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Renewable Energy Challenges and Opportunities in the Kingdom of Saudi Arabia

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Abstract

This paper seeks to introduce the advantages of investing in renewable energy in Saudi Arabia. It concludes that investment in renewable energy is a promising strategy for creating more sustainable jobs for Saudi citizens and promoting the domestic economic diversification. The Saudi renewable energy sector shall increase the Saudi non-oil private sector's contribution to the total Saudi economic activities. This research paper uses Leontief's method to estimate the impact of investment in renewable energy through three main scenarios (investment of 25, 50, and 85 billion Saudi Riyal) over 5 years (2020-2025). The total value added, an additional expected growth in the gross domestic product (GDP) during the period from 2020 to 2025, is estimated to be around 2.7, 4.7, and 6.0 percent of the investment of 25, 50, and 80 billion Saudi Riyal in renewable energy respectively. The expected number of new jobs that would be generated in all three scenarios are 44,000, 90,000, and 150,000 thousand jobs. Moreover, further development of the Saudi renewable energy sector should encourage domestic energy consumption to be more efficient and less polluted. However, challenges typically thwart progress in the renewable energy sector. These challenges include technical problems, cost issues, and lack of financial sources. This paper proposes some solutions that should help circumvent these particular challenges.

Keywords: renewable energy, input-output table, value added, energy efficiency, diversification, less pollution, sustainable jobs

1. Introduction

By the end of 2018, Saudi Arabia was consuming for domestic energy usage more than three million barrels of oil every day; among these, 500 thousand barrels were solely for desalination. Moreover, the demand for water and energy is expected to increase significantly in Saudi Arabia due to high population growth (approximately 3.2% annually in recent years [2012-2017]) and economic growth (Rambo et al., 2017). The total number of oil barrels used inside the Kingdom is predicted to be around eight million per day by the end of 2050 (Negewo et al., 2012). This current level of domestic consumption of energy places a heavy burden on the government budget and prevents the exploration of opportunities to export more barrels of oil (Sdralevich et al., 2014). However, renewable energy investments would increase the demand for domestic economic activities such as construction, manufacturing, services and utilities, as well as the activities of small and medium enterprises (SMEs), which should help generate more jobs for Saudi citizens (Al-Gheethi et al., 2015). Therefore, this research's objective is to propose a transformation roadmap for the Saudi economy so that it achieves a higher level of diversification and sustainability. In conclusion, this paper will discuss, specifically, the challenges and opportunities of investment in the renewable energy sector, renewable energy sources, the Saudi renewable energy contribution to the local production system, the labor market, and the value added.

2. Challenges and Opportunities for Widespread Renewable Energy Development

Investment in renewable energy has faced many challenges worldwide, such as those of financial and technical natures, as well as a small market share. Renewable energy technology, maintenance, and training are still very costly compared to conventional sources of energy. Thus, the share of renewable energy as compared to total energy was no greater than 12% worldwide and less than 10% in the United States in 2017. In addition, the challenges related to investment in renewable energy in Saudi Arabia include high temperatures and significant amounts of dust, which are not appropriate for photovoltaic (PV) and concentrated solar power (CSP) technologies. The efficiency of PV systems is found to decrease at high temperatures, while dust reduces the

output level of reflectors, especially of the CSP system. However, the addition of cooling and washing systems could solve these problems (Baras et al., 2012). In summary, renewable energy development faces various challenges, such as technological issues, the high initial cost of renewable energy projects, low efficiency, and a shortage of funding. On the other hand, investment in renewable energy is an effective policy for generating more jobs for the local community and promoting domestic economic activities. Additionally, the use of renewable energy, even if only partially, should help reduce the level of pollution and increase the level of environmental quality.

3. Renewable Energy Sources

The types of renewable energy sources handled by this research are solar energy (Photovoltaic [PV], and Concentrated Solar Power [CSP]) and wind energy. This research focuses on these sources because it seems that they are more suitable for Saudi Arabia's weather and geography. As discussed, solar energy has two essential types: Photovoltaic (PV) and Concentrated Solar Power (CSP). Solar photovoltaic (PV) technology is the dominant technology for generating renewable energy because it is very efficient and easy to install. The other kind of technology, such as CSP is excellent on a large scale for producing electricity in cities. CSP technology could be used for desalination as well as for generating electricity on a big scale. Wind technology is also considered as a cheap source of renewable energy worldwide.

3.1 Solar Energy

The Middle East region receives around 3,000-3,500 hours of sunshine per year, with over 2500 kWh/m2 of solar energy per day (El-sebaii et al., 2010). Saudi Arabia has additional potential for investment in solar energy because it has the Empty Quarter, which can hostsolar arrays, and clean sand, which can be used to manufacture silicon PV cells and mirrors (Aksakal & Rehamn, 2009). Solar PV technology uses semiconductor materials to convert solar energy directly into electricity. Besides, solar PV can be used in small-scale projects, and it does not require a large area. Saudi Arabia could use solar PV technology in remote areas because these small villages need a limited amount of electricity, such as for water pumps and lighting. In addition, solar PV energy can be used for road lights, road instruction signals, tunnel lighting, and traffic lights. Concentrating Solar Power systems (CSPs) technology uses mirrors to concentrate solar energy by 50 to 10,000 times. This heat creates steam for moving turbines and generating electricity. The CSP requires many laborers (especially during construction) and machinery due to an increased demand for glass, iron, and other materials (Asplund, 2008).

3.2 Wind Energy

Wind energy is expected to be the dominant source of renewable energy because it has a faster growth rate compared to other types of renewable energy souces. The main advantages of wind energy are clean and less polluting. Some negative effects on the environment of using wind energy are killing some birds and destructing some forest (Iskander, 2015). Saudi Arabia has many attractive areas for producing wind energy, particularly around the Arabian Gulf and the Red Sea coastline zones.

4. The Contribution of Saudi Energy Efficiency and Renewable Energy to Saudi Arabia (GDP, Labor Market, and Value Added)

The Saudi economy would gain many benefits from increasing domestic investment in renewable energy. These new renewable energy investments expected to augment the domestic economic growth. Investment in renewable energy predict to enhance significantly various sectors of the economy, such as construction, services, and research and development (R&D). This paper estimates and calculates the contribution of investment in Saudi renewable energy to the Saudi economic activities, value-added and the labor market by using Leontief's input-output model (Chemingui & Lofgren, 2004; Al-Hawwas, 2010). As long as the renewable energy sector has higher value-added activities and uses input materials from most economic sectors, investment in renewable energy should generate more expansion on a big list of domestic economic activities due to new investments in renewable energy. Any expansion on a domestic production system shall increase the demand for laborers. In 2019, the International Renewable Energy Agency (IRENA) estimated the number of (direct and indirect) jobs in renewable energy worldwide during the period between 2017 and 2018. There were approximately more than 10.3 million jobs in renewable energy worldwide in 2013 and 11.0 million in 2018. According to IRENA, the higher number of renewable energy jobs can be found in Germany, China, Brazil, India, the United States, and Japan. There is a wide range of occupation in renewable energy, such as engineering, marketing, retail, administration, and customer service. Jobs in renewable energy could be classified into different fields such as research and development, manufacturing and distribution; project development; construction and installation; and operation and maintenance (Sastreas et al., 2010).

5. Methodology

The main purpose of using Leontief input-output model as a methodology for this research is to study the contribution of investment in renewable energy to the other sectors of production. A macroeconomic input-output model is a quantitative tool for calculating the rate of growth resulting from increased investment in renewable energy (Pestel, 2014). The input-output model has a high capability of capturing the flow of goods and services between different sectors of production. Furthermore, this model captures the flow stream of goods and services in the economy as a whole. The purpose of calculating this new expansion in the production system is to estimate the further additional increase in demand for goods, services, and labor due to the flow of investment in renewable energy. The input-output model traces economic activities as a process of interrelations among different sectors of production and the final demand entities. Thus, the input-output model considers the circulation of inputs of raw materials (or services) and outputs of finished or semi-finished goods (or services) among different sectors of production and the final demand sector. Overall, the Leontief approach has the ability to calculate the tradeoff coefficient between different domestic entities of production and the final demand (government, investors, household consumption and trade) (Miller, 2009).

The sizes of interchangeability between the production sectors depend on the tradeoff coefficient between domestic entities of production and the final demand (government, investors, household consumption and trade) (Miller, 1998). The tradeoff coefficient means the distribution of sector A output to other sectors of production, which could be read as aij/ai. According to table (3) Saudi Arabia 'A' matrix input-output, the tradeoff coefficient of Agriculture Act (1) to Construction Act (7) is around ab/aa = 0.32, or 32 percent of Agriculture production consumed directly by Construction sector. Any investment increase in sector Act (7) would result in a new expansion of the production of Agriculture sector Act (1). This increase in production of Act (7) would increase the demand on all inputs. In our example, the demand increase from Act (7) will be distributed to other sectors of production in the existing economic system; one of them is increasing the demand on Act (1) outputs.

According to Miller and Blair (2009), Leontief's input-output model can simulate the forward and backward connections between the domestic production sectors and the final demand sectors. It is a backward and forward movement that any expansion in sector B would push forward the demand on the other sectors of production and import. Some output of sector B is input to other sectors of production such as A, C, D, which there demand on the other sector of production would increase as a backward effect. In the end, the whole system of production shall expand because of expanding investment in B. The Leontief model is eligible for calculating this kind of dynamic movement in the model. These calculations are intended to help us estimate the amount of expansion in the economic system due to increasing investment in renewables.

The main purpose of using this particular methodology is to study the contribution of investment in renewable energy to the other sectors of production. As long as the renewable energy sector has a high level of diversification, investment in renewable energy should generate more expansion on a big list of domestic economic activities due to new investments in renewable energy. Any expansion on a domestic production system shall increase the demand for laborers and the volume of value added (gross domestic product (GDP)).

The Leontief table divides the national economy into n+1 sectors, which can be grouped into two major categories; one is the producing sector, and the other is the final demand sector, which can be further divided into sub-groups (government spending, household consumption, investment and net exports). Hence, the total output of any sector of production will either be in the form of an intermediate input to both itself and the other sectors of production or it will go to the final demand sector, which consumes the rest of these outputs. Therefore, the total goods and services produced by a particular production sector should be consumed by the n sectors of production and the n+1 sector (the final demand sector). In short, the input-output model reveals the flow of goods and services among all economic production sectors and the consuming sector (which is further sub-divided into the final components of expenditure GDP) over a period of time, usually one year. The Saudi input-output table is divided into three essential sectors (domestic consumption sector, value-added sector, final uses) as it appears in figure (1).

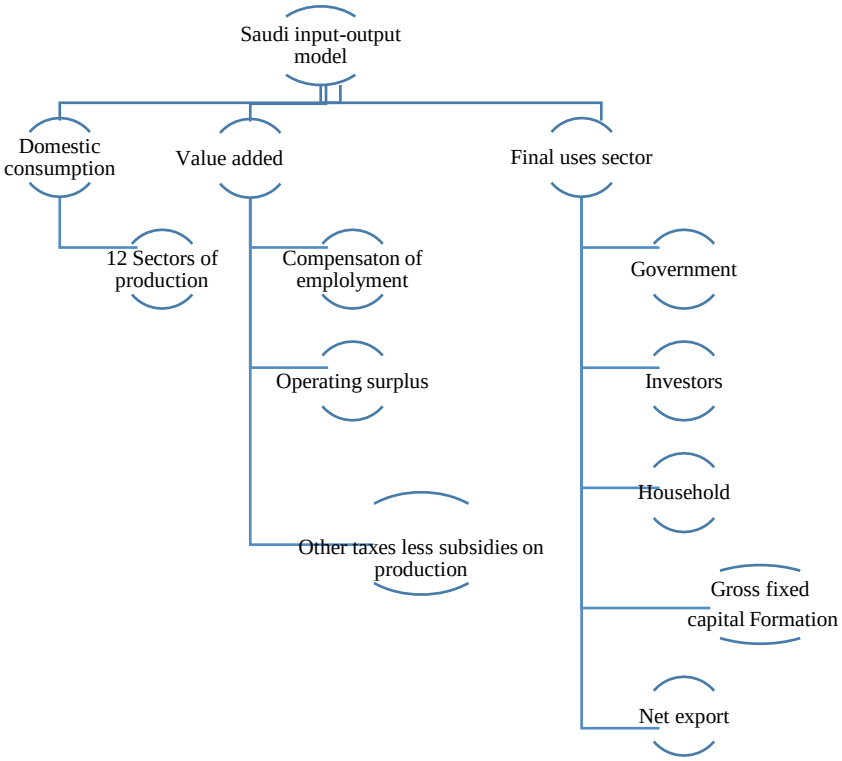

Figure 1. The Saudi Arabian input-output elements (Note 1)

Source: General Authority of Statistic (GSTAT, 2015).

Table 1 provides a snapshot of the Saudi input-output table (2015). Table 1 contains three areas; area number (1) contains information about trade between the sectors of production (in value "Billions of SR"). Area (1)'s columns represent the supply side, for instance, the total output of the agriculture sector that is consumed by the agriculture sector, manufacturing and wholesale and retail trade. The other side of the matrix is the raw side, which includes the total demand of each sector of production. Area (2) contains the final government and household consumption of the three sectors of production. Area (3) includes the value added by each sector of production. The primary data were collected from different sources, including the Organization for Economic Co-operation and Development (OECD), the General Authority for Statistics (GSTAT), and the Saudi Arabian Monetary Authority (SAMA). In addition, some information obtained from the Saudi National Transportation Plan (NTP 2020), Saudi Vision (Vision 2030), and any announcement by the Public Investment Fund (PIF). This research used the Leontief's I-O model as a quantitative method for calculating the expected economic growth from new investments in renewable energy at Saudi Arabia (Al Yousif & Albaker, 2017).

Table 1. The Saudi Arabian input-output table (2015)

GDP Activities (Billions of SR)	Agriculture	Manufacturing	Wholesale & Retail trade, Restaurants & Hotels	Final consumption expenditure by government	Final consumption expenditure by households
Agriculture	7.928	880	5.548	2.142	39.097
Manufacturing	9.631	19.404	141.391	1.355	377.167
Wholesale & Retail trade, Restaurants & Hotels	1.122	4.952	14.178	0	71.848
Compensation of employment	8.502	45.195	55.423		
Operating surplus	60.404	202.153	212.346		

Source: General Authority of Statistic (GSTAT, 2015).

Table 2 evaluates trade-offs among different entities of production. For instance, the amount of output from entity ACT1 goes to entity ACT2 and vice versa in billions of SR. Table 2 rows include the distributions of output between different sectors of production and table 2 columns include the distributions of output to all

sectors of production. Table 2 below explains the total flow of goods and services between different sectors of production and the summation of the total amount of input and output between all sectors has to be zero.

Table 2. Saudi Arabia input and output table for 2015 (Note 2)

Sectors (Millions of SR)	Act(1)	Act(2)	Act(3)	Act(4)	ACT(5)	ACT(6)	ACT(7)	ACT(8)	ACT(9)	ACT(10)	ACT(11)	ACT(12)
Agriculture, Forests and Fishing	7,928.44	-	879.76	-	2,945.79	66,593.89	-	5,548.10	-	4,728.94	-	2,679.10
Crude petroleum and Natural gas extraction	-	-	1,083.72	320.73	39,103.75	44,389.04	4,102.07	9,906.40	-	3,109.79	-	-
Other mining	-	-	-	-	-	14,104.74	1,214.78	11,383.76	-	-	-	-
Petroleum refining	4,068.56	1,500.01	812.03	787.38	6,309.68	37,565.30	8,486.82	13,794.84	7,521.18	31,963.72	1,306.22	2,257.73
Other Manufacturing	9,631.16	1,427.76	3,560.46	1,836.97	19,403.80	89,152.27	10,118.58	141,391.47	27,260.98	42,758.07	6,775.50	14,301.90
Electricity, Gas, and Water	902.54	147.45	375.83	174.93	2,399.76	15,026.12	1,009.46	6,086.17	9,129.61	4,934.21	1,304.35	2,705.04
Construction	1,210.68	280.06	846.97	425.92	8,580.69	31,272.74	3,256.62	22,591.14	11,498.54	14,770.98	2,324.58	7,598.37
Wholesale and Retail trade	1,122.24	103.54	565.66	181.50	4,951.95	17,981.01	2,483.10	14,178.27	7,358.96	7,523.20	1,090.83	2,143.26
Restaurants and Hotels, transport, Storage, and Communication	628.08	461.88	1,087.75	1,152.43	9,013.98	13,172.65	2,401.64	18,652.42	36,272.70	18,191.89	1,587.14	2,693.10
Financial, Insurance, Real estate, and Business services, Ownership of dwellings (Imputed rent)	1,365.90	364.04	553.56	311.57	6,338.67	22,964.42	2,928.46	18,206.00	26,762.40	10,140.72	6,701.92	6,199.23
community, social, and personal services	1,189.71	250.06	483.59	234.32	4,589.29	16,065.55	1,545.50	5,406.75	6,246.36	5,136.39	872.83	1,747.41
Producers of government services	372.47	64.90	264.84	110.20	2,559.34	7,365.29	879.19	4,219.70	2,089.91	2,482.41	409.63	759.15

Source: General Authority of Statistic (GSTAT, 2015) & Author estimations.

Table 3 calculates the 'A' matrix as ($a_{ij} = X_{ij}/X_j$). 'A' matrix calculates the input coefficients between all production sectors. Let us say that X_2 consumes 10% of the total production of X_1, and a_{12} is the share of X_1 used as input to X_2. In short, table 3 provides the distribution of output by one sector of production among all other sectors of production. The next step in the Leontief I-O methodology is the identity matrix (see Table 4). This step is vital for calculating Leontief's inverse matrix. This matrix is used to calculate the next table (Table 5), which is the (I-A) matrix. Table 5 has one condition, which is that diagonal values are positive, and off-diagonal values are negative.

Table 3. Saudi Arabia 'A' matrix input and output table

Sectors	Act(1)	Act(2)	Act(3)	Act(4)	ACT(5)	ACT(6)	ACT(7)	ACT(8)	ACT(9)	ACT(10)	ACT(11)	ACT(12)
Agriculture, Forests and Fishing	5.99%	0.00%	3.75%	0.00%	0.20%	65.86%	0.00%	9.32%	0.00%	1.44%	0.00%	0.76%
Crude petroleum and Natural gas extraction	0.00%	0.00%	4.62%	0.15%	2.64%	43.90%	1.08%	16.64%	0.00%	0.95%	0.00%	0.00%
Other mining	0.00%	0.00%	0.00%	0.00%	0.00%	13.95%	0.32%	19.12%	0.00%	0.00%	0.00%	0.00%
Petroleum refining	3.08%	0.25%	3.46%	0.38%	0.43%	37.15%	2.24%	23.17%	4.10%	9.77%	0.32%	0.64%
Other Manufacturing	7.28%	0.24%	15.17%	0.89%	1.31%	88.17%	2.67%	237.48%	14.86%	13.06%	1.66%	4.07%
Electricity, Gas, and Water	0.68%	0.02%	1.60%	0.08%	0.16%	14.86%	0.27%	10.22%	4.98%	1.51%	0.32%	0.77%
Construction	0.92%	0.05%	3.61%	0.21%	0.58%	30.93%	0.86%	37.94%	6.27%	4.51%	0.57%	2.16%
Wholesale and Retail trade	0.85%	0.02%	2.41%	0.09%	0.33%	17.78%	0.66%	23.81%	4.01%	2.30%	0.27%	0.61%
Restaurants and Hotels, transport, Storage, and Communication	0.47%	0.08%	4.63%	0.56%	0.61%	13.03%	0.63%	31.33%	19.78%	5.56%	0.39%	0.77%
Financial, Insurance, Real estate, and Business services, Ownership of dwellings (Imputed rent)	1.03%	0.06%	2.36%	0.15%	0.43%	22.71%	0.77%	30.58%	14.59%	3.10%	1.64%	1.76%
community, social, and personal services	0.90%	0.04%	2.06%	0.11%	0.31%	15.89%	0.41%	9.08%	3.41%	1.57%	0.21%	0.50%
Producers of government services	0.28%	0.01%	1.13%	0.05%	0.17%	7.28%	0.23%	7.09%	1.14%	0.76%	0.10%	0.22%

Source: General Authority of Statistic (GSTAT, 2015) & Author estimations.

Table 4. Saudi Arabia identical matrix table

Sectors	Act(1)	Act(2)	Act(3)	Act(4)	ACT(5)	ACT(6)	ACT(7)	ACT(8)	ACT(9)	ACT(10)	ACT(11)	ACT(12)
Agriculture, Forests and Fishing	1	0	0	0	0	0	0	0	0	0	0	0
Crude petroleum and Natural gas extraction	0	1	0	0	0	0	0	0	0	0	0	0
Other mining	0	0	1	0	0	0	0	0	0	0	0	0
Petroleum refining	0	0	0	1	0	0	0	0	0	0	0	0
Other Manufacturing	0	0	0	0	1	0	0	0	0	0	0	0
Electricity, Gas, and Water	0	0	0	0	0	1	0	0	0	0	0	0
Construction	0	0	0	0	0	0	1	0	0	0	0	0
Wholesale and Retail trade	0	0	0	0	0	0	0	1	0	0	0	0
Restaurants and Hotels, transport, Storage, and Communication	0	0	0	0	0	0	0	0	1	0	0	0
Financial, Insurance, Real estate, and Business Services, Ownership of dwellings (Imputed rent)	0	0	0	0	0	0	0	0	0	1	0	0
community, social, and personal services	0	0	0	0	0	0	0	0	0	0	1	0
Producers of government services	0	0	0	0	0	0	0	0	0	0	0	1

Source: Author estimations.

Table 5. Saudi Arabia (I-A) matrix input and output table

Sectors	Act(1)	Act(2)	Act(3)	Act(4)	ACT(5)	ACT(6)	ACT(7)	ACT(8)	ACT(9)	ACT(10)	ACT(11)	ACT(12)
Agriculture, Forests and Fishing	0.94	0.00	-0.04	0.00	0.00	-0.66	0.00	-0.09	0.00	-0.01	0.00	-0.01
Crude petroleum and Natural gas extraction	0.00	1.00	-0.05	0.00	-0.03	-0.44	-0.01	-0.17	0.00	-0.01	0.00	0.00
Other mining	0.00	0.00	1.00	0.00	0.00	-0.14	0.00	-0.19	0.00	0.00	0.00	0.00
Petroleum refining	-0.03	0.00	-0.03	1.00	0.00	-0.37	-0.02	-0.23	-0.04	-0.10	0.00	-0.01
Other Manufacturing	-0.07	0.00	-0.15	-0.01	0.99	-0.88	-0.03	-2.37	-0.15	-0.13	-0.02	-0.04
Electricity, Gas, and Water	-0.01	0.00	-0.02	0.00	0.00	0.85	0.00	-0.10	-0.05	-0.02	0.00	-0.01
Construction	-0.01	0.00	-0.04	0.00	-0.01	-0.31	0.99	-0.38	-0.06	-0.05	-0.01	-0.02
Wholesale and Retail trade	-0.01	0.00	-0.02	0.00	0.00	-0.18	-0.01	0.76	-0.04	-0.02	0.00	-0.01
Restaurants and Hotels, transport, Storage, and Communication	0.00	0.00	-0.05	-0.01	-0.01	-0.13	-0.01	-0.31	0.80	-0.06	0.00	-0.01
Financial, Insurance, Real estate, and Business services, Ownership of dwellings (Imputed rent)	-0.01	0.00	-0.02	0.00	0.00	-0.23	-0.01	-0.31	-0.15	0.97	-0.02	-0.02
community, social, and personal services	-0.01	0.00	-0.02	0.00	0.00	-0.16	0.00	-0.09	-0.03	-0.02	1.00	0.00
Producers of government services	0.00	0.00	-0.01	0.00	0.00	-0.07	0.00	-0.07	-0.01	-0.01	0.00	1.00

Source: Author estimations.

Table 6 shows the inverse matrix $(I\text{-}A)^{-1}$. The inverse matrix calculates coefficient vectors among different sectors of production. Agriculture and utility made the lowest contribution to the total Saudi output. Their coefficients with other sectors of production are very small compared to mining, quarrying, and manufacturing. Table 7 is the value added table. This table explains the gross domestic product (GDP). The value added table presents the total value resulting from the domestic production sector for a year. Table 7 also includes the compensation of employees, other taxes less subsidies on production and operating surplus. As is clear from this table, the manufacturing and construction sectors make a significant contribution to the total value added in the Saudi economy, as these sectors are highly labor-intensive.

Table 6. Leontief Inverse Matrix (I-A)-1 of Saudi Arabia for 2015

Sectors	Act(1)	Act(2)	Act(3)	Act(4)	ACT(5)	ACT(6)	ACT(7)	ACT(8)	ACT(9)	ACT(10)	ACT(11)	ACT(12)
Agriculture, Forests and Fishing	1.08	0.00	0.07	0.00	0.01	0.96	0.01	0.36	0.09	0.05	0.01	0.02
Crude petroleum and Natural gas extraction	0.01	1.00	0.08	0.00	0.03	0.71	0.02	0.49	0.08	0.04	0.01	0.01
Other mining	0.01	0.00	1.01	0.00	0.00	0.25	0.01	0.32	0.04	0.01	0.00	0.00
Petroleum Refining	0.05	0.00	0.08	1.01	0.01	0.70	0.03	0.59	0.15	0.14	0.01	0.02
Other Manufacturing	0.14	0.00	0.34	0.02	1.04	2.32	0.07	4.08	0.61	0.32	0.04	0.10
Electricity, Gas, and Water	0.01	0.00	0.03	0.00	0.00	1.28	0.01	0.25	0.10	0.03	0.01	0.01
Construction	0.02	0.00	0.08	0.00	0.01	0.63	1.02	0.76	0.18	0.09	0.01	0.04
Wholesale and Retail Trade	0.02	0.00	0.05	0.00	0.01	0.37	0.01	1.47	0.11	0.05	0.01	0.01
Restaurants and Hotels, transport, Storage, and Communication	0.02	0.00	0.09	0.01	0.01	0.44	0.02	0.73	1.33	0.10	0.01	0.02
Financial, Insurance, Real estate, and Business Services, Ownership of Dwellings (Imputed Rent)	0.02	0.00	0.07	0.00	0.01	0.52	0.02	0.68	0.27	1.07	0.02	0.03
community, social, and personal services	0.02	0.00	0.04	0.00	0.01	0.29	0.01	0.24	0.08	0.03	1.00	0.01
Producers of government services	0.01	0.00	0.02	0.00	0.00	0.14	0.00	0.15	0.03	0.02	0.00	1.00

Source: Author estimations.

Table 7. Saudi Arabia value added table for 2015

Sectors (Million SR)	Act(1)	Act(2)	Act(3)	Act(4)	ACT(5)	ACT(6)	ACT(7)	ACT(8)	ACT(9)	ACT(10)	ACT(11)	ACT(12)
Compensation of Emplolyment	8,502	29,857	1,298	6,313	45,195	11,251	38,608	55,423	43,157	32,656	216,863	192,337
Other Taxes Less Subsidies on Production	(3,381)	-	110	-	(916)	158	1,803	5,348	4,744	1,430	1,527	-
Operating Surplus	60,404	559,200	9,894	56,609	202,153	30,375	120,104	212,346	195,271	269,651	51,883	30,775
Value Added total	65,526	589,058	11,303	62,923	246,432	41,785	160,517	273,119	243,172	303,738	270,275	223,112

Source: General Authority of Statistic (GSTAT, 2015) & Author estimations.

6. Empirical Scenarios

This research paper uses Leontief's method to estimate the impact of investment in renewable energy through three main scenarios (investment of 25, 50, and 85 billion Saudi Riyals) over 5 years (2020-2025) to reduce any expected inflation pressure and growth in remittances. These scenarios have different economic outcomes based on the amount of investment in renewable energy. The purpose of having these scenarios is to compare the cost of investment in renewable energy and its outcomes. This evaluation will provide the reader with three major pieces of information: the expected level of expansion in the domestic production system, the expected additional growth in the value added, and the estimated number of new jobs (direct and indirect).

The establishment of a new project in renewable energy will create new demand for different sectors of production. Some sectors of production are expected to expand in response to this new demand. Moreover, the impact of new investment in renewable energy was distributed among the sectors of production based on the level at which these production sectors were involved in the renewable energy sector. Also, the Saudi government should enhance the domestic producers to meet the new demand from the domestic renewable energy projects. Table 8 contains the distribution of renewable energy demand on the Saudi sectors of production (Note 3).

Table 8. The level of demand distribution of the renewable energy sectors

Sector of Production	*Level of Involvement*	*Sector of Production*	*Level of Involvement*
Constriction	Level (1)	Petroleum refining	Level (2)
Manufacturing (Note 4)	Level (1)	Restaurants and Hotels, Transport, Storage and Communication	Level (2)
Wholesale and Retail trade	Level (1)	Financial, Insurance, Real estate, and Business services	Level(2)
Agriculture and fishing	Level (3)	Crude petroleum and Natural gas	Level (3)
Other Mining	Level (3)	Utilities (Electricity, Gas, and water)	Level (3)
Community, Social, and Personal services	Level (3)	Producers of government services	Level (3)

Source: Author estimations.

From Table 9, the total value added, an additional expected growth in the gross domestic product (GDP), is estimated to be around 2.7 percent of the investment of 25 billion Saudi Riyal in renewable energy during 5 yaers. The same methodology was used to calculate the new value added resulting from the investment of 50 billion and 85 billion Saudi Riyals in renewable energy. There is an expectation that value added will increase by around 4.7 percent and 6.0 percent for an investment of 50 billion and 85 billion Saudi Riyals during the period from 2020 to 2025. Table (11), finally, shows the expected number of new jobs[5] that would be generated in all three scenarios, i.e., 44,000, 90,000, and 150,000 thousand jobs.

Table 9. The total expected additional growth in Saudi GDP by 2025

The level of Investment (billion SR)	*25*	*50*	*85*
New value added generated By investment in renwable energy	2.7	4.7	6.0

Source: Author estimations.

Table 10. The number of laborers in renewable energy by 2025

The level of Investment (billion SR)	*25*	*50*	*85*
Number of new jobs	44 thousand	90 thousand	150 thousand

Source: Author estimations.

7. Conclusion

Investment in renewable energy inside the Kingdom of Saudi Arabia has many economic benefits. The primary hypothesis of this research is "investment in renewable energy is an optimal solution for solving various kinds of problems, such as unemployment and less economic diversification." Most of renewable energy empirical research papers concluded that investment in renewable energy is a very promising solution for generating more jobs and driving economic growth. There are, additionally, numerous benefits of investment in renewable energy, including creating more jobs for Saudis, making new sources of income and reducing the domestic consumption of fossil fuel and saving more oil for export.

Overall, this research encourages the Saudi government to invest actively in the renewable energy sector and localize relevant supply chains. Some can argue that it is cheaper to import renewable energy equipment and machines from abroad, because localizing renewable energy industries could increase the cost of renewable energy. However, localizing renewable energy production could be a promising approach for creating more work opportunities for Saudi citizens through three channels (direct, indirect, and induced). Direct jobs would be mostly in project development, construction, installation and maintenance. Indirect jobs would be available in other manufacturing sectors supplying the renewable energy sector and financial sector, including the banking system, with equipment, materials and services. Employees of these new renewable energy sector projects would ultimately generate induced jobs through the new expenditures on local goods and services. This new demand will lead to an expansion in the local businesses and social activities, such as groceries, hospitals, schools and restaurants. Further research could be explored by investigating the economic benefit of solar energy or wind energy.

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Notes

Note 1. This figure built on the latest available supply and used tables for Saudi Arabia.

Note 2. This table built based on the latest update available from the General Authority of Statistics.

Note 3. There is not enough actual data for renewable energy in Saudi Arabia. Thus, this research relies on the literature to visualize the flow of renewable energy investments.

Note 4. The high renewable energy technology machines and devices are not expected to be produced locally. However, the local producers are expected to supply other requirements such as wires, cement, pipes, Aluminum, services, and others.

Note 5. According to the kingdom's ministry of energy (2019), the number of new jobs in the Saudi renewable energy sector was estimated to be around 4500 jobs as a result of SAR 5.66 billion investment in this sector.