries.

The British historian Arnold Toynbee (1934) studied 21 human civilizations of the world to conclude that the only cause for the existence, disintegration, and disappearance of civilizations was that of Challenge-and-Response. That is, unless a nation, a society, or even an individual faces a challenge to warrant a proportionate response, there will be no survival or prosperity whatsoever. By the same token, whenever an overall economy relies on windfalls of natural resources' revenues, the rest of the economy becomes

[4] General Authority for Statistics. (2018). *The Annual Report of Foreign Trade Statistics 2016.* https://www.stats.gov.sa/sites/default/files/annual_report_2016_en.pdf.

reluctant to explore innovative pathways to prosperity and to effectively realize its own potential in terms of growth and competitiveness trajectories.

3.2. Diversification

Gelb (2010) looks at economic diversification from the perspective of resource-rich countries. He establishes that in the 1960s, around 80% of the developing country exports were a primary commodity; but in 2010, about 80% were industrial products (Gelb, 2010). As a result of this process, several countries shifted from primary-based economies in the 1960s towards becoming industrial hubs, such as China, India, Brazil, and Malaysia.

Gelb pays particular attention to the oil-exporting countries as extreme cases within mineral exporters in general (Gelb, 2010). Analyzing data from the top 35 oil-dependent countries in the world, one notices that oil revenues "represented on average 16.2% of GDP or 49.1% of total fiscal revenue" (Gelb, 2010, p. 2). However, Gelb raises the question of why to diversify in the first place and so to abandon one's comparative advantage?

This question implicitly takes the consistency of the natural resource's value in the market as a given. While it is wise to strengthen the comparative and competitive advantage for the short- and probably medium-term performance, the risk of market fluctuations and the risk of alternative emerging technologies must be hedged by diversification and also by innovation.

Sachs and Warner (2001) commence with recognition of the historical fact that the phenomenon of the natural resource curse was brought to the forefront in the interwar era. At that time, several countries in Latin America experienced economic difficulties due to the slump in commodity prices worldwide. However, other researchers argued that the failure of resource-led development in these countries could be ascribed to forecasts of declining global demand and prices. Sachs and Warner argue that the "curse of natural resources is a demonstrable empirical fact, even after controlling for trends in commodity prices" (Sachs & Warner, 2001, p. 828).

Through regression, using growth statistics for the period 1970-1989, Sachs and Warner concluded that resource intensity tends to correlate with slow growth. On the other hand, they mention the issue of practical significance, that is, many developed countries, such as the USA, were once developed using their natural resources as a catalyst. They cite here Habakkuk (1962), who refers to the natural resource abundance in the 19th century

USA, arguing that it was the principal reason for the apparent economic growth that exceeded the comparative development of England at the time of reference. The availability and accuracy of data for the 19th century might question the accuracy of this finding.

3.2.1. Crowding out other sectors

In their explanation of the resource curse, Sachs and Warner (2001) admit that there is no universal theory to explain the resource-abundance curse; and that it is conventionally explained by the crowding-out rationale, whereby the natural resource sector crowds out a growth-driving sector in the long-run and consequentially harming growth. The question here is which sector in any economy can be plausibly considered the primary driver of growth? In Sachs and Warner (1995, 1997) this linchpin of growth is the traded-manufacturing sector or activities across several sectors.

Their argument is as simple as to maintain that wealth from natural resources' sector will result in an increased demand for non-tradable goods and will also drive wages to higher limits. Increases in prices of non-tradable goods coupled with higher wages represent an unbearable burden on the traded manufacturing activities within an economy.

Presently, this argument gained credibility with the wide-spread application of the anti-dumping measures to protect traded products of an economy, as the one mentioned under the Agreement on Implementation of Article VI of the General Agreement on Tariffs and Trade (GATT, 1994) and is kept in effect under the WTO afterward. The Gulf countries, who share the relative abundance of natural resources, witness a plethora of low-priced imports, a classic Dutch disease side-effect, which was detrimental to the development of manufacturing.

3.3. Innovation

Crowding-out other sectors might hold true only if no other variables are in the interplay. Such variables may include innovation or technological spillovers resulting from the prevalence of quality education across society. In this respect, Sachs and Warner cite Gylfason, Herbertsson, and Zoega (1999) who consider education as the critical factor in determining economic growth. Moreover, it is argued that riches from natural resources could 'crowd-out entrepreneurial activity or innovation' (Sachs & Warner, 2001, p. 835). The reason beyond this crowding-out is the possible increase in wages in the sectors feeding on the natural resource. Nevertheless, a country might be able to achieve a

leapfrog in their economies have they used innovative technologies in the lucrative sector (Lee, 2019).

3.4. Institutional Quality: A prerequisite or a byproduct of development?

Analysis of macroeconomic factors is not complete without a closer look into the entity that manages the macroeconomic policies; the public institutions. de Ferranti (2002) highlighted the advanced economies' utilization of natural resources as an expediting vehicle for development where it can lead to diversification and improvement in other sectors. This utilization cannot be achieved without good governance and institutional quality that minimizes the possibility of a severely limiting corruption. When a government that set the rules and regulations of the market becomes corrupt, it will seek to maximize its utility by strengthening its grip on the lucrative resource.

To support this opinion, some researchers draw the attention to an important fact that natural resource wealth generates a temptation towards rent-seeking among government officials and a possible tendency to corruption and less efficient governments, which constitute an obstacle to sustainable economic growth (Sachs & Warner, 2001). This can be witnessed in oil-rich countries; in the Transparency International's Corruption Perception Index (CPI) for 2017, we can see Venezuela (ranking 169), Nigeria (148), Russia (135), and Kazakhstan (122), exhibiting weak performance.

On the contrary, some other resource-rich countries performed well in the CPI 2017, including Norway (3), United Arab Emirate (21), and Qatar (29). Saudi Arabia was hovering in between the two groups, ranking 57th. The CPI ranks 180 countries by their levels of corruption according to surveyed business people and scholars. The survey includes an economy's ability to attract FDI, along with the overall business framework in that economy[5].

Hence, it is safe to say that coupling a resourceful country with the factor of a high level of corruption makes the economy prone to the resource curse.

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[5] Transparency International (2018). Corruption Perception Index (CPI) for 2017. Website: https://www.transparency.org

For context-specific policies for growth promotion, there is a debate on whether to pursue horizontal policies (by stressing macroeconomic stability, advancing openness and sector-neutral role for the government) or opting for vertical policies (through targeting specific sectors or even going down to the corporate level). The last century has witnessed the failure of state-controlled, centralized planning, which proved to be both costly and ineffective as the collapse and eventual dissolution of the Soviet Union in 1991 has revealed. In contrast, some other economists favor designed industrial policies in a departure from conventional thinking (Fay, 2012). Such industrial policy can go further to be a cooperation between the public and private sector, as demonstrated in the successful case of the Korean public-private R&D consortium (Lee, 2015). However, Stiglitz and Yusuf (2001) revisited their 1996's praise of the industrial policies in East Asia, and mentioned that those policies that aimed to support the private sector were not long term: "the costs of subsidies significantly outweigh the benefits [..] with the exception of exports from Korea" (Stiglitz & Yusuf, 2001, p. 24)

Lee and Kim (2009) postulate that institutional quality, in terms of security of property rights, the rule of law, and democracy versus autocracy can make or break economic growth in the long-run. On this basis, the developing countries have to opt for institutional streamlining in three dimensions: market regulation; market stabilization, and market legitimization (Rodrik et al. 2004 cited by Lee and Kim, 2008). However, the significance of institutions for long-term growth is meticulously compared to policies represented, for instance, by education attainment, and the researchers take "a compromise view for the two contrasting findings in the literature" (Lee & Kim, 2009, p. 545). Lee and Kim find that institutions and policies work together in determining economic growth "while controlling for the initial income levels, population, and geography" (Lee & Kim, 2009, p. 534). In this respect, R&D is singled out as an essential factor in long-term economic growth.

3.5. Human Capital: Education and Labor

It is found that factors of economic growth are context-specific. This specificity is entailed by either of two different stages of development: low- to the middle-income stage of development; and middle- to high-income countries.

For countries in the first stage, what matters more are institutions or primary/secondary education, whereas countries in the second stage are affected by tertiary education and

technological innovation. Per capita GDP was used to determine the income level for countries in the two categories.

Further, institutional quality and human capital have been viewed as variables of considerable significance in the regression of analyzing the causes of strong versus weak economic performance in resource-rich economies. These new variables of institutional quality and human capital are eloquently addressed by other researchers – namely, Acemoglu, Johnson, and Robinson (2001), Lee and Kim (2009), and Alexiou, Tsaliki, and Rasha Osman (2014)– as important factors in shaping the socioeconomic landscape that leads to economic prosperity (Lee & Kim, 2009).

Other researchers highlighted that while the resource dependence crowds-out the human-capital-intensive manufacturing sector which increases unemployment, public investment in education contributes to the human capital accumulation, reduces the crowding-out effect, and increases the private rate of return on investments in human capital (Sun, Sun, Geng, & Kong, 2018).

It is worthwhile to mention Justin Lin who argues in favor of the state's role as a facilitator in intervening to encourage firms, manufacturers, and sectors to best exploit a country's comparative advantage (Lin, 2009). He speaks about the nation's endowment structure represented by a relative abundance of labor and skills, capital accumulation and access, and natural resources. In order for the country to discharge its mandate of facilitating economic growth, it should first improve the endowment structure within a framework of an endogenous process of development.

3.6. Conclusion from the literature

The natural resource curse deprives the economy of having sufficient growth for a country to become industrial. It is particularly evident when the resource is oil and natural gas due to their broader and lucrative market. This dominant sector overshadows the rest of sectors, particularly tradeable sectors, by stifling their opportunity to prosper and produce the response for the challenge of survival. Crowding out sectors paired with a low institutional quality exacerbates the curse and paralyzes an economy from competitiveness, diversification, and innovation. The behavior of ignoring the economic imperative to develop a diverse economy and an innovative human capital can be ascribed mainly to the prevalence of rent-seeking behavior.

The literature review laid out the criteria by which the Saudi economy is to be analyzed to conclude whether a resource curse exists or not, and if so, how severe it is. These can be sorted into three main criteria, each of which has been linked to hindering economic growth:

1. **Diversification**: which includes competitiveness, innovation attempts, and other revenue-generating attempts away from the oil industry.
2. **Human Capital**: the educational side and the labor side, as mentioned in the literature review.
3. **Institutional Quality**: A benchmarking-analysis for the Saudi status in major indices, along with a policy analysis regarding the institutional work of the government agencies.

The consolidated criteria are the basis of this paper as they represent an analysis of the economy's symptoms until the root-cause. Diversification starts by sectoral observation to evaluate the current status, followed by a deeper look into the diversification attempts in order to forecast the trajectory of the current status; whether it is a transitional phase or a result.

The human capital conveys the potential impact of the diversification attempts, in case the status is a transitional phase. Alternatively, if the status is a result of previous attempts or the lack of, then the human capital serves as an explanation of the result and the attempts that led to it.

Lastly the institutional quality is the Keynesian bedrock of the economy and its growth. This criterion is expected to quality-check the work of the paper regarding the status and trajectory concluded from the two previous criteria; the institutional quality is expected to be a logical reflection of the result from diversification and human capital.

4. Research Question

The literature review showed several studies regarding the negative effect of resource abundance on economic development, without pinning a specific element of the economy that can be taken into consideration for policymakers. This generalist approach of studying the resource-development relationship in the literature conveys the importance of studying each country separately to consider their geopolitical, social, and demographic differences. Given the limited research regarding the Saudi case in terms of

laying down all resource-curse aspects and assessing their existence in the Saudi economy, this paper will adopt this methodology. The literature demonstrated several aspects in regard to the resource curse, and this paper will explore them to reach an answer to the following question:

The Research Question: Does Saudi Arabia suffer a resource curse? If so, how evident is it?

5. Analysis and Results

The aspects to be taken into consideration vis-à-vis resource curse are diversification (which includes sectoral performance), human capital, and institutional quality. Each of the three criteria includes a status quo assessment and a trend or trajectory forecast. The lack of data has been substituted with empirical analysis and observations. Also, looking into the Saudi fiscal policy would give an indication of the economy's trajectory and the government's priorities and direction in its investments in the economy.

5.1. Diversification

First, we assess the **status of diversification** using exports and also using revenue-generating sectors, then we analyze the **attempts to diversify** the economy. The main diversification attempt is innovation, which builds a competitive edge for a country.

5.1.1. Diversification status

We look into the trend of the exporting sectors in terms of their value and their share of the total exports. We noticed the oil sector (crude petroleum) being the dominant sector in the kingdom both in dollar value and in the share of export, as seen in Figure 4 and Figure 5.

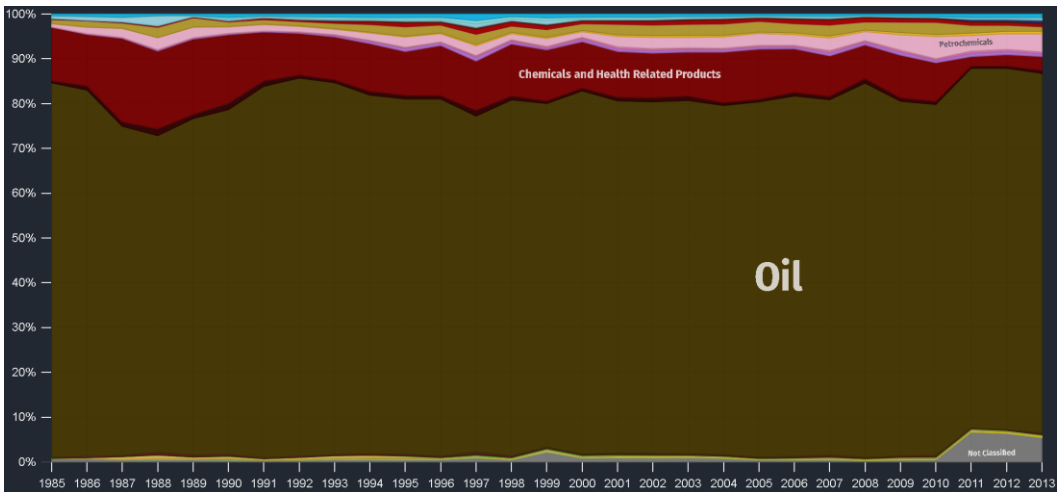

Figure 4: Oil share of the total export shows a dominating share for crude petroleum with a much smaller value for the closest second "Chemicals and Health-Related Products" that are value-added exports (Source: The Observatory of Economic Complexity, MIT university).

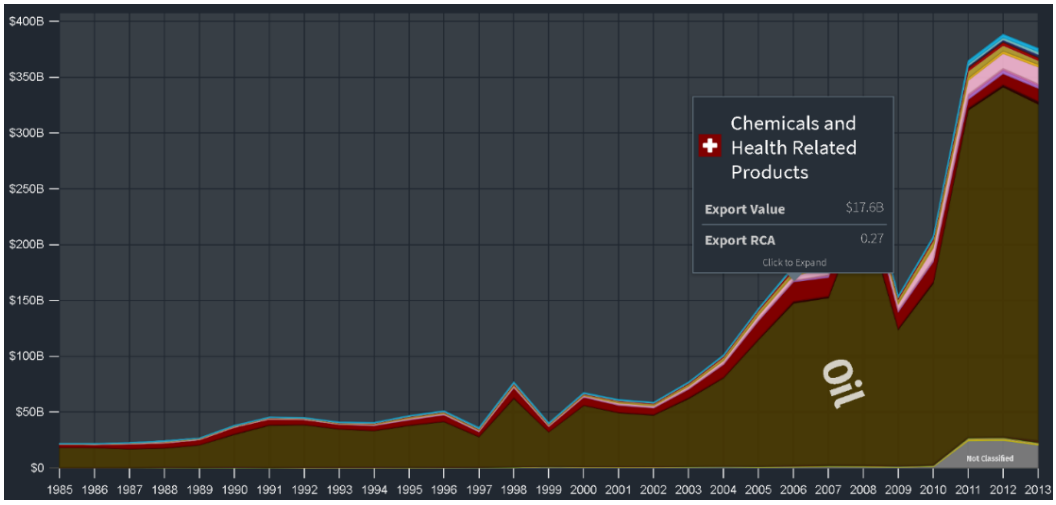

Figure 5: Oil rent of the total revenue has been the primary source of income for the kingdom. Chemicals and Health-Related products gained traction as a value-added exports but are not witnessing growth (Source: The Observatory of Economic Complexity, MIT university).

Another indicator of diversification is how correlated the GDP growth with the oil revenue; having them moving together indicates the oil revenue's influence on the annual GDP. This indicator too shows that the Saudi economy is prone to be highly influenced by petrodollars, as in Figure 6 in the next page.

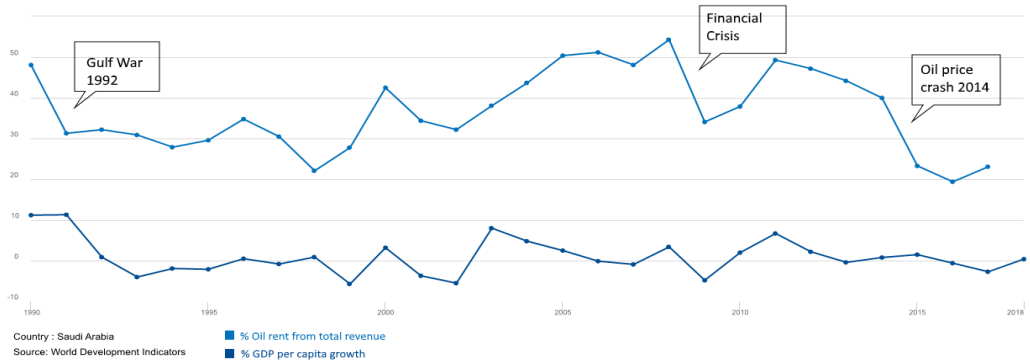

Figure 6: The oil revenue has a direct impact on the Saudi economy, which can be seen more evidently in the years with steep oil rent change seeing a similar direction for the GDP year-to-year percentage change, with a one year lag for the GDP change (Source: World Development Indicators, The World Bank)

Not only the correlation is evident in Figure 6, oil rent in Saudi Arabia is higher than of most oil-exporting countries, including Kazakhstan and Norway, as seen in Figure 7.

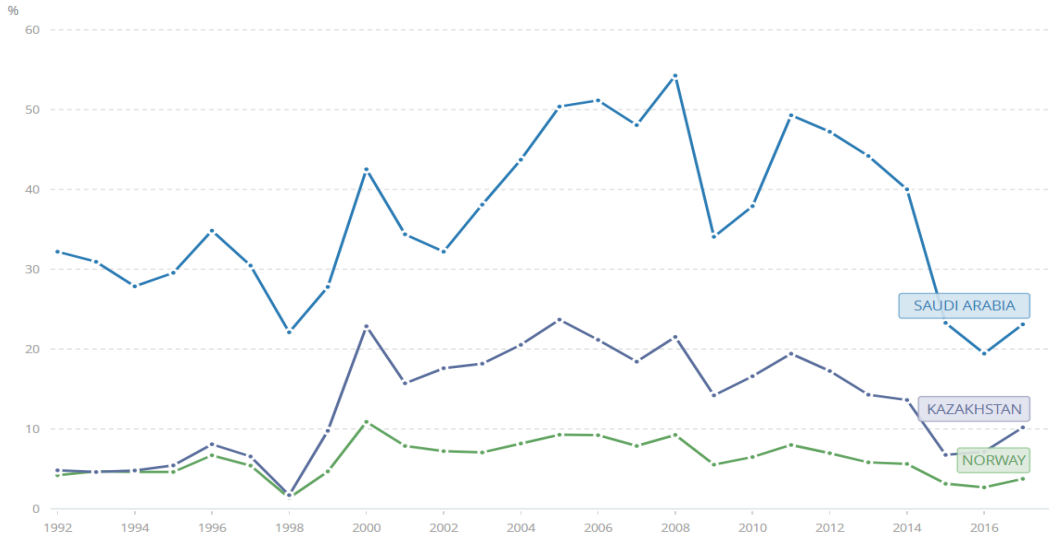

Figure 7: Oil rent as a percentage of GDP is the highest in Saudi Arabia. Source: The World Bank).

5.1.2. Diversification Attempts: Sovereign Wealth Fund

The Saudi sovereign wealth fund is ranked 11th among sovereign wealth funds with around $320 billion of assets. In comparison to Norway, it is considered much less than the potential for a top-exporting country. It excels, however, in comparison to Kazakhstan, which has much less population density, and is neighbored by G20 economies; China and Russia.

#	Profile	Total Assets (billion)	Region
1	**Norway Government Pension Fund Global**	**$1,099**	**Norway**
2	China Investment Corporation	$941	China
3	**Abu Dhabi Investment Authority**	**$697**	**UAE**
4	Kuwait Investment Authority	$592	Kuwait
5	**Hong Kong Monetary Authority Investment Portfolio**	**$509**	**Hong Kong**
6	GIC Private Limited	$440	Singapore
7	**National Council for Social Security Fund**	**$438**	**China**
8	SAFE Investment Company	$418	China
9	**Temasek Holdings**	**$375**	**Singapore**
10	Qatar Investment Authority	$328	Qatar
11	**Public Investment Fund**	**$320**	**Saudi Arabia**
23	Kazakhstan National Fund	$60	Kazakhstan

Table 2: Largest sovereign wealth funds in terms of asset value. *Source: Sovereign Wealth Funds Institute [SWFInstitute.org].*

The sovereign fund is contributing 4% of the Saudi GDP and has a strategic partnership with SoftBank to invest in companies that are considered high-risk investments for sovereign wealth funds, like pre-revenue technology companies. The lack of transparency in its work, and the interference of the government in its work are considered the two main fallbacks that are potentially preventing the fund to fulfill its diversification goal of "localizing edge technology & knowledge" and "[empower] new sectors", which are mentioned in the Vision 2030 strategy.

5.1.3. Diversification Attempts: Aramco

Saudi Aramco, the state-owned oil company, is the most profitable country in the world, due to oil exports and also to innovation in the oil industry and petrochemical products.

With more than 65 thousand employees worldwide, 80% of whom are Saudi citizens, Aramco is present in main cities around the world to cover its global client base, such as Seoul, Tokyo and three offices in China. Also, it has joint-venture refineries in Fujian, China (Fujian Refining and Petrochemical Company), Seoul, Korea (S-Oil), Houston, USA (Motiva) and Minato, Japan (Showa Shell Sekiyu).

In 2012, Aramco made its presence in Korea to be through the affiliated company Aramco Korea[6]. It has an operations office in Seoul and a Technology office in Daejeon (in partnership with KAIST). Also, Aramco is the biggest shareholder in S-Oil, which in turn owns 33.4% of Hankook Silicon, making it the 2nd largest shareholder. Hankook Silicon is a polysilicon producer, the core raw material for solar photovoltaic (PV) cells. This strategic transaction is part of the mother company's diversification in both energy- and non-energy-related trials. The latest attempt was on September 2019 when the company announced operating a gas well using solar energy[7]. Diversification attempts has not yet become a solid alternative revenue stream for the company.

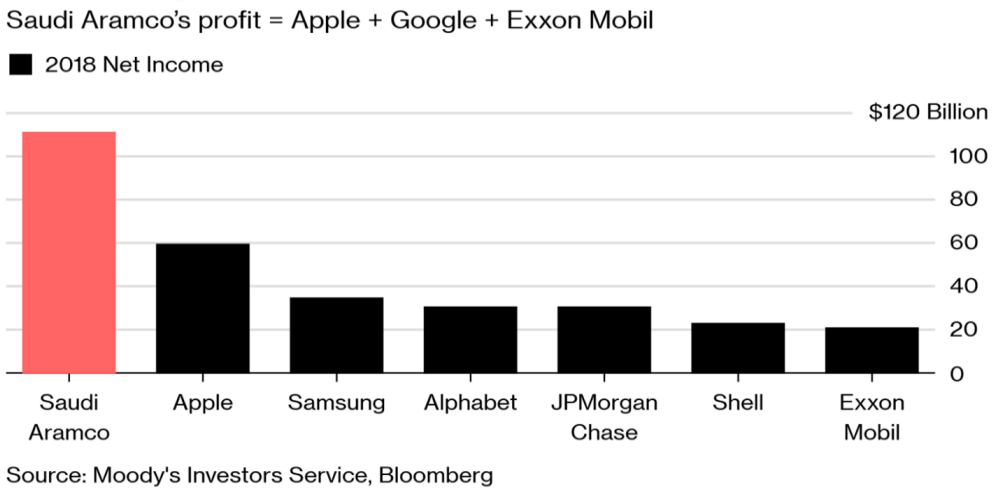

Figure 8: Saudi Aramco is expected to be the biggest publicly-traded company in the world upon its anticipated IPO in November 2019.

5.1.4. Diversification Attempts: Innovation

The crowding-out effect of the resource-based lucrative sector can hinder the private sector, but if the oil sector is highly productive, then was it also innovative, to sustain development? How was Saudi Arabia's government approach to innovation? And will this help the private sector around it, even the non-energy-related, by having a positive spill-

[6] Aramco Asia Korea Limited. [korea.aramco.com]
[7] "Using renewables to power unconventional gas wells in Wa'ad Al-Shamal" Saudi Aramco website. Accessed on September 19, 2019 [https://www.saudiaramco.com/en/news-media/news/2019/renewables-powering-gas-wells-waad-al-shamal]

over? This section elaborates in analyzing historical trend and data to answer these questions.

Public governance of resources is a key in maximizing the benefit of its income to the national economy (Iimi, 2006), but implementing committed governance of resource management can be influenced heavily by the internal politics of a country. On the other hand, investing in innovation can lead to longer-term ROI on the invested resources with little interference of political variables. We will look into the Saudi government's attempts to innovate in the energy sector, then analyze whether innovations in the energy sector affects the non-energy sectors.

5.1.4.1. Innovation Attempts in Renewables

Innovation in technology already led to a drastic decrease in the cost of production (Krautkraemer, 1998), yet it does not change the fact of the scarcity of the resource or the reliance of one source of income. Hence, while the kingdom did not provide incentives nor support to the private sector to innovate, the government took upon itself to innovate in the energy sector in order to produce another revenue stream from the lucrative energy industry. These attempts were characterized by being short-term, lacked follow-up, and were highly influenced by the oil prices. This is a look at some of the significant attempts in the Saudi Arabian recent history.

*SOLERAS (**Sol**ar **E**nergy **R**esearch **A**merican and **S**audi):*

In October 1977, the US and Saudi Arabia agreed to equally fund a $100 million solar photovoltaic energy development research (Alamoud, 1988). The main project was the Solar Village, a solar farm 50km from the Saudi capital, to power three villages (~ 4000 inhabitants) using solar energy.

The project was completed in 1981 and operated until 1986. After a successful performance at first, its efficiency dropped 20% and operational cost hiked due to unexpected heat along with other issues(Huraib, Hasnain, & Alawaji, 1996). Also, in 1984, SOLERAS installed a solar thermal seawater desalination pilot plant in Yanbu city. It was closed years later for economic reasons.

HYSOLAR program:

In January 1980, West Germany and Saudi Arabia agreed to fund a 35.2 million Deutsche Mark ($19.3 million) HYSOLAR program (60% funded by the Federal Republic) to produce hydrogen from solar energy. The project ran from 1986 to 1991. It was supposed to be the end of Phase I (Grasse, Oster, & Aba-Oud, 1992) but then it was abruptly terminated and considered "educational"(Abaoud & Steeb, 1998) for researchers.

KACST projects

King **A**bdulaziz **C**ity for **S**cience and **T**echnology (KACST) research support center, which is the Saudi representative for the previously mentioned joint projects, conducted more than 20 solar energy-related projects during and after SOLERAS and HYSOLAR programs, but none were reported feasible or profitable(Alawaji, 2001).

King Abdullah City for Nuclear & Renewable Energy (KA-CARE)

KA-CARE is a governmental entity that was established in 2010 to be "entrusted with setting and implementing the national atomic and renewable energy policy."(Royal Court, 2010, p. 2) The entity has been researching energy efficiency and renewable energy, as well as supervising the establishment of the first atomic reactor in the kingdom.

5.1.4.2. Potential Influence of Oil Prices on Innovation Attempts

The kingdom has not started applying taxes until 2018 when 5% of Value-Added Tax (VAT) was introduced. Hence, the primary income for the country has been oil revenues from the state-owned Aramco, where expansionary or contractionary policies are determined upon.

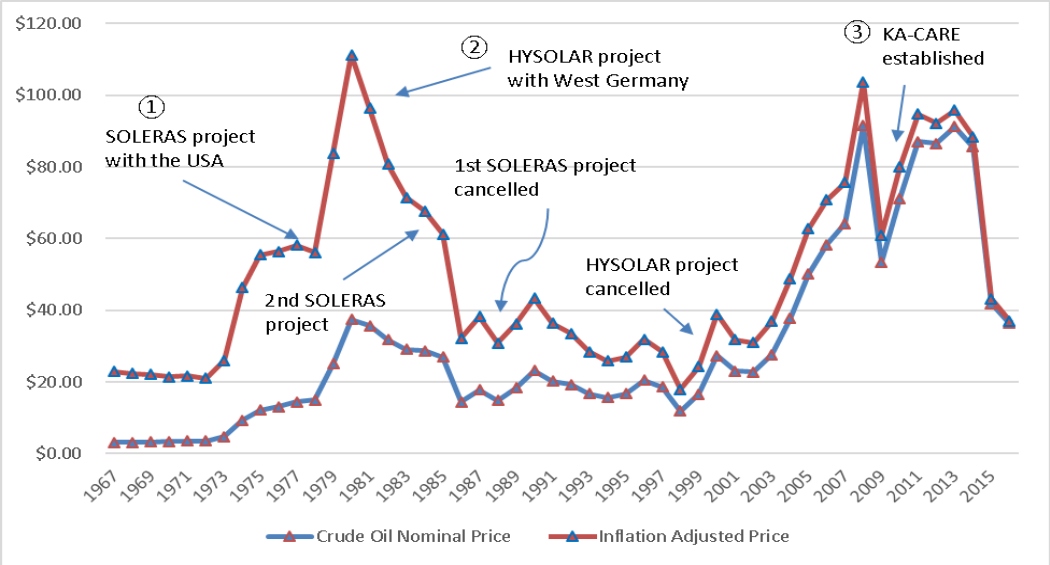

Figure 9: Timeline showing primary renewable energy projects commencement dates coinciding with significant oil price declines; The first oil price decline for more than a dollar since oil production. ② The most significant oil price decline to its date. ③ The steepest oil price decline to its date, as a result of the Financial Crisis (Oil prices are for Brent crude oil, as it is one of three global benchmarks in oil markets).

SOLARIS project started during the highest price decline since oil production started, and the commencement of HYSOLAR was also during the highest price decline to its date. Both projects were canceled during price recovery. SOLERAS was canceled due to short-term commercial infeasibility, while the cancellation of HYSOLAR went without documented reasoning. While there is no proven causation between the two, given the stagnant progression in local solar technology innovation albeit the heavily-invested public project raises a concern regarding the institutional governance in the kingdom and whether its reliance on oil made it less tempted, or less *motivated*, to innovate. However, the 2010 KA-CARE initiative for renewable energy, while it was established during the aftereffect of the Financial Crisis where oil prices also crashed, is still undertaking the establishment of the first nuclear reactor in the Kingdom.

5.1.5. Analyzing Spill-Over Effect of Energy-related Innovation on Non-energy Sector

Although the attempts to innovate were unsuccessful, the kingdom premiered in oil-related innovation, from refineries to petrochemicals.

Given the high innovation in the oil industry and the unsuccessful attempts in renewables discussed earlier, we assessed the effect of innovation in oil on the non-oil industries, or more broadly the non-energy. The assessment found that innovation in oil did not hinder the non-oil innovation; instead, there was a strong correlation between the two. Given this result, we assessed if the innovation in the energy industry could have a positive spill-over effect on the non-energy.

The result shows that while the correlation is high, the causation is not evident. This can be justified by the technology chosen; short-cycle technologies have higher probability of gaining traction and competitive advantage in the markets in the short-term (Lee, 2019, p. 222), while long-cycle technologies need longer breath of investment. The technology of renewables was fairly new during the different times of the attempts and hence considered a long-cycle technology that needed longer breath and commitment than what Saudi Arabia has done. Details of the conducted analysis using Granger's Causality Test between innovation in energy- and non-energy sectors is in the Appendix: Effect of Energy-Related Innovation on Non-Energy.

5.1.6. Economic Competitiveness

Competitiveness in the global market is becoming more challenging, and the resource curse compounds the challenge with a decline in the competitiveness of other economic sectors.

Saudi Arabia exhibits this characteristic, with Mishrif and Alabduljabbar (2018) noting that the policies implemented by the KSA to correct distortions in the labor market, such as educational and wage policies, has only shifted the labor force to the public sector. The steady increase in the public sector workforce has widened the gap with the private sector. This gap, in return, created a skewed preference among Saudi citizens for the public sector jobs as mentioned in the earlier section, resulting in lack of adequate human capital for the private sector, leading to a decline in the competitiveness and productivity of other sectors apart from the oil industry. Also, the private sector faces higher fees and fewer chances to win government contracts if they fall below a certain level of hiring

locals, putting these companies in the crossfire of inadequate human capital and increasing fees.

	Global competitiveness index (0 worst ~ 100 best)	Ease of doing business rank (190th worst ~ 1st best)
Kazakhstan	62.9	25th
Saudi Arabia	70.0	92nd → 62nd
Norway	78.16	7th
Canada	79.6	22nd
Netherlands	82.38	36th
World Average	**60.7**	**95 (median of 190 ranks)**

Table 3: Economic Competitiveness and the Ease of Doing Business , in which the World Bank ranks countries around the world, and where the first indicates the best (WEF, 2018; The World Bank, 2018c).

Generally, the global competitiveness index measures the potential for economic growth in the respective countries with a score of 100, indicating the most competitive country, while a score of 0 shows the least competitive country. In this case, Saudi Arabia had a global competitiveness score of 70.0 compared to Kazakhstan that had a score of 62.9. On the other hand, resource-rich developed countries such as Canada, and the Netherlands, and Norway had global competitive index scores of 78.16, 79.6, and 82.38 respectively.

Thus, the resource-abundant developing countries, while having a lower global competitive index score, are not far off the developed world.

However, Saudi Arabia ranked low in the ease of doing business index, albeit jumping 30 ranks since the previous year. This jump needs continuation to ensure that it is a reflection of a reform and not a result of temporary measures.

5.2. Human Capital

To read the government's priorities, it is helpful to look into its fiscal policy and where does the total revenue go to. The 2019 budget allocation is demonstrated in Figure 10.

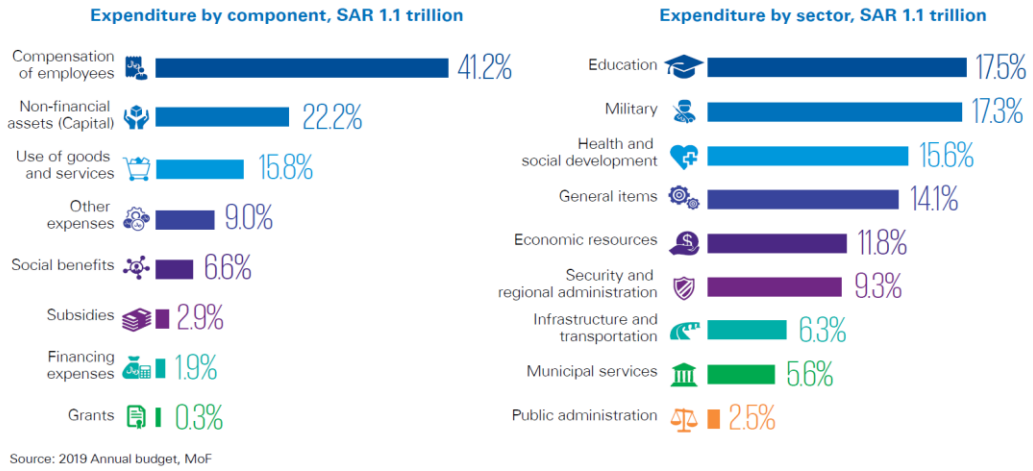

Figure 10: Saudi Arabia's sectoral expenditure. (Chart Source: KPMG's "Kingdom of Saudi Arabia Budget Report" from the Saudi Ministry of Finance).

Looking into the sectoral expenditure on the right, we should note that while spending on education is generally considered a good indication for long-term diversification, an allocation of over 80% of the spending on education has been on education workers' reimbursement, which does not convey a targeted allocation for development. Also, having the military spending in a close second might not expedite the attempt to diversify, although the political unrest in neighboring countries can justify the allocation of military spending.

In the left side, compensation of employees reached 41.2%, which is justifiable as the public sector is the biggest employer in the economy, hiring 56.9% of total Saudi workforce. This should not indicate weakness in the private sector, since data shows that 81% of the private sector employees are non-Saudi. At the same time, unemployment rate is 12.9%, which indicates a potential mismatch between local skills and the needs of the private sector. To compare these data with other oil-rich states, the next Figure 11conveys an indication of a very low labor participation.

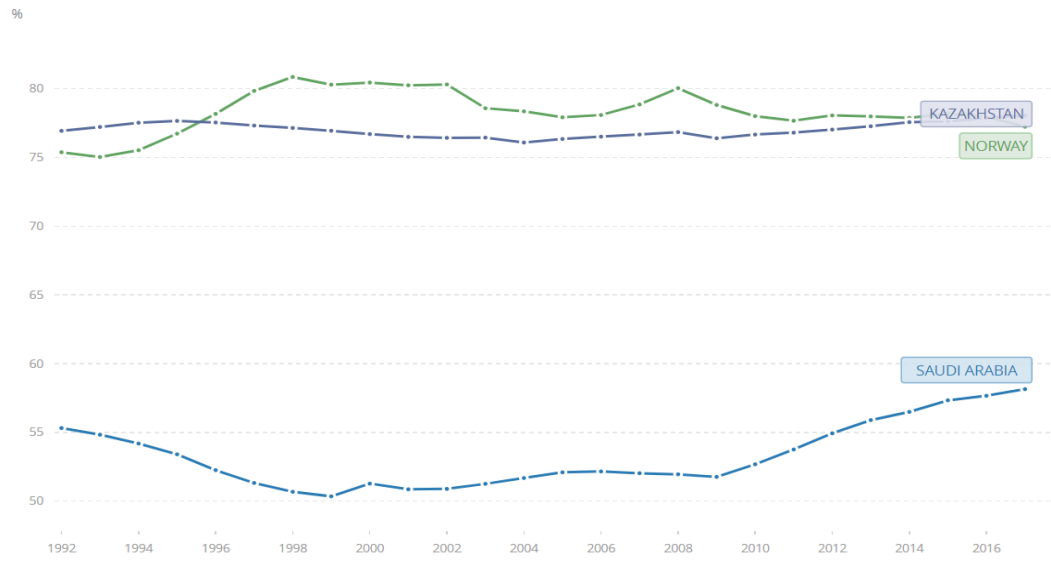

Figure 11: Labor force participation rate and productivity: a trend comparison showing Saudi Arabia way behind both Norway as an advanced economy and Kazakhstan as a developing economy. Source: The World Bank, 2018

Figure 11 compares the three resource-rich countries in terms of labor participation rates and productivity. The labor participation rate refers to the number of individuals available for employment (whether employed or actively seeking employment) as a proportion of the overall national population. In this case, Saudi Arabia's labor participation rate has persistently been much lower than both Norway and Kazakhstan with no more than 60% of participation rate since 1992.

The literature review also showed that the resource curse also has a significant impact on the labor market by, for example, reducing labor productivity. In this case, Samargandi, Fidrmuc, and Ghosh (2014) state that the abundance in oil wealth in the KSA has created distortions in investment decisions. The result was evident in the contrasting case of the non-banking financial institutions (such as insurance companies, Islamic bonds, and the stock market) that have a positive impact on the economy while suffering under-development for decades, and was mainly staffed by foreign professionals until recently. Such contrast reflects the inherently oil-based nature of the Saudi economy. Currently, Saudi Arabia has a young local population with a relatively high birth rate, resulting in the rapid growth of labor force participation. Unless capital accumulation and investments - which are critical for economic growth- are made to keep up, there will be a drastic decline in wages. While the government can provide high wages for the public sector, the

labor market will suffer from an increasing skewness in benefits towards the public sector, which would harm the competitiveness further. The vast welfare state created by the oil has engendered generous subsidies and transfers that show a particular preference for workers in the public sector (Samargandi et al., 2014). As a result, some chooses not to work in the private sector, causing delay participation in the labor force. In turn, the local workforce in the KSA has a low level of productivity, suppressing the growth of other sectors in the economy.

5.3. Institutional and Governance Quality

When observing all the beforementioned aspects, one might question the quality of the institution from which policies stem, as the literature review results showed that poor economic management policies are a major cause of weak economic growth. Al-Sheikh and Erbas (2016) note that the royal decrees in 2011, which created a policy package aimed at addressing the unemployment problems have exacerbated the effects of the resource curse. The decrees require government agencies and ministries to hire more citizens as well as additional salary increases and improved transfers of wealth through welfare payments. At the same time, the royal decrees also implemented the policy of the Saudization.

These royal decrees exacerbated the labor market tensions without any significant positive effect on the wages and employment levels in the private sector. Over the long term, the measures introduced by the royal decrees could even worsen the levels of unemployment without arresting the wage declines prevalent in the private sector (Cinti, 2011). The continuation of these economic management policies might lead to heightened disparities between the wages in the private and public sector in the long term.

	TI Corruption Perceptions Index (0 worst ~ 100 best)	Open Budget Index (Budget Transparency) (0 worst ~ 100 best)	Public Integrity Index (0 worst ~ 10 best)
Saudi Arabia	49	1	5.05
Kazakhstan	31	53	5.95
Canada	81	71	8.74
Netherlands	82	71	9.39
Norway	84	85	9.79
World Average	**43**	**43**	**6.62**

Table 4: Indicators of Institutional and Governance Quality (Source: Transparency International, 2018; International Budget Partnership, 2017; European Research Centre for Anti-Corruption and State-Building (ERCAS), 2017)

While the TI index in Table 4 measures the mere perception of corruption, it is still a valuable indicator as it influences businesses decision of investing in the country. Secondly, the open budget index measures the perceived transparency of budget making and resource allocation information by the central government with countries scoring 100 being the most transparent.

Saudi Arabia scored one, indicating an opaque budget-making process. The lack of transparency in budgeting data extends to the inability for academics to perform analysis and unbiased research on an economy. This paper faced a hurdle of obstacles due to the lack of, inaccuracy, or outdatedness of economic data in the kingdom.

Finally, the public integrity index measures the capacity of the society to ensure responsible public resource spending and control corruption with countries scoring 10 having the highest capacity. the Public Integrity Index score reflects six measures: judicial independence, administrative burden, trade openness, budget transparency, freedom of

the press, and e-citizenship (using social media for public accountability). In this case, Saudi Arabia scored a midpoint of 5.05, which shows an ample space of improvement. This finding has not come as a surprise since the developed nations in Table 4 are adopting a democratic political system which, by design, is supposed to be a system of checks and balances and comes with holding the public officer accountable for tax-payers' money in order to have informed voters.

Since income inequality and labor productivity can be, indirectly, related to institutional quality, it is mentioned as part of the institutional quality, as in the following subsections.

5.3.1. Funding Public Institutions

Public institutions can be seen as a cause and also as an effect, where the effect is seen in how funding these institutions using petrodollars distorted the labor market. One of the high distortions created by the KSA's fiscal policy resulting from the oil abundance is the increasing disparity between improving wages in the public sector and declining wages in the private sector. The IMF's Article IV Consultation to Saudi Arabia mentioned that the wage gap in favor of the public sector over the private skewed the labor market incentives towards the government's jobs, causing fewer incentives to work for the traditionally more efficient and productive private sector. Unlike South Korea, public sector's employees do not go through rigorous examinations, in addition to the job security regardless of productivity, and the exacerbating nepotism in the hiring process.

Based on this finding, it can be inferred that the benefits of Saudi Arabia's oil wealth are not felt equally in the public and private sectors, which may be indicative of a resource curse.

Moreover, Albassam (2015) notes that an economy that highly relies on income generated by a natural resource is at risk of being unstable and may collapse based on reduction of global prices of that commodity. The average income for generations in the future is expected to be below the average income of the current generations as oil exhaust after the expected 50 years given the current production level. In this case, in order to achieve full employment in the KSA for the future generations, it would require a decline in the wages for the public sector over the long term below the current wages, which is unlikely to happen due to its sociopolitical impact. As a result, the overall intergenerational incomes remain unsustainable. Therefore, the oil curse in the KSA has created income inequality through the wages gap.

The results here confirm the results of the literature review that the abundance of oil causes income inequality in the country.

Country	Total natural resources rents (% of GDP), 2017 estimates
Saudi Arabia	27.20
Kazakhstan	10.19
Norway	3.75
Canada	0.89
Netherlands	0.51

Table 5: Oil rent in Saudi Arabia compared to top oil-exporters

6. Discussion

Every aspect in the Analysis section suggests the dependence of Saudi Arabia on the oil sector as its primary source of economic development, which can be attributed to the fact that its government has favored the energy sector in terms of development and the distribution of innovative and developmental resources. The consequence was the rapid development of the oil industry and the slow advancement of the other sectors.

This type of over-dependence on oil has an inherent threat of the fluctuations in the commodity's market prices. Being a mineral, oil also becomes exhausted with time, leading to the threat of an economic meltdown. However, it is encouraging that the Saudi government is in the process of initiating and revolutionizing its economic policies in which it intends to reduce the extent to which the country depends on oil for its financial stability.

Nevertheless, while the country failed to produce a diversified output away from oil in the past, it is currently ongoing its most significant attempt yet of diversification. This welcomed attempt can have a change in the Saudi economy's structure, especially with the Saudi track record of being a relatively stable place for the private sector in the middle east.

6.1. The Economic Reform "Saudi Vision 2030"

Saudi Arabia's economic development plans used to be set every five years since 1970[8], with some goals extended to an extra interval. The government tried several solar energy partnerships with other countries[9], but it lacked continuity. Now the drive has not been higher with the dwindling oil prices and tightening budget. In 2016, the government launched a reform plan, under the name *Saudi Vision 2030*[10], which covers a wide array of sectors, including energy.

In 2017, the Ministry of Petroleum & Minerals changed its name to Ministry of Energy and opened a Renewable Energy Development Office to focus on Solar- and Wind-energy projects, to localize renewable technology[11] in order to be an exporter of renewable energy. Given the Kingdom's track record of renewable energy projects, that has been mentioned in section 5.1.4.1, the Saudi strategic plan is ought to have more determination and commitment than its predecessors in order for solid outcomes to materialize.

6.2. The Kingdom's Track Record

In parallel with the exponential growth in oil exploration and production, the Kingdom had an economy where the oil-related sector was maturing rapidly while other sectors were still evolving from their inception point. Nevertheless, Saudi Arabia sought to diversify its energy resources using cooperative renewable energy research projects with developed nations in the 1980s and 1990s, yet they were incomplete, as mentioned in section (5.1.2).

The Kingdom succeeded in owning Aramco gradually using the fair market value while keeping Aramco's private mindset and adaptability in order to achieve efficiency in international management and operations. This benefit of having both the agility of the private sector and the political influence, and being positioned uniquely as a leading player in the *Saudi Vision 2030* economic reform, gives Saudi Aramco a unique position

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[8] "Plan Documents." *Ministry of Economy & Planning*, www.mep.gov.sa/en/knowledge-resources.

[9] SOLERAS project in 1977 with the USA, HYSOLAR project in 1980 with West Germany and 20 standalone projects funded by the government until the establishment of King Abdullah City for Atomic and Renewable Energy in 2010.

[10] Mentions about the Saudi Vision 2030 are from its official online website: www.vision2030.gov.sa.

[11] "A renewable energy market." *Saudi Vision 2030*, www.vision2030.gov.sa/en/node/87

in the Saudi economy's future, as evident in Aramco's latest expansion in South Korea by owning S-Oil along with major silicon producers. Hence, the opportunity for the company to lead the innovation in energy is invaluable as a gateway for sustainable growth and to keep the competitive edge of Saudi Arabia as an energy hub for the world.

6.3. The Focal Point of Institutional Quality

While policy-making procedures and cabinets change and vary as governments change even in democratic societies, institutionalized public departments have controls in their policy-making that ensure a minimum level of transparency and commitment, which was very limited in the case of Saudi Arabia, evidently in the budget transparency and in the lack of commitment for innovation-related projects.

Missteps in policy-making can go astray in countries with low-quality institutions, yet with institutionalized public activities, the country ensures a minimum level of scrutiny and accountability. The Saudi policies towards the labor market created an unhealthy skewness of benefits towards the public sector, depriving the private sector of qualified caliber with affordable wages, as mentioned in section 5.2. The policies that followed in the last decade exacerbated the problem.

Having that said, the future is not necessarily bleak for the kingdom, and amends are being executed to break out of the curse.

The Vision 2030 reform introduced promising tools for the central government to hold offices accountable, and the preliminary results are showing, where the adoption of a government-wide paperless workflow is showing significant implications for the economy, in minimizing corruption, increasing efficiency, and in streamlining procedures for businesses and eliminating redundancies.

The finding by Alkhareif, Barnett, and Alsadoun (2017) supports this optimistic opinion, where they measured the potential output growth of the Saudi economy and the real output from 1980 to 2015, and found that the potential output was positive in the whole period, but is closing in with the real output at the end of the period after reforms started taking place (Alkhareif et al., 2017).

7. Conclusion

The indicators analyzed point out the existence of a persistent resource curse in the Saudi Arabian economy. The resource curse was not due to the oil abundance by itself nor due to lack of attempts in diversification, but the short-lived attempts in diversification and the way of managing oil wealth were the main source of the resource curse. All the studied criteria from diversification and innovation attempts to human capital and institutional quality point to a lingering oil dependence. From a monetary policy point of view, the kingdom was able to avoid a vicious procyclical effect by pegging its currency to the dollar and trading oil using the US dollar. Having that said, the Saudi economy was better in several criteria than other oil-rich states. The inflated public sector employment, while essentially a bad labor policy and hurts the private sector, indicates that the government tends to use its non-competitive hiring process as part of lowering unemployment.

8. Limitation

The major limitation for this study was the availability of data. Public data for Saudi Arabia are not up-to-date, whether related to labor, wages, or innovation. Some data had to be requested by calling public offices, and some data were obtained by attending conferences held by the Saudi ministry of finance, where data presented are not offered publicly.

Another unexpected hurdle was the inability to use official documents due to the absence of its publication date. In addition, labor data were scattered between government agencies. The existence of such limitations is another indicator of the low level of institutional quality discussed earlier.

9. Prospects and Recommendations

The ongoing attempt to diversify, called the *Saudi Vision 2030*, is the most significant attempt yet, and it can have tangible outcomes conditional to the long-term commitment of the government in proceeding with the reform.

The reform from the government side must be complemented by the private sector. Serious steps towards encouraging innovation in the private sector and using Public-

Private Partnerships to empower the private sector would yield more effective outcomes than taking part in the innovation process.

As part of the reforms, the kingdom is seeking international strategic partnerships with other governments, such as the South Korean government, to learn from their economic reform experience, which is commended. Norway represents good resource stewardship that can be observed, yet it is unwise to copy the Norwegian policies, or any other country's policies or path for that matter. Policies are adaptive throughout the countries' different stages of development (Denning, 2008), and might not be applicable for others.

The reform must go hand-in-hand with improving the institutional quality and governance to ensure the integrity, accountability, and commitment of the different agencies to the intended economic reform. Institutional quality does not materialize without sufficient and timely data for both public institutions and academics to study and analyze in order to recommend and set proper policies accordingly.

10. Appendix: Effect of Energy-Related Innovation on Non-Energy

We show here the full analysis for the statement in section 5.1.5 regarding the significant correlation and the lack of causation between energy and non-energy sector in Saudi Arabia.

The analysis has two hypotheses:

Hypothesis I: The innovation in the energy sector has moved in the same direction with the trend for innovation in the non-energy sector.

Hypothesis II: Innovation in the energy sector influenced the trend for innovation in the non-energy sector

10.1. Indicators and Methodology

We added another resource-rich country which is used as a benchmark in the literature of resource-rich economies, which is Norway, to be used as a benchmark of whether the Saudi case vis-à-vis its results is aligned or different from Norway, one of the most robust and diversified oil-rich economies in the world. To test the hypotheses, we first measure the innovation in each of the two countries, Norway and Saudi Arabia, using a data set

for energy-related and another set for non-energy innovation. Then, we test the first hypothesis using correlation, while testing the second hypothesis for causation.

Measurement of innovation can be of different methods, as each has its characteristics, and researchers agree that accurately measuring innovation can be difficult and does not have an optimal approach. One primary measure is the R&D to GDP ratio (Lee, 2016), or to use patent citation data (Lee, Miyagawa, Kim, & Edamura, 2016), or to use patent applications (Chung & Lee, 2015).

Our purpose is to observe innovation in energy against non-energy sectors. Hence, the R&D to GDP ratio might not be suitable for our purpose since it measures innovation overall.
Patent applications contain the sector they are filing under, which is sufficient enough to classify energy- and non-energy patent applications. While applications might not be accepted upon examination by the patent office, the number of trials by itself is an indicator of an active R&D work.

The primary source of data is the World Intellectual Property Office (WIPO) which coordinates with both national and regional IP offices worldwide, including the US Patent and Trademark Office (USPTO) and the European Union's Intellectual Property Office (EUIPO); the leading international offices in which institutions globally file their patents at.

To specify the energy-related patent applications, we chose the categories under which patents are filed. The categories are Electric Energy, Basic Materials Chemistry, Materials, Environmental Technology, Engines and Turbines, and Thermal Processes. These categories are expected to cover most of the broad spectrum of energy sources and their intertwined fields. Other categories are summed into the non-energy patents.

While this categorization of energy-related patents can be a subject of scrutiny, patents in resource-rich countries falling under the abovementioned categories are saturated with energy-related patents. Also, due to the limitation of application data, this categorization can serve as the best available indicator for the energy-related patents.

Several data sources were used, including calling the Saudi patent data office, to ensure that all the data representing all the selected nations were as consistent as possible. This process was followed by the cleaning and sorting of data into a more meaningful form (as in appendix 1). This study mainly employed the quantitative approach to the analysis

of data (Oakshott, 2014, p. 84). The original review of the collected data was performed on both MS Excel and EViews software. The former was used for correlational analysis while the latter was used to test for Granger causality.

10.2. Correlation Analysis

To test the correlation, we have compiled patent applications for Saudi Arabia since 1985, the earliest year to find a recorded application in the country. Norway has an earlier record, so we expanded the observed data for Norway to be from 1980.

The null hypothesis for this test is **H_0:** There is no significant correlation between energy- and non-energy patent applications. Alternatively, **H_1:** There is a significant correlation between energy- and non-energy patent applications.

Correlation results between energy and non-energy innovations are:

	CORRELATION
Saudi	0.870028
Norway	0.930315

In charts, we find the following positive slopes in the two countries, reflecting a positive correlation between energy and non-energy patents in both of them:

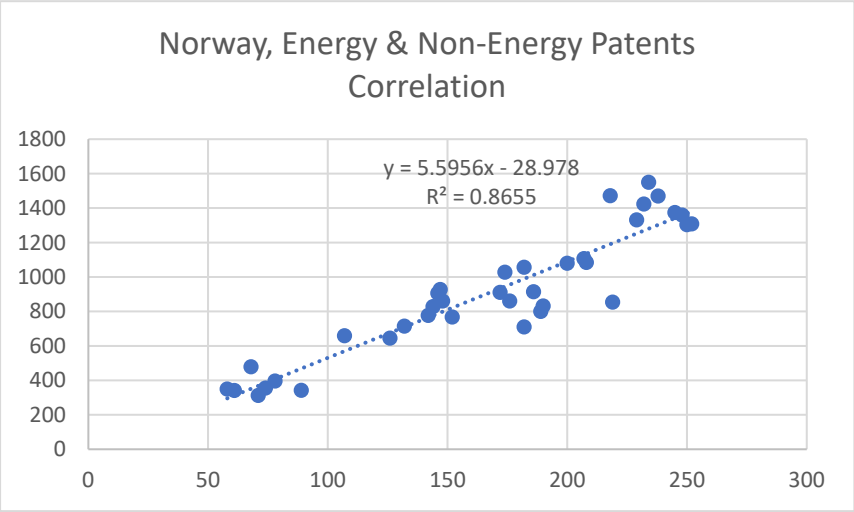

Figure 12: Substantially significant correlation is shown between Energy and Non-Energy related patents, with R^2=0.87

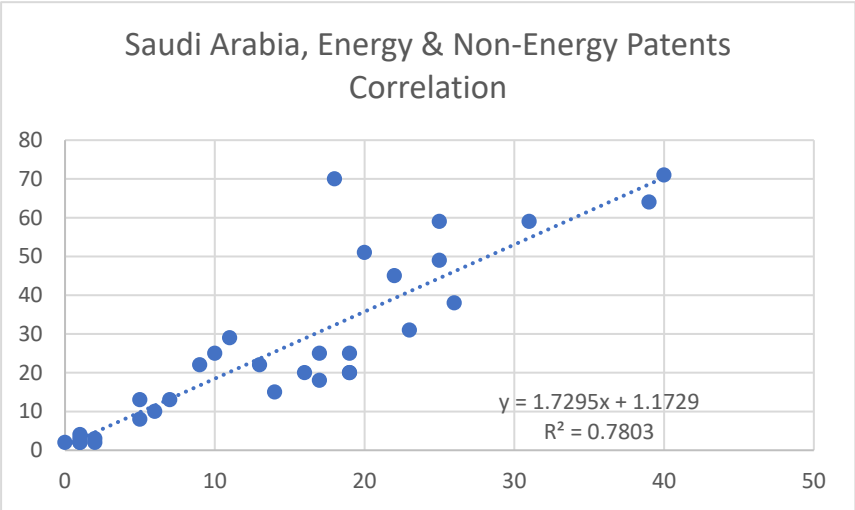

Figure 13 Significant correlation is shown between Energy and Non-Energy related patents, with R2=0.78

This significant correlation confirms our first hypothesis and allows us to reject the null hypothesis.

10.3. Causality Test Results

To test for the 2nd hypothesis, the Granger Causality test is chosen for this test as it is intended to determine whether innovation in the energy sector causes any subsequent innovation trends in the non-energy sectors. Granger causality test is a suitable way of measuring causality between two variables (Berzuini, Dawid, & Bernardinell, 2012). It involves the use of data series to determine the probabilistic causation among different variables.

We ran the test on each country's energy and non-energy sectors to use it for our **hypothesis II**: Innovation in the energy sector influenced the trend for innovation in the non-energy sector. In other words, the increase in innovation in the energy sector does have a positive spillover effect on the non-energy sector's innovation.

The null hypothesis for this test is **H_0:** Energy-related patents do not Granger Cause the non-energy related patents. Alternatively, **H_1:** Energy-related patents do Granger Cause the non-energy related patents.

After running it, the Granger Causality Test showed no causation effect of energy-related patents on the non-energy patents. Below are more details regarding the test.

Detailed Causality Analysis

The Granger causality test aims to verify the explanatory power of past values of one variable, in our case the energy-related patents, on another variable, the non-energy. The test first runs a regression of y on its lagged values (lag meaning past). It then adds lagged or past values of the first set to see if the regression, including both lagged values of both sets has better explanatory power than the regression, including lagged values of the second set alone.

Causality in the name of the test is not necessarily causality as we mean it in everyday language, i.e., that one thing causes another. Although this relationship may hold, what the test indicates is more of the significance of one set in predicting the other using their historical records.

We used Eviews software to conduct this test, and the output inside the boxes is the raw output of the software, followed by an explanation for each country in our study. This test is dependent on the number of lags used to run it. We have tested a different number of lags for the two countries (results are shown for the lag of 2), and the results were relatively within the same reading for each country. The key points of focus for this test were the p-values for each set of data.

Results for Norway

Pairwise Granger Causality Tests Sample: 1980 2016 Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
NOR_NON_ENERGY does not Granger Cause NOR_ENERGY	35	0.96762	0.3915
NOR_ENERGY does not Granger Cause NOR_NON_ENERGY		0.54876	0.5834

In the output above, the test consists of two parts, each with two regressions run as described above to compute the test statistic. The first part runs a regression of the number of energy patents as the dependent variable and past values of both energy and non-energy patents as the independent or explanatory variables. The second part of the test runs a regression of the number of non-energy patents as the dependent variable and past values of both energy and non-energy patents as the independent variables. The number of lags in the output represents the how many past values of the number of patents are included; i.e., how many past values of non-energy patents are included in the first part of the test and how many past values of energy patents are included in the second part of the test. The number of lags is 2 in this test, meaning that values for the previous two years are included.

The test checks bi-directional or two-way Granger causality. The null hypothesis of the first part the test is that one variable, x, does not Granger cause another y, i.e., the past values of x do not help in the prediction of y. The ordering of the variables is switched in the second part of the test, i.e., the second part of the test checks if y Granger causes x. The statistic computed is the F statistic and corresponds to testing the hypothesis that all coefficients the lagged values of the x variable in the first part of the test are statistically significant. **In the absence of F critical values, the essential test statistic is the p-value (next to the F statistic).** It indicates the lowest probability at which the null hypothesis can be rejected. In the first part of the test for Norway, the p statistic is 0.3915 or 39 percent.

The test can only be rejected at the standard probability levels statisticians are usually comfortable rejecting a null hypothesis (i.e., 0, 5 and 10 percent). Hence, we cannot reject the null, and we say that non-energy patents do not Granger cause energy patents in Norway. The second part of the test (perhaps the part of more interest to you) tests the null hypothesis that energy-patents do not Granger cause non-energy patents. The

p-statistic for that test is 0.5834 or 58 percent. As 58 percent is higher than 0, 5 and 10 percent, we again cannot reject the null hypothesis, and we conclude that energy-patents do not Granger cause non-energy patents in Norway.

Results for Saudi Arabia

Pairwise Granger Causality Tests

Sample: 1983 2016
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
KSA_NON_ENERGY does not Granger Cause KSA_ENERGY	32	0.83116	0.4464
KSA_ENERGY does not Granger Cause KSA_NON_ENERGY		1.58416	0.2236

The results of the Granger Causality tests for Saudi Arabia are shown above. The first part of the test has a null hypothesis that non-energy patents do not Granger cause energy patents in Saudi Arabia. The p-statistic for that test is 0.4464 or 45 percent, which is higher than 0, 5 and 10 percent. We, therefore, cannot reject the null hypothesis, and we conclude that non-energy patents do not Granger cause energy patents in Saudi Arabia. Similarly, with a p-statistic of 0.2236 or 22 percent, we cannot reject the null hypothesis that energy patents do not Granger cause non-energy patents in Saudi Arabia.

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