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Structural change and sectoral interlinkages in the Saudi economy: An input–output analytical approach

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Abstract

Identifying the forces that create the structural transformation of the economic landscape of Saudi Arabia is key to developing appropriate policies and strategies. The difficulty of this task increases with the interdependencies inherent in a modern economy. To provide an understanding of the sources of structural change within the Saudi economy, an input-output analysis approach was employed. This methodological framework enabled the estimation of changes within individual sectors as well as inter-sectoral linkage changes. This analysis showed that there are considerable variations in the pattern of changes among the sectors. A firm's self-reliance in the production of intermediate goods indicates that agriculture, water supply, and health services are largely driven by internal factors. In contrast, the information and professional services sectors show changes predominantly as a result of sectoral interactions with other sectors. The input-output analysis presented the different forms or sources of input-output structural change of different Saudi economic sectors, which are important for formulating sectoral strategies. Hence, it helps to devise such policies that would empower the economy to grow robustly while minimizing the adverse effects of internal and external changes on the synergies across the sectors of the economy.

Keywords: Economic transformation, Input-output analysis, Inter-sectoral linkages, Policy implications, Saudi economic sectors, Structural change.

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1. Introduction

The Kingdom of Saudi Arabia (KSA) seems to be at a turning point in its economic reform agenda, with a strong focus on diversification policy. This is especially true if plans like 2030 are put into action, which aims to completely reduce the country's reliance on oil and improve areas that provide goods and services, like tourism, education, health care, and infrastructure. But for this to happen, we need to look more closely at the unwrapped structural changes that are slowly happening in its economic sectors. This is harder to do because of how the Saudi Arabian economy works and how economies are becoming more globalized [1-7].

Leontief [8] started input-output analysis in 1936. It gives us a way to look at these complicated issues using numbers. It shows how different areas are connected and how changes in one area's indicators can affect other areas.

That need must be for more action with the foundation economy, which is further aggravated in Saudi Arabia by the general movements in the direction of renewable sources and energy source market instability [9]. This means putting in place genuine structural reform measures to accelerate economic diversification that will lead to sustainable economic growth [1, 10, 11]. Given that markets are often out of equilibrium and the larger part of the reconstruction and modernization efforts were focused on oil and gas production, the role of other sectors in structural changes shouldn't be undervalued.

This is a good time to use input-output analysis because it gives a big picture view of the economy by showing how changes in final demand or production methods can impact the whole economy [12]. It is possible to look closely at how the structure of the Saudi economy has changed over time using this method. This information helps people make good decisions that will help the Vision 2030 goals come true.

The Gulf economy's evolution is taking place within a global picture that has not remained static, where globalization is making all economies more interconnected, and the dislocation of one economy impacts others [13]. Because of this, it is important to figure out what economic factors have caused the change in Saudi Arabia's economic structure. These factors could be new scientific discoveries, changes in international economic trends, or changes in Saudi Arabia's own economic policy. This will help people come up with long-term solutions that will ensure growth. Recent research has utilized input-output methodology for analysis of various economies to notice the changes taking place in them, but there is hardly any study that has focused on the Saudi economy [2, 14]. The study will examine where structural change in the Saudi economy began and how both economic conditions affected it.

While analyzing the Saudi economy, this research adds to the existing literature on structural change and economic diversification, which could be applied to any oil-exporting country at the time of transformation. Furthermore, it contributes to the technique by employing input-output analysis in a particular economic and geopolitical setting, which helps draw some conclusions about the usefulness and flexibility of the approach in other countries. The current paper has a broader interest, aiming not just to provide an analysis of structural transformation in the Saudi economy but also to offer insights into how the patterns of these transformations, in particular, alter economic strategy and planning in the future. This is expected to enhance the strategic objectives of Vision 2030 by enabling the Kingdom to move toward a more diverse and sustainable economic model.

2. Literature Review

Input-output analysis is a crucial economic tool that graphically depicts industrial interdependence in an economy. Leontief [15] developed it in the 1930s, further refining the classical concept of supply chain links by measuring the interdependencies in goods and services production and consumption across all sectors of an economy. Matrices are used in this quantitative approach to show how the output of one sector becomes the input of another. This gives a full picture of how industries relate to each other. For example, it can be used to show how changes in one sector can affect other sectors and the economy as a whole, as well as how industry-specific shocks affect the economy and how different industries contribute to it.

Leontief's input-output analysis approach, which consists of delineating a square matrix with rows and columns representing economic branches, earned him the Nobel Prize in Economics in 1973. Economists can follow the production chains backwards by looking at the cell where row i and column j meet. This cell tells us how much output from sector I is needed as an input for sector j A more practical use of input-output analysis is that it helps policymakers figure out which areas could be used to boost economic growth or make structural changes, especially in planned economies. This approach has clarified the complexity of modern economies. The advantage of this approach lies in its ability to deconstruct economic processes into quantifiable variables, factors, and fractals of an economy's economic structure, thereby qualifying it for inclusion in the field of economic planning and forecasting. To put it another way, as economies become more connected around the world, input-output analysis is one of the most important tools for both policymakers and businesses to figure out how to position their activities in the context of their specific fields [16]. It goes beyond just analyzing production numbers to tracing the chains of economic linkages and the major parts played by the sectors.

The relationship with Leontief [8], who first mentioned this idea in the 1930s, is responsible for the importance of input-output analysis in economics research. The method gave real-world evidence of how industries are linked, which made it possible to look at the economy as a system of linked sectors in a clear and organized way [8]. Furthermore, Leontief's proposed approach was controversial because it deviated from the econometric tradition, which focused on the interaction between demand and supply forces in specific markets, and instead embraced the consideration of all economic activities as one. They say that this new way of looking at things changed the way we see how economies work and interact in a much more realistic and complex way. This, in turn, helped us better understand how economies work on a larger scale. The model garnered historical recognition through its practical application, particularly during the Second World War, when Leontief

employed it to optimize resource allocation across various US economic sectors [15]. This work illustrated the relevance of the model in the context of strategic economic planning, which was critical for the war.

Then the method became a major tool in quantitative economics, especially for the evaluation of economic policies, the prediction of industries' performance, as well as the economic environment of production activities [12].

Leontief earned the Nobel Prize in Economics in 1973 because of the contribution he made to the development and application of input-output analysis. The Nobel Committee drew attention to the fact that his model was so revolutionary that it allowed one to examine the structure and functioning of economic systems with a view to making quantitative assumptions about their behavior [17]. The award underscored the significance of this technique in the study of economies as well as in economic planning and policy. Today, input-output analysis is still an essential element in the preparation of national accounts and devising economic policies and strategies, illustrating again that Leontief's work in the field of economics came at the right time.

On the other hand, input-output analysis has proven to be useful in understanding and managing the structural economic changes that emerging and transitional economies are undergoing. Chenery and Watanabe [18] applied the input-output model to determine the patterns of industrial development and change in production patterns in the less developed countries. This study dealt with the interrelationship between the different levels of economic growth and shifting patterns of inter-industry output and demand. Emerging economies tend to be in a stage of growth where there is a shift from agriculture to industry and then later to services. Input-output analysis proves to be highly beneficial for these economic structural changes.

The model has proven useful in identifying sectors with the highest level of forward and backward linkages, offering guidance in formulating plans aimed at promoting economic progress.

The increased use of input-output analysis in developing economies has brought insights into globalization and trade liberalization policies. The 'multinationalization' of input-output models along global value chains (GVCs) has facilitated the identification of each country's contribution at various stages of production. It explains how developing domestic sectors could move up in the value chain and increase their global output share [13, 19]. In turn, the understanding of these complex relationships allows policymakers and companies to better fit into the paradigm of international trade and gain leverage in the global competitive environment. Additionally, concerns for the environment have broadened the scope of input-output analysis to determine the environmental consequences of increasing national income. Researchers have been able to show how industrial activities harm the environment and identify the limits of how to generate profit by examining both economic and ecological factors together [20]. This dual approach has been instrumental in assisting emerging economies in complementing their economic development objectives with eco-efficient and green growth strategies. In this context, input-output analysis combines the needs of the economy with the necessities of the natural environment, enabling emerging economies to formulate policies that encourage equitable, inclusive, and sustainable growth.

The oil industry has long driven Saudi Arabia's economy, accounting for most of the kingdom's exports and government revenue for many years. It is this heavy reliance on hydrocarbons that has prompted the government to undertake major economic diversification measures aimed at insulating the economy from oil price shocks [21, 22]. In the past, scholars have described the Saudi Arabian traditional economic structure as dominated by a strong public sector, where the government plays a dominant role in planning and investment. The oil boom of the 1970s funded extensive infrastructural, health and educational, and social service programs, which in turn facilitated the swift growth in the economy while transitioning the traditional economy towards a more focused modern structural shift towards industrialization. With the changing economic realities and the understanding that the oil supply is limited, Saudi Arabia has pursued several economic development strategies to expand their economy. These have included attempting to establish other oil-related industries, such as petrochemicals, and encouraging foreign investments in economic cities and other special economic zones. In an effort to balance the Saudi economy, the Saudi government has also provided social and economic services like education, health, tourism, and information technology [23].

The most ambitious of these initiatives, Vision 2030, made its debut in 2016. Vision 2030 is a comprehensive strategy that outlines the objectives of financial economy-generating activities while also fostering the development of various public services, including healthcare, education, construction, sports, and tourism. This vision aims to open some government-owned sectors, establish a vibrant employment sector, and develop the factors necessary for the maintenance of continuous economic growth. We further anticipate that these initiatives will position the Kingdom of Saudi Arabia as a global investment magnet and a central hub connecting Asia, Europe, and Africa [23].

Crown Saudi Arabia presented the Vision 2030 program in 2016 and has since made it clear that one of its objectives is to lessen Saudi Arabia's reliance on oil and shift towards developing other sectors that include health, tourism, recreation, education, and infrastructure [23]. The plan further acknowledges the oil crisis even as it integrates the burgeoning young population into the country's economy. To realize this vision, we must achieve economic growth, decentralize public service delivery through privatization and alliances, develop non-oil industries, and stimulate the private sector to create jobs.

The Public Investment Fund (PIF), responsible for diversifying investments beyond oil and positioning Saudi Arabia as a global investment hub, plays a crucial role in implementing Vision 2030. The Vision includes more progressive economic reforms that aim to completely change the economic structure of Saudi Arabia.

Saudis want to change both their economy and society in order to bring in new ideas and investments from around the world so that they can carry out their diversification policy [2, 23-25]. The investments in NEOM, a cross-border planned city in Saudi Tabuk Province, aim to bolster the emerging economies through futuristic endeavors in technology, advanced manufacturing, tourism, and other related industries.

Vision 2030 aims to significantly transform both the Saudi Arabian economy and the labor market. The essence is to build a robust economic system that is less vulnerable to changes in global oil prices and has the potential to grow over the

years The economy is changing because capital markets are getting stronger, fiscal policies are being put in place to get money from sources other than oil, and laws and rules are being changed to make it easier for businesses and investors to do business. Willner [26] expects such extensive reforms to reposition the Kingdom among the world's most competitive countries, diversify the investment portfolio, increase the participation of the private economy, and augment the volume of exports.

Since its discovery in the 1930s, the petroleum industry has consistently been the backbone of the Saudi economy, earning the highest revenues and serving as the center of economic activity. This is why I wholeheartedly concur with your assertion that the oil industry has exerted significant influence over the economics of the Saudi state. The Kingdom's oil exports have consistently provided the country with significant leverage in the international arena, which is why Alkhathlan and Javid [27] assert that the expansion of state-sponsored development projects was made possible. In this instance, the abundance of resources created a rentier state, where the majority of maintenance expenses relied solely on the oil industry's revenue, resulting in reduced tax obligations for citizens and other sectors. Due to this plentiful and relatively inexpensive source of revenue, the country has historically overlooked economic diversification, leading to a structural inertia that continues to center a significant portion of the economy on oil. Being dependent on oil has some negatives, primarily being the dependency on the price of oil, which should not fluctuate greatly, lest there be a lot of uncertainty in the economy. The global recession has highlighted the risks of excessive reliance on the oil market, as its collapse can significantly impact the economy. Alkhathlan and Javid [27] highlight the worrying vulnerability of the economy, asserting that diversifying it would eliminate this concern.

Programs like Vision 2030, which aim to reduce reliance on oil and develop other areas of the economy, represent the first steps the Saudi government has taken toward economic diversification. Conversely, it is important to acknowledge that policies, social reengineering, and investment strategies must adapt when economic activities shift away from oil. In addition, there are causal relationships between the oil industry and other variables, such as the labor market in Saudi Arabia.

The oil-based economy has also led to a high influx of expatriates, resulting in retarded development of the private sector outside of oil and petrochemicals and overreliance on foreign labor This has further exacerbated the educational disparity by undervaluing sectors unrelated to oil [23]. As a result, the government is making every effort to assist individuals in acquiring a broader range of skills and competencies that can enhance the economy and integrate the expanding workforce into sectors beyond oil, particularly in light of Vision 2030's aim to enhance the influence of the private sector [23].

The oil sector primarily controls the structure of the Saudi economy, necessitating modifications to the input-output analysis approach. In this respect, Soytas and Havrlant [28] have been useful by developing a comprehensive set of input and output tables for the Saudi economy, which incorporates oil and its related industries. Their work has also taken into account the Saudi economy's low level of diversification and its high level of government control. This allowed them to analyze how changes in the oil sector affected other economic sectors, enabling them to capture essential features of the Saudi economy. The examined methodology encompassed the effects of subsidies and government services, along with imports and exports, providing a comprehensive understanding of the country's economic circulation.

Incorporating Saudi Arabia into the framework of input-output analysis certainly comes with its own unique set of challenges, like the availability and reliability of the required data or even the definitions of the sectors. The Saudi Arabian Monetary Authority [29] and the Central Department of Statistics and Information (CDSI) provided the majority of the required economic data, but Soytas and Havrlant [28] faced the challenge of working with data that wasn't entirely suitable for input-output analysis. Because of these problems, researchers have come up with new ways to figure out how different industries are related. For example, they can estimate indices using non-survey methods, non-parametric surveys, or assumption-based modeling, which combines survey data and estimates to fill in some gaps [30].

Moreover, the Saudi government's diversification initiatives have made the Saudi input-output structure increasingly important in determining future growth plans. In Vision 2030, analyzing the Saudi input-output structure becomes crucial because it enhances. We predict how economic activity will change after sectoral changes like de-nationalization, the creation of new sectors, and changes in investment models based on what we know about how economies are connected. Input-output analysis and its econometric models can be used in these ways to help with strategic economic planning and making beneficial policies. They help us understand both the short-term and long-term effects of diversification strategies [31].

Implementing input-output analysis in Saudi Arabia or other analogous contexts bears methodological and data constraints. The most challenging aspect is ensuring the accessibility and comprehensiveness of data, which serve as sources for constructing accurate input-output tables. Hertog [32] notes that the limited generation, availability, and frequency of economic data make it challenging to obtain an updated or accurate synthesis of economic relationships. Besides, in the case of Saudi Arabia, the primary influence of the oil sector might distort the results by hiding some intricacies of inter-industry relations. To solve this problem, we need to carefully think about how to divide the data into pieces that better show how the parameters are related to each other, without putting too much emphasis on the oil share.

Another issue pertains to the structural characteristics of rentier state economies. State expenditures, which rely on the earned oil revenue harvest, have the potential to alter the absorption parameters, thereby complicating the testing of the economy's activities as a whole, Hvidt [33]. These kinds of changes could make the input-output model less consistent, which would make it harder to study how the different sectors are connected and figure out how the multiplier affects output. Massive public spending and subsidies, which are indeed part of the model but rarely properly captured and classified in the official statistics, emerge in the Saudi context.

Lastly, Vision 2030 and other reforms that have gained momentum in the Kingdom of Saudi Arabia are rapidly changing the economic fundamentals of the country. As the global economy matures in distinct areas, the Saudi economy, which is expanding and integrating into other economies, faces the risk of relying on outdated input-output structures. It's hard to do

input-output analysis that looks ahead and takes into account how the global economy is becoming more diverse because it needs not only current facts but also big ideas and assumptions about how economic policies and response strategies will change [23]. As a result, economies in transition test the limits of input-output analysis. This calls for the creation of better modeling methods that are better suited to the situation.

Previous research that utilized input-output analysis to identify any structural changes within economies demonstrates the versatility and utility of the method in many settings. One such instance is that of Dietzenbacher and Los [34], who also used the method to analyze structural changes in an economy and, as a result, were able to provide in-depth information on the changes in economies over time. These kinds of studies also record changes in production and efficiency within and across borders, as well as changes in the structure of consumption. This shows how economic growth, changes in a society's comparative advantage, or changes in trade policy can have an effect on the economy. Hasanov and Razek [3] did an empirical study in Saudi Arabia. Students can use input-output analysis to judge how well economic diversification strategies work by separating the oil and non-oil sectors to get a full picture of how they have changed over time. Additionally, input-output models have significantly influenced society's comprehension of the shifts in economies from agrarian to industrial to service-oriented. For instance, Chenery [35] account illustrates this process of transformation and offers a valuable set of descriptive information for tracking development changes. Their pioneering work thus helps set targets for income and resource policy for countries like Saudi Arabia, which are trying to transform their economies through industrialization and the expansion of the services sector, as stated in Vision 2030.

These methods are very effective in monitoring changes in resource allocation, employment practices, and the structure of industries. In Saudi Arabia, where economic reform aims to introduce aggressive structural changes, the input-output analysis can aid policymakers in identifying the interdependence between the oil sector and the rest of the economy, as well as pinpointing areas of strength or weakness. Models of this type enable Saudi economists to estimate the outcomes and quantitatively measure the effects on the economy. According to Miller and Blair [12], this type of model is crucial for planning and policy-making purposes.

3. Methodology

It was necessary to give a brief outline of this matrix because the way to break down the change in output depends on looking at the inputs and outputs, especially the Leontief inverse.

We follow the approach of the famous [36] I / O, which has the following mathematical form:

$$x = Ax + f$$

where x is the vector of gross output, f is the vector of final demand, $A = \left(a_{ij}\right)$ is the matrix of direct inputs a_{ij} into the set of n production sectors, with properties:

$$a_{ij} \geq 0, \qquad i, j = 1, 2, ..., n$$

$$\sum_{i=1}^{n} a_{ij} > 0, \quad j = 1, 2, ..., n$$

The equivalent form of the Leontief model is:

$x = \left(I - A\right)^{-1} f = Bf$ [37](Vision 2030)[37](Vision 2030)[37]

Where: i is the identity (unit) matrix, and the matrix $B = \left(I - A\right)^{-1} = \left[b_{ij}\right]$ is the Leontief inverse matrix see, [36, 38, 39].

The decomposition technique analyzes differences in two-period sectoral output into threedifferent parts. The technique is based on Sonis et al. [40], where they note that the output change $\Delta\mathbf{X}$ can be stated in the following way:

$$\begin{aligned}
\Delta\mathbf{X} &= \mathbf{B}_t\mathbf{f}_t - \mathbf{B}_0\mathbf{f}_0 \\
&= (\mathbf{B}_0 + \Delta\mathbf{B})(\mathbf{f}_0 + \Delta\mathbf{f}) - \mathbf{B}_0\mathbf{f}_0 \\
&= \mathbf{B_0}\Delta\mathbf{f} + \Delta\mathbf{B}\mathbf{f_0} + \Delta\mathbf{B}\Delta\mathbf{f} \\
&= \Delta\mathbf{X}^{\mathbf{f}} + \Delta\mathbf{X}^{\mathbf{B}} + \Delta\mathbf{X}^{\mathbf{Bf}}
\end{aligned}$$

where **X** is output, B is the usual Leontief inverse, and **f** is final demand, subscripts ‘0’ and ‘t’ denotes two time periods. The decomposition results in three different components. The first component ($\Delta\mathbf{X}^{\mathbf{f}}$) is the part of output change that is due

to changes in final demand. The second component ($\Delta \mathbf{X^B}$) pertains to the output change that is due to technological progress(i.e., due to changes in the Leontief inverse matrices), and the last part ($\Delta \mathbf{X^{Bf}}$) is the part due to synergistic interaction between final demand and technological change.

Further, the decomposition can be made to trace the output changes by determining whether they originated from the sector itself or from other sectors in the economy. The two componentsare referred to as self-generated and non-self-generated changes, respectively. For a certain sector i, self-generated changes can be obtained by using b_{ii} , f_i , and their changes through time. If $\mathbf{s}\Delta\mathbf{X}$ represents self-change of output, $\mathbf{ns}\Delta\mathbf{X}$ represents non-self-change of output, the self-change and non-self-change of each part will be:

$$\mathbf{s}\Delta\mathbf{X}_i^f = b_{ii}\Delta\mathbf{f_i} \quad ; \quad \mathbf{ns}\Delta\mathbf{X}_i^f = \Delta\mathbf{X}_i^f - \mathbf{s}\Delta\mathbf{X}_i^f$$
$$\mathbf{s}\Delta\mathbf{X}_i^B = \Delta b_{ii}\mathbf{f_i} \quad ; \quad \mathbf{ns}\Delta\mathbf{X}_i^B = \Delta\mathbf{X}_i^B - \mathbf{s}\Delta\mathbf{X}_i^B$$
$$\mathbf{s}\Delta\mathbf{X}_i^{Bf} = \Delta b_{ii}\mathbf{f}_i \quad ; \quad \mathbf{ns}\Delta\mathbf{X}_i^{Bf} = \Delta\mathbf{X}_i^{Bf} - \mathbf{s}\Delta\mathbf{X}_i^{Bf}$$

4. Data

Based on the methods and principles outlined in the United Nations [41], the General Authority for Statistics in Saudi Arabia has released input-output tables for the years 2018–2019 and 2020–2021. These tables include integrated data on economic activities, which means that they can be used to measure economic aggregates like the gross domestic product in all three ways. The 2018 and 2019 tables were used for this study's 19 sectors, including intermediate consumption, final demand for each sector, and production as a whole.

5. Results and Discussion

Before presenting the results of the input and output analysis, we try to monitor the development of changes in both total output and final demand for each sector for the years 2018 and 2021, as shown in the following table and figure:

Table 1.
Development of changes in both total output and final demand for each sector for the years 2018 and 2021.

Saudi Arabia Sectors	Total Product Change	Final Demand Changes
S1-Agriculture. forestry. and fishing	-11.85	-24.27
S2-Mining and quarrying	10.18	-47.27
S3-Manufacturing	-7.65	-9.17
S4-Electricity. gas. steam. and air conditioning supply	-7.51	9.92
S5-Water supply; sewerage. Waste management and remediation activities	-34.35	-39.55
S6-Construction	-16.1	-55.1
S7-Wholesale and retail trade; repair of motor vehicles and motorcycles	-17.29	-21.11
S8-Transportation and Storage	-1.8	14.51
S9-Accommodation and food service activities	-22.21	-32.98
S10-Information and communication	-5.57	-1.9
S11-Financial and insurance activities	-11.36	-14.95
S12-Real estate activities	-3.54	2.13
S13-Professional. scientific. and technical activities	0.79	-20.67
S14-Administrative and support service activities	-10.67	58.2
S15-Public administration and defense; compulsory social security	0.74	-2.2
S16-Education	6.41	6.45
S17-Human health and social work activities	-17.71	-21.79
S18-Arts. entertainment. and recreation	-65.18	-65.84
S19-Other service activities	-40.19	-24.55

Source: Data stats.gov.

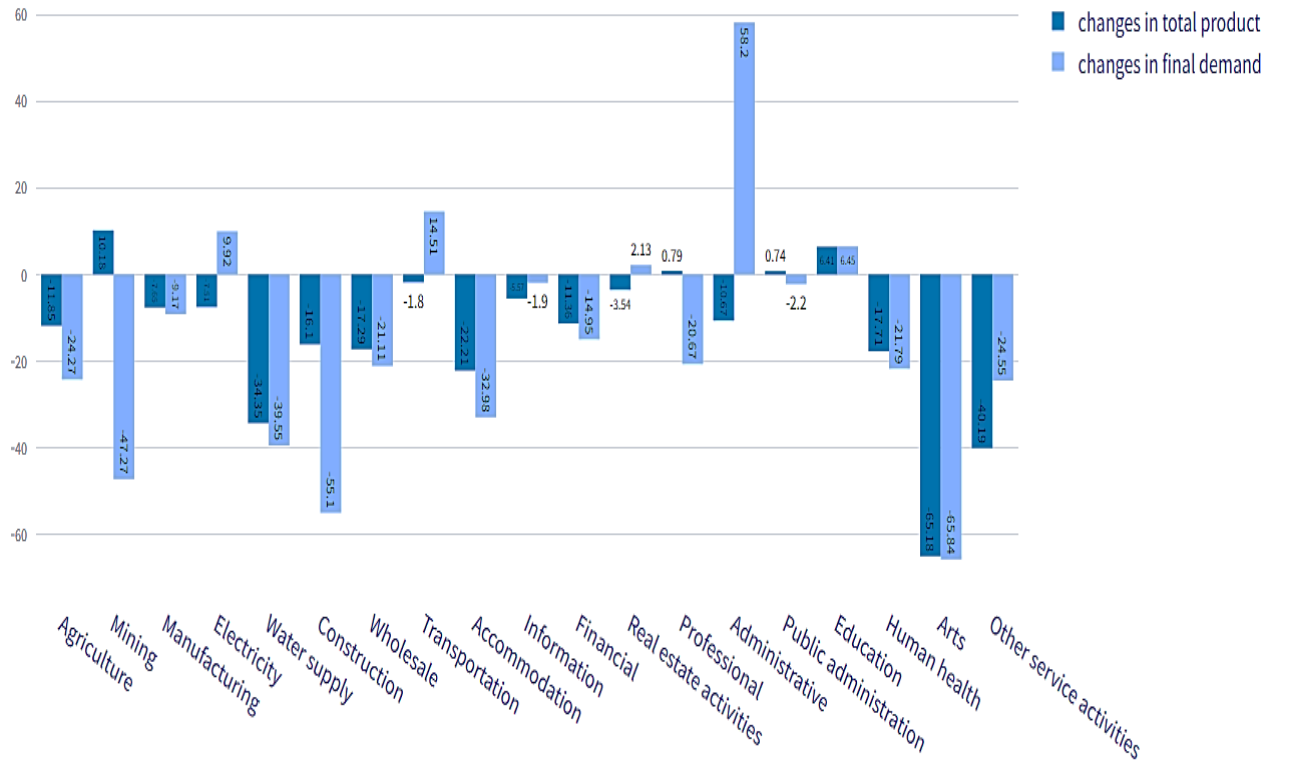

Figure 1.
Development of changes in both total output and final demand for each sector for the years 2018 and 2021.

According to Table 1 (Figure 1), there have been evident cross-sectoral shifts in the economy of Saudi Arabia between 2018 and 2021. The numbers show that almost every sector's total value of production and final demand went down. S5 (water supply and waste management), S6 (construction), S9 (accommodation and food service activities), S18 (arts, entertainment, and recreation), and S19 (other service activities) all saw especially big drops.

The most drastic reduction is seen in S18, where total output and demand, based on indicators registered in averages, decreased by 65 percent or more, probably from year to year, indicating difficult times, especially for the arts and recreation sector. In addition to that, S5 and S19 also experienced substantial decreases, which may suggest prevailing economic forces affecting or changing the focus of the country's activities during this period.

In contrast, some subsectors seemed to manage well or expand. S2 (mining and quarrying) recorded a growth in the value of the gross output, which may have resulted from strong oil and mineral markets across the world, despite end-use demand having fallen. In S8 (Transportation and Storage) and S12 (Real Estate Activities), final consumption demand went up, which suggests that the economy might be getting better or adjusting to the way things are now. Education (S16) is another area that does not conform to the general decline, as both output and demand registered slight improvements. A national policy aiming to improve schooling in line with Saudi Arabia's long-run growth pillars could have led to this. The displayed changes must therefore be as a result of multi-generational factors such as economic policy, world market conditions, and the development strategic blueprint of the respective countries, and probably the COVID-19 issue Based on the performance of many sectors over the whole period under study, the economy appears to be going through a depressive stage, which calls for the reallocation of resources and attaining conditions for recovery and growth.

Based on the data, it is evident that, with the exception of the mining and education sectors, which grew 10.18% and 6.64%, respectively, most industries experienced a decline during the year 2021 when benchmarked against 2018. It is appropriate to attribute this decline to the 2019 global pandemic and its resultant effects, which, as of this writing, still persist. This was also the case in the final approach, among the three sectors of transportation, real estate activities, and education, only these three managed to post a positive demand growth, registering 14.51%, 2.13%, and 6.54%, respectively, while the administrative sector registered an even sharper increase at 58.2%. After having established this dismal record regarding the general output and demand for nearly all industries, we suppose that this phenomenon has three fundamental origins:

- Decomposition 1: changes in final demand.
- Decomposition 2: Due to technological progress (i.e., changes in the Leontief inverse matrices).
- Decomposition 3: due to synergistic interaction between final demand and technological change.

The table below provides a detailed decomposition analysis across various sectors of the economy of Saudi Arabia, with the intention seeming to be unravelling the differential impact of various factors on each economic sector. The numbers are shown to show a change in economic activity that could be caused by policy or by outside factors, and they are broken down in three different ways. Some noticeable patterns emerge concerning the data, as follows:

- The agriculture sector (S1) has slightly rising elements in the third decomposition, which could mean that the effects are lessening or that the sector is recovering in some way.

- Of all the decompositions considered, the indices of mining and quarrying (S2), manufacturing (S3), and water supply activities (S5) show negative results, suggesting that these activities have suffered from the effects being researched for a long time.
- In the electricity, gas, and supply sectors (S4), the indices have remained poor in the first two decompositions but have improved in the third, suggesting the possibility of growth or an improvement from that scenario.
- The defense and public administration services (S15) were the only ones to truly push the limits, especially in Decomposition 1. They went down in the next phase but then back up in Decomposition 3, which means that the transformation or model dislocation that worked for that one can also work for this one.
- They significantly outperform S11 and S12, with their individual activity sectors either performing exceptionally well despite the challenges or moving in two different directions, resulting in S11 excelling in the second level of decomposition and S12 excelling in the third.
- Social and human health work services (S17) and education (S16) probably didn't have a lot of negative and positive values that stretched out. This means that they were probably subject to the variables of interest in a consistent and even way, or they may have had a weaker effect on these variables.

Table 2.
Dissecting Dynamics: A Detailed Decomposition Analysis of Sector-Specific Trends Within Saudi Arabia's Economy.

Saudi Arabia Sectors	Decomposition1	Decomposition2	Decomposition3
S1-Agriculture. forestry and fishing	-89.45	-14.35	3.8
S2-Mining and quarrying	-93.48	-8.15	1.63
S3-Manufacturing	-64.54	-39.34	3.88
S4-Electricity. gas. steam and air conditioning supply	-6.02	-102.79	8.81
S5-Water supply; sewerage. waste management and remediation activities	-101.33	0.82	0.52
S6-Construction	-46.53	-48.49	-4.99
S7-Wholesale and retail trade; repair of motor vehicles and motorcycles	-80.81	-21.92	2.73
S8-Transportation and storage	-154.87	60.89	-6.01
S9-Accommodation and food service activities	-111.27	12.45	-1.18
S10-Information and communication	46.53	-145.46	-1.07
S11-Financial and insurance activities	-258.42	157.79	0.63
S12-Real estate activities	13.73	-119.05	5.32
S13-Professional. scientific and technical activities	36.28	-143.5	7.22
S14-Administrative and support service activities	-145.4	74.46	-29.06
S15-Public administration and defense; compulsory social security	2360.13	-2536.01	75.88
S16-Education	-74.26	-28.99	3.24
S17-Human health and social work activities	-112.6	14.05	-1.45
S18-Arts. entertainment and recreation	-131.28	20.03	11.25
S19-Other service activities	-69.29	-30.99	0.28

Source: Python outputs.

Regression analysis across policy, economy, and business can benefit from the data presented in the table above. It emphasizes the need for actors like policymakers, economists, and entrepreneurs to incorporate this knowledge for future revenue management, investment management, and to identify potential turning points and shifting opportunities within the state's economy.

The data presented in the table above further explains that the primary cause that cuts across the different sectors is the low level of final demand, which, in this instance, is a result of the impact of the Corona pandemic. The other shade of blue, representing final demand changes, is quite noticeable in most sectors. Emphasizing this trend is crucial, as the pandemic's absence of demand leads to a decrease in supply.

On the other hand, some industries, particularly information and communication and real estate activities, show quite a different trend, as the main output variance is caused by technical transactions or, better yet, the advancement of technology. The negative rates of change for the second type of decomposition (decomposition 2), –145.46 and –119.05, respectively, illustrate this. This indicates that the reduction of their aggregate output is mainly due to the changes in the level of primary input factors and intermediate goods rather than changes in the level of output.

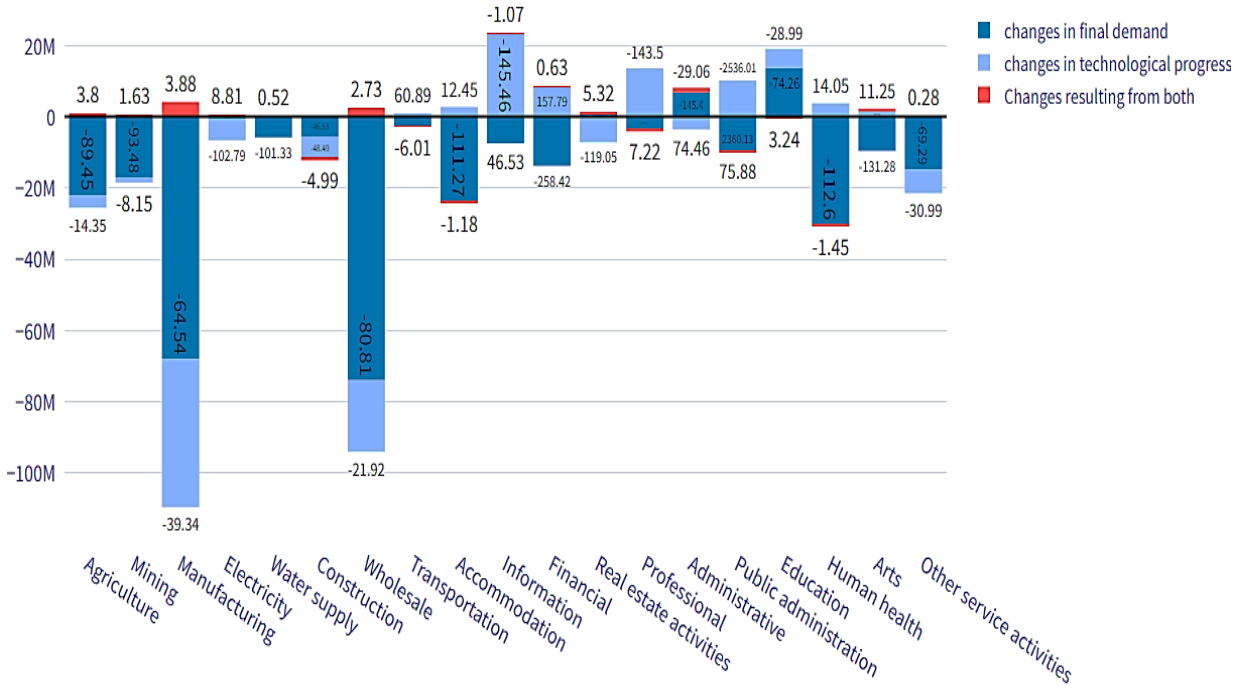

Figure 2.
Dissecting Dynamics: A Detailed Decompositional Analysis of Sector-Specific Trends Within Saudi Arabia's Economy.

Once we've looked at the three parts of structural transformation, we can now separate changes that happen within the sector from changes that happen when it interacts with other sectors. Moreover, the decomposition can also be conducted to identify particular changes in output, whether they came from within the sector or from other sectors of the economy. We refer to the two components as self-generated and non-self-generated changes, respectively.

Table 3 categorizes the factors discussed in the previous discussion into two classes: self-change and non-self-change. The table below provides the results of this division. Table 3 also suggests that there are differences with respect to sources of change in the different sectors that are either more internal or more external. Some sectors, like agriculture, water supply, education, human health, arts, and other service activities, were mostly self-sponsored change sectors because they placed a substantial reliance on their products as intermediate inputs. Most of the changes in areas like professional and information services were caused by outside areas. This meant that a lot of reliance was put on getting these intermediate inputs from outside the industry. The remaining sectors showed a combination of both internal and external sources of change.

Table 3.
Factors into two distinct groups: 'Self Decomposition ' and 'Non-Self Decomposition'.

Sectors	Self Decomposition 1	Self Decomposition 2	Self Decomposition 3	Non-Self Decomposition 1	Non-Self Decomposition 2	Non-Self Decomposition 3
Agriculture	-56.25	-13.27	2.59	-33.20	-1.08	1.21
Mining	-1.37	-0.07	0.02	-92.11	-8.08	1.60
Manufacturing	-32.79	-12.34	1.04	-31.75	-27.00	2.84
Electricity	56.67	8.27	0.91	-62.68	-111.06	7.90
Water supply	-93.90	0.83	-0.24	-7.44	-0.01	0.75
Construction	-25.15	3.09	-1.10	-21.38	-51.58	-3.89
Wholesale	-61.70	-9.47	1.65	-19.11	-12.45	1.07
Transportation	400.72	7.19	1.22	-555.59	53.70	-7.23
Accommodation	-100.43	0.64	-0.16	-10.84	11.81	-1.02
Information	8.39	-18.66	0.35	38.14	-126.80	-1.41
Financial	-169.49	14.97	-1.95	-88.93	142.81	2.58
Real estate activities	71.04	-23.82	-0.52	-57.31	-95.23	5.84
Professional	12.50	-3.54	0.61	23.78	-139.96	6.61
Administrative	-232.71	-4.68	-6.52	87.31	79.14	-22.54
Public administration	2287.83	-1040.42	22.43	72.30	-1495.59	53.45
Education	-78.56	-1.14	-0.08	4.31	-27.85	3.32
Human health	-110.19	2.32	-0.42	-2.42	11.73	-1.03
Arts	-127.48	-29.51	11.71	-3.80	49.54	-0.47
Other service activities	-63.30	1.73	-0.34	-5.99	-32.72	0.62

Source: Python outputs.

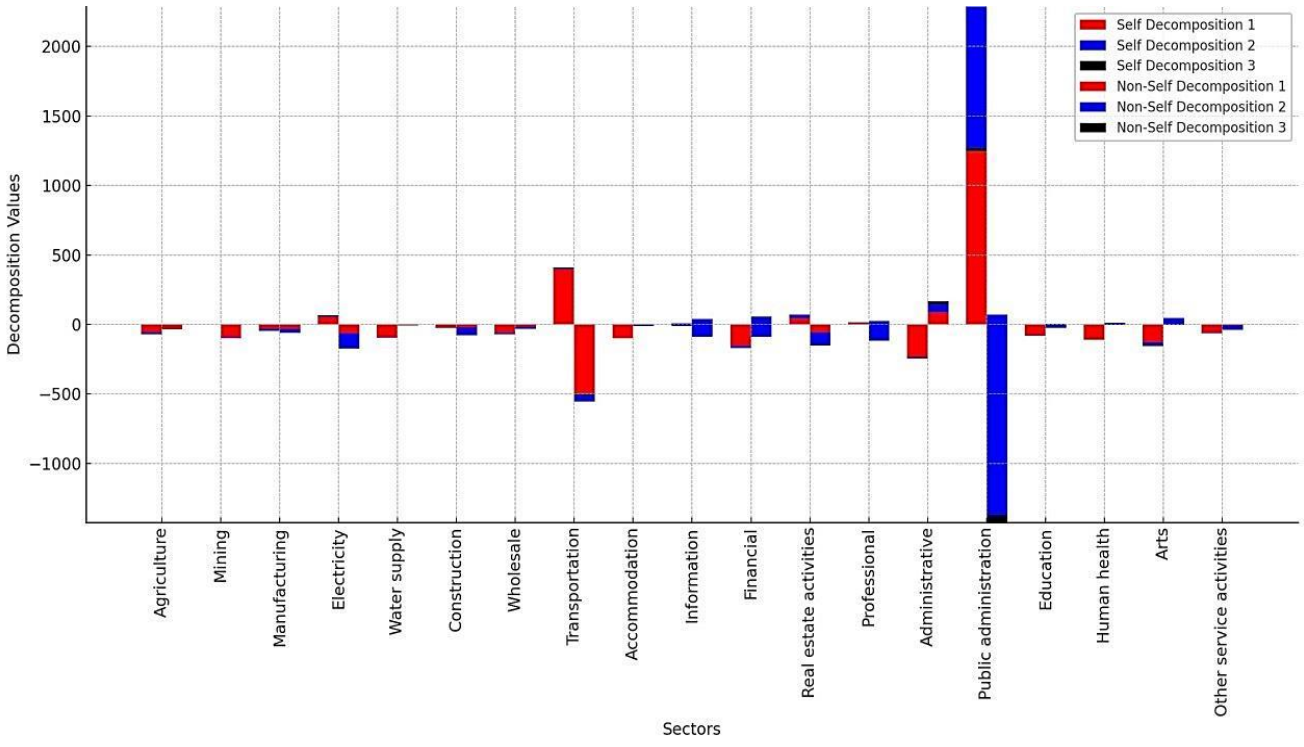

Figure 3.
Stacked bar graph of self-decomposition Vs non-self-decomposition by sector.

6. Conclusion and Implications

Examining new sectors of the Saudi economy using input-output analysis allows us to understand the potential dynamics of growth and change better. Callen et al. [42] note that such an analysis must first stress surveying the sectors that will be important for the economy. The input-output analysis also facilitates the analysis of how these sectors relate to one another as well as to the economy at large; in this case, the pertinent sectors that need nurturing are identified. Saudi Arabia's Vision 2030 program, which aims to expand the economy beyond oil, makes this approach especially pertinent. Researchers can

then use input-output analysis and forecast the sectors that are likely to become the drivers of the economic transformation, which should be useful for state officials and investors.

In the emerging sectors of Saudi Arabia, the use of input-output analysis aids in mapping the relations between different sectors. This method facilitates further sectoral analysis and forecasting about how changes in one part of the economy can affect others. For example, it will be possible to examine the likelihood of renewable energy industries being able to supplant traditional oil and gas industries, as well as the petrochemicals and manufacturing industries. This can be crucial in planning and formulating investment policies, as it enables economic agents to predict possible changes in circumstances and policies of the economy and plan and strategize accordingly.

Equally important, Callen et al. [42] show how input-output analysis can be used to locate not just new sectors but sectors that have specific capabilities with respect to increasing economic diversification and sustainability. This is particularly important for Saudi Arabia, since the country aims to reduce its reliance on the cyclical oil market and promote long-term development through creating new sectors. Emphasizing the need to avoid weak sectors, output-input approaches help in the selection of the order of investment in the areas as well as the policies to be pursued.

New phases in Saudi Arabia's economy highlight opportunities that can fuel growth and change. An input-output analysis, which examines the interrelationships of an economy's branches, can help study and forecast these impacts. The study employed this method in examining the sectors that are expected to develop in the Saudi economy and showed that there was room for diversification besides the oil economy. This provides a picture of a multidimensional economy with different economic sectors that are interdependent with respect to the economy's growth.

The study stresses the potential of the emerging sectors and their promotion in efforts to diversify the economy in Saudi Arabia. Through input-output analysis, we also explain how the renewable energy, tourism, and technology sectors can be new frontiers of growth. The analysis also helps explain the consequences of the growth of these sectors for other aspects of the economy, such as employment opportunities and the growth of industries that support them. This technique gives the policymakers an opportunity to comprehend the economic determinants for the appropriate policy concerning investment and promotion of growth.

Input-output analysis is vital in identifying and understanding the cause of the structural change in Saudi Arabian economic sectors. The study shows the possibilities that new sectors that can grow and add value to the economy have. Therefore, by focusing on these sectors, such as Saudi Arabia, which relies heavily on oil employment, the country can foster growth and establish an economy that is resilient to global economic fluctuations. This particular research shows not only the importance of input-output analysis in the context of economic planning, but it also sets the stage for other economies that want to learn and boost growth in new sectors.

Input-output analysis assists in the formulation of economic policies in any country with respect to the anticipated structural changes in the economy. Arrow et al. [43] emphasize the relevance of this analytical technique in the study of the network of intersectoral linkages in a given economy.

The input-output analysis offers the economic structure of the country in a more understandable form by tracing the interrelationship between various economic sectors and their contributions, so that economists can see the best and the worst-performing sectors that require the government's attention. This broad picture is useful for designing specific action plans to enhance the growth of the backward regions, promote new sectors, and manage the expanding economies well as a result of structural change. The conclusions obtained from input-output analysis help formulate policy interventions that are effective and efficient in the sense that they maximize the use of scarce resources in areas with high expected return outcomes.

Furthermore, Arrow et al. [43] emphasize the importance of using input-output analysis to evaluate the potential consequences of specific policies. For instance, if a policy change is simulated by modulating one sector and this effect is observed in the other sectors, the policymakers are able to know exactly how their actions would affect the economy both directly and indirectly. This capability plays a crucial role in preventing negative outcomes in most policy implementation cases. Therefore, whether implementing tariffs, providing subsidies, or building physical structures, understanding the resulting effects on other economic sectors enhances the decision-making process. In this regard, input-output analysis helps find the most important areas of the economy where policies will be implemented, measure their effectiveness, and determine their effects, making it useful for developing appropriate economic policies.

An input-output analysis can be required by policymakers when they need to design interventions controlling structural shifts in the economy. In this case, Arrow et al. [43] show how important this method of analysis is for understanding how different parts of the economy are connected in complex ways. With the help of this analysis, an economy can be understood as the distribution of flows of goods and services, pointing toward the possible impacts that certain policies may have. In this way, they not only prevent fiscal imbalances but also promote growth in policy centers and control the elements of change that might affect the system. For example, in the case of economies that are diversifying on specialization or ones that are transitioning from reliance on one sector, like oil, input-output analysis can suggest the right sectors to be developed, making it easier for the economy to transform and become more stable.

In addition to the above comments, the input-output model can aid in the formulation of policies intended to ensure the growth and stability of the economy. By pinpointing the key sectors that form the foundation of the economy, policies can be created that preserve them while still encouraging the creation of vertical and horizontal linkages. Such a strategy not only strengthens the economy against adverse conditions but also promotes a greater range of economic diversification and stability.

Because of this, the input-output analysis's broad view is also important for making economic policy, as it provides a solid rationale for making decisions that will significantly impact the future of national economies. Econometric modeling has been utilized by the government for the past few decades to implement targeted economic policies aimed at addressing

the structural changes facing economies. In this context, this type of analysis assists in estimating the potential impacts of policy measures on targeted economic sectors, thereby enhancing the decision-making process. For example, by focusing on major and interconnected sectors within the economy, policymakers can better direct investments and reforms in ways that promote industry growth and effectively manage structural changes.

This approach enables the economic or socio-economic system to pinpoint critical leverage points where policy measures would produce the greatest effect. When economies are going through rapid structural changes, this concern is especially important because it helps us address the negative effects that might occur on jobs, income, and the overall health of the economy. By examining inputs and outputs, we can formulate policies that will assist the economy in transitioning to new structures where its growth aligns with long-term goals. This confirms the necessity for careful planning before implementing economic policies and indicates where input-output analysis connects economic theory with practical policy implementation.

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