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Structural Transformation and Impact of Oil Price Change in Saudi Arabia Economy: Input-Output Structural Decomposition Analysis

التحول الهيكلي وتأثير تغير أسعار النفط في الاقتصاد السعودي: تحليل التحلل الهيكلي المدخلات والمخرجات

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كلية إدارة الأعمال، جامعة العين، العين، الإمارات العربية المتحدة

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ABSTRACT

Structural change and economic growth processes have various impacts on both the micro and macroeconomic levels. The current study aims to shed light on various aspects of sectoral changes in the Saudi Arabian economy due to oil price shocks, which have profound effects on economic growth in various sectors. This paper re-attempts to explore the various sectoral changes by using an input–output structural decomposition analysis for 2010 to 2015. The main focus is on changes in the economic structure of Saudi Arabia, which has been divided into three components –intermediate, technical, and total output – with different levels and plans. The main findings show that since 2010 there has been a remarkable change in the production process and sectoral performance. From a policy perspective, it seems that the economy has advanced fast enough and displayed changes oriented by new policies and diversification plans. Moreover, the economy may show dynamic sustainable economic development, especially with new fiscal plans. Educational development is also one of the key initiatives in Saudi Arabia to enhance economic performance with structural change.

الملخص

للتغيير الهيكلي وعملية النمو الاقتصادي تأثيرًا مختلفًا على مستوى الاقتصاد الجزئي والكلي. وتهدف الدراسة الحالية إلى تسليط الضوء على جوانب مختلفة من التغيرات القطاعية في الاقتصاد السعودي بسبب الهبوط الحاد لأسعار النفط مع تأثيرات عميقة على النمو الاقتصادي والقطاعات المختلفة. وتحاول هذه الدراسة إعادة استكشاف التغيرات القطاعية المختلفة باستخدام تحليل الانقسام الهيكلي للمدخلات والمخرجات من عام 2010 إلى عام 2015. وينصب التركيز الرئيسي على التغييرات في الهيكل الاقتصادي للمملكة العربية السعودية التي تنقسم الى ثلاثة مكونات كمخرجات وسيطة وتقنية وإجمالية بمستويات وخطط مختلفة. وتظهر النتائج الرئيسية أنه في السنوات التالية لعام 2010 حدث تغيير ملحوظ في عملية الإنتاج والأداء القطاعي. اما من ناحية السياسات، يبدو أن الاقتصاد قد تقدم بسرعة كافية إلى الأمام ، ويظهر التغيير الذي يتم توجيهه من خلال السياسات الجديدة وخطط التنويع. علاوة على ذلك ، قد يحافظ ذلك على تنمية اقتصادية مستدامة ديناميكية وخاصة وجود خطط مالية جديدة. ويعد التطوير التعليمي أحد المبادرات الرئيسية في المملكة العربية السعودية لتعزيز الأداء الاقتصادي مع التغيير الهيكلي.

1. Introduction

Structural change is a shift in the fundamental ways in which an economy functions. The expected nature of structural change dynamics is that factor inputs, such as labour and capital, continuously move from lower- to higher-productivity sectors, thus increasing productivity at an aggregate level. This process also highlights the various aspects of growth and development where technical development plays a vital role. Usually, with technical innovation, capital becomes less scarce than labour, which also results in a relative output price change.

The overall process of structural change is vital in many low- and middle-income countries, which depend on continued structural transformation as an important indicator of growth. Gabardo et al. (2017) explained the history of various dynamic aspects of incorporated economic growth and structural change processes. Some researchers in the early era have highlighted macroeconomic fluctuations based on industrial structure change, mainly Robertson (1915), Aftalion (1927), Frisch (1933), and Schumpeter (1939). Looking specifically at Schumpeter (1939), he referred to industrial structural development as industrial diversification rather than structural change. With the passage of time, especially after World War II, economic growth became the priority of many nations; therefore, growth theory occupies a central position in modern economics. In the context of the one sector exogenous model, Harrod (1939, 1948) and Domar (1947, 1948) extended the Keynesian static analysis into a long-run dynamic one. Arrow (1962) presented an endogenous model with a technical progress element and research and development (R&D) aspects. In summary, based on historical aspects, it is difficult to reveal the complex relationship between economic growth and the resulting economic structural changes (Silva & Teixeria, 2008). Moreover, determining whether economic change results in economic growth or vice versa is not straightforward, because structural change is vital as it reflects the responsiveness of any firm, sector, or region with new competitive opportunities. At times, there are implications of certain economic policies but due to the delayed sectoral response, they result in failure (Dietrich, 2010).

When any economy goes through a structural transformation, new and leading sectors are developed by generating a high level of employment and output. This large-scale change also reflects the continuous improvement of the entire infrastructure to cope with the needs of emerging industries. Freeman and Louçã (2001) illustrated the structural change process at the global level by using Kondratieff waves. Figure 1 shows that since the eighteenth-century industrial revolution and technical innovation process, there has been a dynamic structural change process displayed as high waves and ongoing fluctuations in the form of various depressions. However, with various policies and investment plans, economies always moved to be a step ahead and become more innovative. Overall, the era of technical innovation has changed economic growth patterns. In the twenty-first century, the concept of globalisation is penetrating the spheres of development. In this context, there has been a resulting change in government spending policies, human capital development, and trade perspectives. Looking at the sixth stage, from 2010–2050, globalisation will generate the highest wave of discoveries and inventions that will not only change the factor input but will also affect the inter-industry trade and demand patterns. Another justification was documented by Coccia (2018), where sources of long waves can be due to the structural change caused by wars between great powers and new technology.

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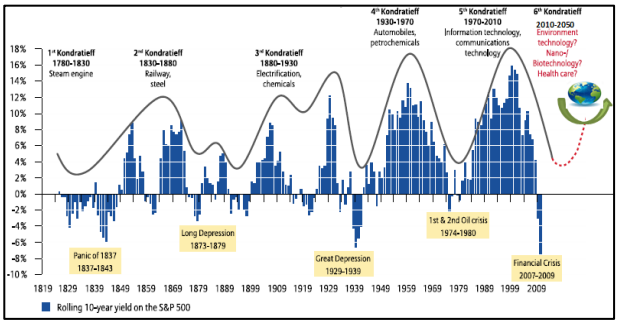
Figure 1: Kondratieff waves and the technical innovation process.
Source: Devezas (2006)



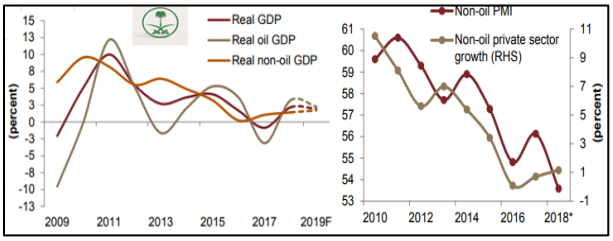
With the implementation of various structural changes and government policies, the Saudi Arabian economy is adjusting to structural change by lowering their dependence on the oil sector. Currently, the oil market has seen a lot of turmoil since the 6th of March 2020, when a meeting between the OPEC countries took place in Vienna. Saudi Arabia, as a major oil producer, announced that it was breaking its commitment with the OPEC+ alliance, which was established in 2016. The Kingdom decided to produce its maximum capacity of oil to capture the market share, but the decision was made at a time when global oil demand was already very low. Moreover, due to overproduction, the global oil price plunged by 24%, as measured by Brent, to $22.58 per barrel. This period also highlighted the vital importance of Saudi Arabia's sectoral performance in coping with economic challenges and upheavals. Being a member of the Gulf Cooperation Council (GCC), there is planning required to achieve non-oil sector economic growth and diversification. The Saudi government has various effective fiscal, stimulation, investment, and private sector participation reforms to keep the economy on track. Based on the structural change phenomenon, the current study aims to examine various perspectives, such as factor input, inter-industry, final demand, and mixed effect by using the total input cost of the economy of Saudi Arab. As explained above, effective initiatives need to strategically push to seek out new growth areas and push towards higher value-added and knowledge-based industries. Relying on decomposition techniques, we argue that dividing the aggregate change in the production proportion of the Saudi Arabian economy can locate the composition of its structural change. Furthermore, we simulate the effects of the Saudi government budget changes and various tax imposition policies. Another important aspect related to economic reforms is to enhance foreign investment and the local workforce in order to achieve high productivity. Based on different perspectives, this study aims to to analyse changes in inter-industry economic activities and structural reforms in Saudi Arabia.

The remainder of this paper is structured as follows. Section 2 explains the overview of the development process in the Saudi Arabian economy. Section 3 considers the literature review of the input–output structural decomposition analysis (SDA). Section 4 discusses the theory and the models based on the SDA input cost-side considering the changes in value-added, inter-industry, final demand, and mixed effect. Section 5 examines the results analysis for improving efficiency and highlights the source of change in economic development in Saudi Arabia. Finally, Section 6 presents the conclusions and some recommended policy implications.

2. Review of the Economic Development in Saudi Arabia

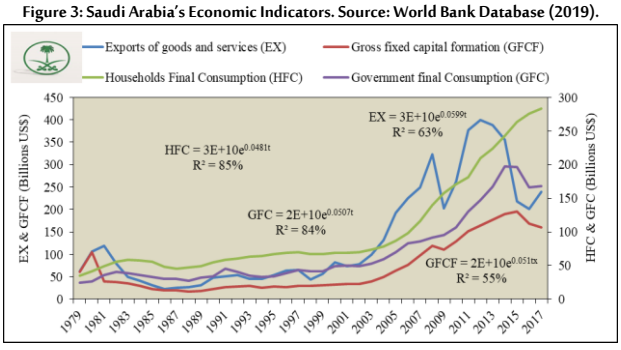
Saudi Arabia's economy is one of the top 20 in the world (G20). The country is mainly dependent on oil with the second largest petroleum reserves and a large share of global petroleum exports. In 2016, the Saudi Arabian government launched its Saudi Vision 2030 to reduce the country's dependency on oil and diversify its economic resources. Figure 2 shows that overall the GDP is maintaining solid growth, and the economy expanded by 1.6%, while the non-oil sector GDP growth rate is rising by 2.4% on a yearly basis. However, the country's growth is facing the risks of apparent lower forecasted oil prices in 2019, and the possibility of a decline in consumption in the Kingdom. It is expected that the non-oil private sector growth will improve to 1.1%, compared to 0.7% in 2017. The risks to growth, albeit diminishing, remain linked to the implementation of VAT, expat fees and levies, and energy price hikes. In fact, so far this year, business surveys – despite remaining in an expansionary mode – have hinted at some fragility. The non-oil purchasing managers' index, while having improved in recent months, averaged 53.6 in the year to September 2018, the lowest since at least 2009.

Figure 2: Saudi Arabia GDP and oil sector performance.
Source: Jawda Investment (2018).



Saudi Arabia is the 26th largest export economy in the world and its main exports consist of crude and refined petroleum, ethylene and propylene polymers, and acyclic alcohols. Exports displayed a 5.9% growth rate during 1979–2017. Another important economic indicator is the gross fixed capital formation, which refers to the net increase in physical assets – investment minus disposal – which shows a 5.1% growth rate. The household and government sectors' final consumption have shown a 4.8% and 5% growth rate, respectively. Since the imposition of the VAT, there have been various ongoing changes in household consumption; however, it has proven to be a structured economic reform by generating high revenues. Figure 3 highlights the various macroeconomic indicators, such as exports, gross fixed capital formation, and household and government final consumption. While all of these variables show a decline after 2014, they later began to rise.

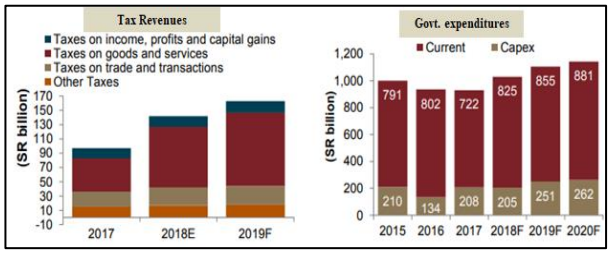
Figure 3: Saudi Arabia's Economic Indicators. Source: World Bank Database (2019).



In 2019, the Saudi Arabian budget showed a detailed upward revision, especially on the expenditure side, which partially relates to a royal decree that reinstated annual and cost of living allowances for citizens during the fiscal year of 2018 and a consolidation of revenues. The government's key objective was to balance operating expenditures with enhanced capital expenditures. These efforts, as well as a focus towards achieving sustainability and fiscal balance, will be beneficial for businesses and public policy planning. Employee compensation is still expected to constitute a substantial

level of total expenditures. Figure 4 shows that various tax impositions are generating revenues for the economy, but the highest share as forecasted for 2018–2019 comes from the VAT. In contrast, there is a substantial proportion of current expenditures reaching SR 881 billion through 2020. Capital expenditures are also increasing with the passage of time.

Figure 4: Saudi Arabia's tax revenues and government expenditures. Source: Jawda Investment (2018).



3. Literature Review

Structural change is a continuous process that results in various significant changes in production structure and economic activities. Usually, with the pace of development and changes in economic activities, it is interesting to disaggregate the contribution of various sectors in a specific economy. This can help to shape the various policies and initiatives to enhance productivity in the specific components that drive economic growth. Here, for example, if there is a change in the total gross output level of an economy, it could be segregated into changes in technical components, which can be shown as a Leontief inverse matrix, or a change in final demand. Furthermore, if we want to examine the overall change in the Leontief inverse matrix, this can be done using direct input coefficients on a sectoral basis, such as a product mix, along the same lines to capture changes in final demand or its compositions in order to reflect the overall changes. In this context, there are certain additional options for analysing structural changes, such as considering changes in employment, value-added growth, and energy use. A pioneering input–output SDA was conducted by both Rose and Casler (1996) and Dietzenbacher and Los (1998). Moreover, Skolka (1989) conducted empirical research for the Austrian economy, which Feldman et al. (1987) applied to the USA.

It is important to monitor the effects of any policy changes to analyse the relevant changes in productivity or level of output. De Souza and Gómez-Ramírez (2019) used the input–output method to analyse Mexico's integration with global production chains. There was an issue, however, as the economy failed to produce sustained output and productivity growth. Their study proposed an integrated explanation for slow growth that hinged on the negative demand externalities of input outsourcing. They concluded that outsourcing lowered domestic demand for the manufacturing sector, especially for capital-intensive basic industries. Moreover, they highlighted that the low cost of outsourcing can affect the aggregate manufacturing sector.

Some researchers have attempted to study other aspects of structural changes from the market, government policies, and technical sides. Ciarli and Valente (2016) discovered that various phases of economic growth led to a change in production and consumption patterns in an economy. Moreover, they found that large market concentration has a positive and significant impact on economic growth with high demand. Later, Zhang (2017) examined the major structural reforms in the Chinese economy due to changes in government policies to enhance citizens' quality of life. These transformation processes brought many changes to the countries' economies. Furthermore, Brondino (2018) highlighted the economic transition in China, which was based on an agricultural- to industrial-based development. He pointed out that in this period there was movement towards technical innovation and the service sector.

Emran and Shilpi (2018) provided a theoretical and empirical analysis of the role of agricultural productivity in the structural transformation of the labour market in small towns and the surrounding rural areas in Bangladesh. They mentioned that agricultural productivity growth induced structural transformation and brought changes in the demand for skilled labour. Furthermore, Compagnucci et al. (2018) found that different economic sectors specifically contributed to the productivity change in accordance with their technological and knowledge intensity. Carmignani and Mandeville (2014) discussed the element of structural transformation in the African economy. They discussed how there was a decline in the agricultural sector, while at the same time the pace of development was very low. This phenomenon is known as a resource curse, as the non-manufacturing industry mainly consisted of mining. Diao et al. (2018) demonstrated how the Tanzanian economy grew very rapidly, and that most of the productivity growth occurred by structural change as employment shares in agriculture declined, while employment shares in services and manufacturing rose.

The technical innovation process is another important factor that can enhance productivity and create structural change in an economy. Antonelli et al. (2017) identified the effects of the introduction of directed technological change on the measure of total factor productivity growth. The results confirmed that Italian economic growth improved due to technological change, with relevant effects on the actual levels of total factor productivity growth. In another study, Freire (2019) interestingly highlighted that technical innovation could lead to a diversification process in developing economies. This can also create structural changes and lead to sustainable economic growth.

Shen et al. (2018) performed an interesting study on the transition process, specifically with regard to reform speed and strategy. They proposed four different combinations for reform: incremental reform with radical speed, incremental reform with gradual speed, structural reform with radical speed, and structural reform with gradual speed. The study shed light on interesting facts on various economic policies, such as price liberalisation, change in government subsidies, balanced budgets, and privatisation of state enterprises. All these policies have different impacts on structural change and inter-industry connectedness. Romano and Traù (2017) elaborated on the relationship between industrial development and structural change with a rapid globalisation process. In particular, their study, mentioned that there was a faster inter-sectoral adjustment in late industrialised economies compared to those nations that had experienced it earlier.

Lee et al. (2018) explored the historical experience of productivity growth in the Asian economies over recent decades, with a focus on the service sector. The study suggested that during the adjustment to higher services' productivity growth, there was a significant expansion of the durable manufacturing sector, which was required to provide the capital stock that accompanies higher economic growth. The latest study by Mondal (2019) examined the role of structural change and sectoral productivity in the Indian and US economies between 1960–2010. It was concluded that in India the agricultural productivity growth should be faster to cover the gap compared to the US economy.

The Malaysian economy has experienced a rapid transformation process by achieving various economic development goals. Bekhet

(2009) mentioned that there was an inter-connectedness between all sectors as producers and consumers; this relationship was reflected in economic connectedness. In input–output models, it is convenient to elaborate on these relationships, since economic activities are displayed from the both input and output sides. He used four input–output models for the Malaysian economy to provide an in-depth analysis. The results suggested that there was weak sectoral connectedness, as the commodities sectors had a minimal role in economic growth. This further shows that in their diffusion of technical processes, these sectors did not generate comprehensive outputs.

Later, Bekhet (2013) investigated the changes in the economic structure of Malaysia with different levels of development between 1980–2005, by using an input–output SDA. He divided the changes into two components: technology and total output. The study concluded that there while there was forward growth, exports as external sectors did not play a dynamic role in this development phase. In another study, Bekhet and Yasmin (2015) further examined the structural change in intermediate demand and total output for the Malaysian economy through the changes in the input coefficient and Leontief inverse matrices for the period from 1980–2013. Here, the results confirmed those from the previous study. Later, Bekhet and Yasmin (2017) explained the changes in the Malaysian economy efficiency by using an SDA analysis. The results suggested that there was a change in the sectoral efficiency of certain sectors; however, others still required more R&D, innovation, and human capital to meet future challenges.

Overall, the studies reported in this section highlighted the growing interest in empirical research into economic development, technical innovation, and structural transformation processes. The most interesting aspect is that using an input–output analysis can provide an in-depth analysis of economic changes and their effects on each sector. Among others, the current study can fill some major gaps in the empirical literature review in three main ways. First, the study divides the overall economic structure into three components: technical coefficients, intermediate, and total output. Second, there are very limited studies available in Saudi Arabia in the context of structural change analysis. Third, due to various new Saudi government policies, this study can suggest valuable policy implications for decision making in the long run.

4. Data Sources and Methodology

This study used Saudi Arabia's input–output tables published by the Organisation for Economic Co-operation and Development (OECD). This is a series of input–output tables documented as various economic activities from 1995–2015. The current study utilised the latest six input–output tables for 2010–2015, respectively. There are 36 sectors in the original input–output tables (in USD$ million); no aggregation was undertaken, and all the sectors were considered individually (Table 1).

Table 1: Saudi Arabia Input-output Sectors.

No.	Sectors	ISIC3 codes
1	Agriculture, hunting, forestry and fishing	01,02,05
2	Mining and extraction of energy producing products	10,11,12,13,14
3	Mining and quarrying of non-energy producing products	10,11,12,13,14
4	Mining support service activities	10,11,12,13,14
5	Food products, beverages and tobacco	15,16
6	Textiles, wearing apparel, leather and related products	17,18,19
7	Wood and products of wood and cork (except furniture)	20
8	Paper products and printing	21, 22
9	Coke, refined petroleum products	23
10	Chemicals and l pharmaceutical products	24
11	Rubber and plastics products	25
12	Other non-metallic mineral products	26
13	Manufacture of basic metals	27
14	Fabricated metal products, except machinery and equipment	28
15	Computer, electronic and optical products	30, 32, 33
16	Electrical equipment	31
17	Machinery and equipment	29
18	Motor vehicles, trailers and semi-trailers	34
19	Other transport equipment	35
20	Other manufacturing; repair and installation of machinery and equipment	36,37
21	Electricity, gas, water supply, sewerage, waste and remediation services	40, 41
22	Construction	45
23	Wholesale and retail trade; repair of motor vehicles	50, 51, 52
24	Transport and storage	60, 61, 62, 63
25	Accommodation and food services	55
26	Publishing, audiovisual and broadcasting activities	64
27	Telecommunications	64
28	IT and other information services	72
29	Financial and insurance activities	65, 66, 67
30	Real estate activities	70
31	Other business sector services	74
32	Public administration and defence; compulsory social security	75
33	Education	80
34	Health and social work	85
35	Arts, entertainment, recreation and other service activities	90, 91, 92, 93
36	Private households with employed persons	95

Source: OECD (2020).

Leontief (1936) suggested the SDA as a research area to reveal important flows in an economy in the form of various coefficients over different periods of time. The SDA has been widely employed to explore the relationships between inter-industry activities by researchers such as Carter and Brody (1970a, 1970b), Ciaschini (1989), Rose and Chen (1991), Ang (1995), Miller and Blair (2009), Bekhet (2012), and Herrendorf et al. (2013).

The general explanation and theoretical perspective of the relevant methodology has been already discussed. The upcoming section is divided in two parts: changes in the intermediate demand as measured by the A coefficient and the Leontief inverse matrix, $(I–A)^{-1}$, and changes in total output requirements.

4.1. Decomposition by Using *A*:

In an input–output matrix, A is a square table with elements aij, representing the amount of input, i, required per unit of output, j. A column of the matrix depicts the inputs needed for the production of a specific output and, therefore, can be considered a technique. The overall changes in sectoral activities play an important role in capturing various growth policies. To explore how changes in intermediate demand, Ax, can be attributed to changes in the size of sectoral activity, x, and the technical relation of production, A, via the relationship suggested by Bekhet and Yasmin (2015):

$$\Delta[Ax] = MA\Delta x + \Delta AMx$$

where:

$$Mx = \frac{(x_0 + x_t)}{2}$$

$$MA = \frac{(A_0 + A_t)}{2}$$

$$\Delta A = A_t - A_0$$

Here, M stands for mean (Proops, 1988). For the decomposition of $\Delta[Ax]$ for various years — 2010, 2011, 2012, 2013, 2014, and 2015 — the tables were applied to the Saudi Arabian economy. The results are shown in Table 2 in the results analysis section.

4.2. Decomposition by Using $(I-A)^{-1}$:

In the next step, the change in sectoral activities that can help to design various economic policies to enhance economic growth was analysed. As we highlighted in the previous section, the change in intermediate demand, Ax, can be used to examine the change in the size of sectoral activity, x, and the technical relations of production, A. As such, we examined the change via the relationship suggested by Bekhet and Yasmin (2015):

$$u_t = (I - A_t)^{-1} y_t - y_0$$

i.e.,

$$u_t = [(I - A)^{-1} - I)y_t$$

So,

$$\Delta u = MC\Delta y + \Delta CMy$$

where $C_t = [(I - A)^{-1} - I]$. Overall, the decomposition of $\Delta[(I - A)^{-1} - I]y_t$ for the 2010, 2011, 2012, 2013, 2014, and 2015 periods was applied to the Saudi Arabian economic figures. These results are displayed in Table 3.

4.3. Decomposition of Change in Total Output:

The last step was vital, as here we could show that the changes reflected in total output could be further attributed to changes in final demand and inter-industry trading. The basic input–output equation (Bekhet & Yasmin, 2015) was as follows:

$$x = (I - A)^{-1} y$$

Then, it followed as:

$$\Delta x = M(I - A)^{-1}\Delta y + \Delta(I - A)^{-1} My$$

where

$$My = \frac{(y_0 + y_t)}{2}$$

$$M(I - A)^{-1} = \frac{[(I - A_0)^{-1} + (I - A_t)^{-1}]}{2}$$

$$\Delta y = (y_t - y_0)$$

$$\Delta(I - A)^{-1} = [(I - A_t)^{-1} - (I - A_0)^{-1}]$$

The change in total output represented two dimensions of changes in the economic structure, i.e. changes in the structure of final demand, Δy, and the change in the structure of inter-industry trading $\Delta(I - A)^{-1}$. The composition of Δx for 2010, 2011, 2012, 2013, 2014, and 2015 was applied to the Saudi Arabian economic figures. These results are summarised in Table 4.

4. Results Analysis

Saudi Arabia has various economic policies and plans for the pace of development that can be seen with the change in sectoral activities. Table 2 reveals that most elements of $MA\Delta x$ scored more than zero, whereas ΔAMx scored less than zero, meaning that the efficiency in some sectors has increased over time. Considering the values of changes in intermediate demand, $MA\Delta x$, during 2010–2011, certain sectors showed high shares, such as mining and the extraction of energy producing products (10.43%), chemicals and pharmaceutical products (5.90%), manufacture of basic metals (5.57%), wholesale and retail trade, repair of motor vehicles (9.82%), transport and storage (5.50%), financial and insurance activities (5.87%), and other business sector services (6.79%). However, over time, due to various economic changes, the sectoral technical relationship has changed, and these sectors have displayed different proportions of values.

In contrast, the values of ΔAMx between 2010–2011, 2011–2012, 2012–2013, and 2013–2014 displayed a notion that with time there was a change in sectoral performance. This change is vital to Saudi Arabia's development plans, which originated in 1970 and brought huge changes reflected prominently in the GDP growth per capita. Another interesting point is that all the negative ΔAMx elements between 2010–2011, 2011–2012, 2012–2013, 2013–2014, and 2014–2015 occurred mainly in those sectors that benefited the most under different plans from 2010 to the current period, especially after 2011. For example, the latest 2015 analysis shows that most of the sectors are very efficient, such as mining support service activities (-0.10%), IT and other information services (-0.54%), financial and insurance activities (-0.62%), and education (0.09%), which showed efficiency as an effective indicator. It also demonstrates that the economy is allocating resources to non-oil sectors to diversify the country (see Table 2).

Table 2: Changes in Intermediate Demand As %

	$\Delta A_{x2010-2011}$		$\Delta A_{x2011-2012}$		$\Delta A_{x2012-2013}$		$\Delta A_{x2013-2014}$		$\Delta A_{x2014-2015}$	
Sectors	$MA\Delta x$	ΔAMx	$MA\Delta x$	ΔAMx	$MA\Delta x$	ΔAMx	$MA\Delta x$	ΔAMx	$MA\Delta x$	ΔAMx
1	1.79	-0.06	1.39	-0.76	0.51	-1.27	3.91	-6.48	0.70	3.39
2	10.43	5.00	7.64	3.27	-2.29	-0.09	76.44	46.87	24.88	26.96
3	1.31	-0.21	0.92	-0.71	0.81	1.44	-0.06	-0.58	0.05	1.09
4	0.24	0.00	0.14	-0.30	-0.06	-0.07	-0.09	-1.38	0.24	-0.10
5	1.67	1.37	2.28	-1.27	1.09	0.91	-3.37	1.44	0.48	3.22
6	0.70	0.90	1.08	0.34	1.12	-0.56	2.78	0.43	0.23	1.60
7	0.78	0.08	0.81	0.14	0.61	0.25	0.93	-0.26	0.00	0.19
8	0.92	0.51	1.08	-0.42	1.06	0.58	1.84	0.10	0.11	1.31
9	3.17	1.80	3.69	8.36	6.08	30.23	0.46	118.56	1.04	12.46
10	5.90	-1.69	4.87	-1.44	7.46	-3.25	-8.20	-43.77	-0.46	-10.81
11	1.35	0.96	1.65	0.63	1.64	-0.94	1.33	-4.69	0.09	-0.03
12	0.86	1.71	1.18	1.08	1.22	-3.54	-0.13	-13.55	-0.17	0.53
13	5.57	1.36	4.96	2.57	3.49	3.13	10.29	-1.22	1.07	3.64
14	0.26	0.58	0.38	0.83	0.41	-1.87	0.77	-4.09	0.06	0.55
15	0.11	0.10	0.18	0.22	0.22	-0.34	0.38	-1.14	0.00	0.27
16	0.12	0.39	0.21	0.50	0.25	-1.08	0.54	-2.15	0.01	0.38
17	0.09	0.20	0.14	0.40	0.17	-0.78	0.32	-2.28	0.05	0.25
18	0.03	0.11	0.11	0.46	0.11	-0.26	0.35	-1.93	0.02	0.08
19	0.03	0.06	0.02	0.13	0.12	-0.34	0.11	-1.19	0.01	0.06
20	0.24	0.59	0.46	0.47	0.62	-0.85	0.83	-3.06	0.06	0.47
21	2.70	0.43	2.95	-2.51	3.08	1.02	1.92	-15.63	0.31	0.71
22	1.43	2.96	2.00	4.93	4.01	-4.94	4.24	-27.92	-0.30	2.11
23	9.82	-0.49	12.58	1.17	10.50	7.24	16.21	3.72	0.70	5.75
24	5.50	-1.08	5.28	-4.15	7.66	-0.74	4.63	-6.97	0.33	5.38
25	0.92	0.42	1.65	-0.11	2.09	1.04	1.94	-18.28	-0.03	0.85
26	0.07	0.00	0.09	-0.06	0.09	-0.01	0.13	-0.12	0.00	0.03
27	4.69	2.34	4.96	-1.57	6.37	-0.30	5.35	-10.45	-1.50	6.14
28	1.51	-1.04	1.46	-0.77	2.02	0.23	2.15	8.06	-0.10	-0.54
29	5.87	-2.24	7.55	1.56	10.10	-4.22	7.54	-37.44	-0.20	-0.62
30	0.92	2.16	2.27	2.61	2.53	-3.02	3.76	-15.42	0.00	0.40
31	6.79	3.59	9.55	-6.33	10.82	-4.26	14.38	-15.59	-0.17	1.35
32	0.08	0.21	0.11	-0.41	0.09	0.01	0.08	-0.82	0.00	0.05
33	0.07	-0.10	0.07	-0.03	0.08	0.15	0.08	0.29	0.01	0.09
34	1.35	0.77	2.86	3.32	4.23	-2.44	5.92	0.81	-0.20	4.51
35	0.57	0.44	1.21	0.08	1.43	-0.76	2.04	-3.65	-0.02	1.01
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**77.85**	**22.15**	**87.77**	**12.23**	**89.70**	**10.30**	**159.81**	**-59.81**	**27.28**	**72.72**

The second part of the result analysis is summarised in Table 3, which shows that the total change in Δu (see Section 4.2) between 2010–2011, 2011–2012, 2012–2013, 2013–2014, and 2014–2015 was 56.96%, 84.08%, 107.14%, 110.38%, and 82.87% for total demand, respectively. However, the change for the technical relationships of production between 2010–2011, 2011–2012, 2012–2013, 2013–2014, and 2014–2015 were 43.04%, 15.92%, -7.14%, -10.38%, and 17.13%, respectively. Therefore, the changes in $MC\Delta y$ and ΔCMy for the periods of 2012–2013 and 2013–2014 showed a different trend compared to previous years, such as 2010–2011. This demonstrates that Saudi Arabia has undergone significant modernisation that has brought prosperity and change to Saudi society. Furthermore, due to the changes in the oil price, the country has taken various initiatives to diversify away from oil to ensure sustainability. Several of the government's five-year development plans have also outlined diversification as a priority objective.

Table 3: Changes in Intermediate Demand $(I-A)^{-1}$ As %

	$\Delta C_{y2010-2011}$		$\Delta C_{y2011-2012}$		$\Delta C_{y2012-2013}$		$\Delta C_{y2013-2014}$		$\Delta C_{y2014-2015}$	
Sectors	$MC\Delta y$	ΔCMy	$MC\Delta y$	ΔCMy	$MC\Delta y$	ΔCMy	$MC\Delta y$	ΔCMy	$MC\Delta y$	ΔCMy
1	1.13	0.48	1.98	-1.15	0.88	1.50	1.99	-0.46	1.21	0.73
2	9.04	7.13	2.92	6.52	19.36	-14.50	13.94	5.30	16.73	6.47
3	-0.04	0.72	-0.96	0.50	0.52	-1.52	2.86	-0.31	1.96	0.47
4	0.23	0.02	0.12	-0.30	-0.05	0.07	0.06	-0.07	0.07	-0.01
5	1.24	1.90	2.77	-1.59	1.56	-1.27	1.40	-0.15	0.98	0.65
6	0.22	1.36	0.87	0.50	0.71	1.22	1.49	-0.06	1.03	0.40
7	0.59	0.27	0.54	0.33	0.40	-0.07	0.73	-0.10	0.47	0.07
8	0.61	0.83	1.35	-0.60	1.22	-0.65	1.22	-0.10	0.84	0.27
9	2.70	2.49	4.46	8.08	6.39	-38.37	4.91	5.71	6.24	2.43
10	4.71	-0.73	4.31	-1.07	6.11	6.59	6.68	-3.32	4.70	-2.17

11	0.94	1.42	1.33	0.87	1.16	1.87	1.89	-0.50	1.17	0.07
12	0.66	2.09	0.74	1.41	0.43	5.39	0.78	-0.77	0.31	0.10
13	3.68	3.13	1.25	5.18	0.20	-1.25	6.80	-0.94	4.40	0.88
14	0.20	0.70	0.24	0.96	0.20	2.65	0.48	-0.26	0.25	0.10
15	0.08	0.13	0.18	0.23	0.16	0.52	0.28	-0.09	0.16	0.06
16	0.09	0.46	0.15	0.55	0.13	1.55	0.28	-0.14	0.13	0.07
17	0.07	0.24	0.11	0.43	0.11	1.08	0.22	-0.14	0.11	0.05
18	0.02	0.13	0.08	0.49	0.10	0.36	0.21	-0.13	0.08	0.02
19	0.03	0.08	0.03	0.13	0.11	0.47	0.08	-0.07	0.03	0.01
20	0.17	0.71	0.42	0.51	0.58	1.25	0.55	-0.22	0.30	0.10
21	1.98	1.11	3.03	-2.59	3.39	-0.93	2.52	-1.11	1.47	0.15
22	1.27	3.46	1.84	5.19	4.62	6.82	1.56	-1.43	0.69	0.36
23	6.53	2.21	12.67	1.30	10.11	-7.09	15.14	-1.31	10.92	1.48
24	4.25	-0.05	6.68	-5.10	7.81	2.37	7.50	-1.22	5.04	1.13
25	0.68	0.68	1.93	-0.28	2.11	-0.96	1.16	-1.08	0.35	0.16
26	0.05	0.02	0.11	-0.08	0.10	0.03	0.10	-0.01	0.07	0.01
27	2.96	4.02	6.74	-2.74	6.61	1.48	7.66	-1.28	4.75	1.48
28	1.32	-0.94	1.96	-1.11	2.08	0.05	2.20	0.31	2.11	-0.14
29	4.50	-1.25	7.67	1.59	10.42	7.27	7.89	-2.86	4.80	-0.03
30	0.74	2.57	2.43	2.59	2.94	4.17	2.45	-1.04	1.37	0.12
31	4.75	5.73	11.58	-7.72	10.69	7.77	10.77	-1.94	7.25	0.44
32	0.06	0.25	0.11	-0.42	0.10	-0.01	0.05	-0.05	0.02	0.01
33	0.06	-0.10	0.08	-0.03	0.09	-0.19	0.05	0.00	0.03	0.01
34	1.07	1.12	3.05	3.30	4.30	3.97	3.41	-0.25	2.20	0.98
35	0.41	0.63	1.29	0.04	1.51	1.21	1.06	-0.28	0.62	0.20
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	56.96	43.04	84.08	15.92	107.14	-7.14	110.38	-10.38	82.87	17.13

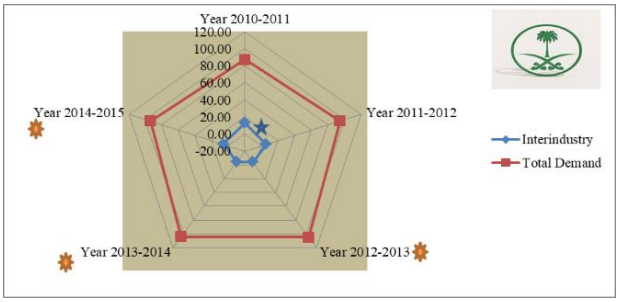
Finally, the total change in gross output between 2010–2011 was broken down into 87.09% for total demand and 12.91% for inter-industry terms. These findings display that economic activities have changed over time and reflect an output level change in various sectors. However, the total change in gross output between 2011–2012, 2012–2013, 2013–2014, and 2014–2015 periods were 94.39%, 104.40%, 104.26%, and 93.87%, respectively, for total demand, and 5.61%, -4.40%, -4.26%, and 6.13% for inter-industry terms, respectively (Table 4).

Table 4: Changes in Total Demand As %.

	$\Delta(I-A)^{-1}y^{2010-2011}$		$\Delta(I-A)^{-1}y^{2011-2012}$		$\Delta(I-A)^{-1}y^{2012-2013}$		$\Delta(I-A)^{-1}y^{2013-2014}$		$\Delta(I-A)^{-1}y^{2014-2015}$	
Sectors	$MB^{-1}\Delta y$	$\Delta B^{-1}My$	$MB^{-1}\Delta y$	$\Delta B^{-1}My$	$MB^{-1}\Delta y$	$\Delta B^{-1}My$	$MB^{-1}\Delta y$	$\Delta B^{-1}My$	$MB^{-1}\Delta y$	$\Delta B^{-1}My$
1	0.65	0.14	1.57	-0.41	2.19	0.93	1.87	-0.19	1.27	0.26
2	47.84	2.14	26.59	2.30	-68.88	-8.94	9.94	2.18	30.97	2.31
3	-0.20	0.22	-0.17	0.17	1.74	-0.94	1.78	-0.13	1.16	0.17
4	0.04	0.01	0.18	-0.11	-0.05	0.05	0.11	-0.03	0.07	0.00
5	1.07	0.57	2.13	-0.56	1.12	-0.79	2.23	-0.06	1.33	0.23
6	-0.13	0.41	0.28	0.18	-0.55	0.75	1.36	-0.03	0.88	0.14
7	0.01	0.08	0.00	0.12	0.10	-0.04	0.83	-0.04	0.62	0.02
8	0.26	0.25	0.78	-0.21	0.64	-0.40	1.22	-0.04	0.80	0.10
9	2.98	0.75	-2.73	2.85	18.62	-23.67	6.53	2.34	6.81	0.87
10	4.44	-0.22	3.04	-0.38	9.36	4.07	5.44	-1.36	4.36	-0.77
11	-0.26	0.43	0.03	0.31	0.77	1.15	1.79	-0.21	1.30	0.02
12	-0.04	0.63	-0.43	0.50	-2.77	3.32	1.13	-0.31	0.68	0.04
13	-0.66	0.94	-2.01	1.82	1.79	-0.77	6.47	-0.39	4.48	0.31
14	0.42	0.21	0.02	0.34	-1.55	1.64	0.76	-0.11	0.38	0.04
15	-0.04	0.04	-0.10	0.08	-0.43	0.32	0.25	-0.04	0.13	0.02
16	0.50	0.14	0.13	0.19	-0.88	0.96	0.45	-0.06	0.22	0.02
17	0.32	0.07	-0.04	0.15	-0.65	0.67	0.31	-0.06	0.17	0.02
18	0.06	0.04	-0.13	0.17	-0.10	0.22	0.20	-0.05	0.09	0.01
19	0.05	0.02	-0.04	0.04	-0.39	0.29	0.10	-0.03	0.04	0.00
20	0.30	0.21	0.27	0.18	-0.77	0.77	0.64	-0.09	0.36	0.04
21	0.53	0.33	2.38	-0.91	3.58	-0.57	2.71	-0.46	1.47	0.05
22	6.51	1.04	6.01	1.83	7.95	4.21	3.01	-0.59	1.14	0.13
23	3.55	0.66	10.36	0.46	7.04	-4.38	14.44	-0.54	9.84	0.53
24	1.77	-0.02	4.42	-1.80	13.21	1.46	6.37	-0.50	4.34	0.41
25	0.83	0.21	2.90	-0.10	1.01	-0.59	0.18	-0.44	0.34	0.06
26	0.08	0.01	0.11	-0.03	0.20	0.02	0.07	-0.01	0.07	0.00
27	1.24	1.21	3.83	-0.96	4.69	0.91	6.47	-0.53	3.72	0.53
28	0.52	-0.28	0.63	-0.39	0.36	0.03	1.74	0.13	1.74	-0.05
29	1.40	-0.37	3.22	0.56	8.31	4.48	6.77	-1.17	4.82	-0.01
30	0.01	0.77	6.41	0.91	26.10	2.57	3.03	-0.43	0.91	0.04
31	-0.94	1.72	9.05	-2.72	10.23	4.80	10.28	-0.79	6.58	0.16
32	7.74	0.07	-1.09	-0.15	24.36	0.00	0.65	-0.02	0.10	0.00
33	3.95	-0.03	6.89	-0.01	17.00	-0.12	0.10	0.00	0.19	0.00
34	1.55	0.34	7.43	1.16	13.00	2.45	3.71	-0.10	1.95	0.35
35	0.58	0.19	2.07	0.02	7.30	0.75	1.30	-0.12	0.61	0.07
36	0.13	0.00	0.39	0.00	0.73	0.00	0.03	0.00	-0.08	0.00
Total	**87.09**	**12.91**	**94.39**	**5.61**	**104.40**	**-4.40**	**104.26**	**-4.26**	**93.87**	**6.13**

The change in total demand highlights the impact analysis, which means that the productivity process changes the supply and demand mechanism. It can also be concluded that the Saudi government has succeeded in moving towards economic diversification in the last two development plans, although the economic diversification was a slow-paced process. Changes in inter-industry processes display the vital changes within the sector itself. This means that the introduction of new technologies, various production processes, and productivity are reflected here (Figure 5).

Figure 5: Decomposition of changes in inter-industry and total output (2010-2015). Source: Table 4.



Moreover, the private sector's performance is still low, which calls for a prompt intervention from the Saudi government to improve the legislative environment and competition, attract major international companies to the Saudi market, and raise its level of efficiency to achieve the Kingdom's main goal of being less dependent on the oil sector and the revenue it created. These findings reflect the fact that Saudi Arabia's economic problems do not stem from the weakness of its institutions. Quite the opposite, forged by oil exports, the structures of its rentier economy are well-established and difficult to advance (Faudot, 2019).

5. Conclusion and Policy Implications

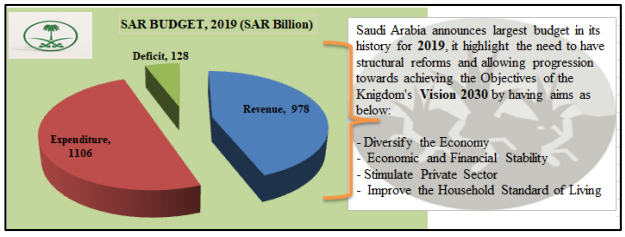
In summary, the current results mainly displayed three aspects in the Saudi Arabian economy as part of the structural transformation process. First, a change in the intermediate demand, shown as $MA\Delta x$ and ΔAMx, has enhanced productivity for more sectors based on the required inputs. Second, the technical relations, shown as Δu, showed that a high proportion of the Kingdom's sectors have mostly been transformed by the modernisation process. This clearly depicts the overall change in economic activities with the passage of time. Finally, the total change in gross output also highlighted the prominent changes as the total demand shows variation. This is an effective indicator to represent the change in sectoral productivity or output level as part of the structural change.

Some important policy implications can be proposed in this context. First, based on the results most of the sectors in Saudi Arabia are showing a change in productivity and demand levels. This sectoral change encourages more vital plans to boost non-oil sectoral performance. Amid the oil price shock and COVID-19, this is a time when the Saudi Arabian economy can reduce its reliance on oil revenues for economic growth, given that the global oil market is seeing severe upheavals with lower oil demand, and Saudi Arabia is trying to transform its economy by introducing new ways to generate income. This is the time needed to diversify by delivering a comprehensive reform programme to strike the right balance between all sectors.

Second, the findings lead to another indicator that, due to demographic transitions that will significantly increase the number of working-age Saudis by 2030, a productivity-led economic transformation could enable Saudi Arabia to double its GDP again and create as many as six million new jobs by 2030. Eight sectors – such as mining and metals, petrochemicals, manufacturing, retail and wholesale trade, tourism and hospitality, healthcare, finance, and construction – have huge potential to generate more than 60% of this growth opportunity (McKinsey & Company, 2015). In the analysis, these sectors already appeared to be showing sectoral productivity.

Third, with the passage of time and ongoing government reforms and regulations, the Kingdom of Saudi Arabia has emerged as a significant economy. One of the key prominent sectors, as reflected in our results, is financial activities. Therefore, it is important to be committed to managing finances efficiently and effectively, creating agile public organisations, and tracking both their performances and that of the government. This is a key point in time when the Saudi government has launched a fiscal programme and its initiatives and public finance has seen a marked improvement in fiscal discipline and the gradual reduction of budget deficit indicators. This is due to the successful implementation of several initiatives to develop a non-oil budget and improve spending efficiency. The main thrust of the government's 2019 budget was the continued implementation of the Vision 2030 programmes, initiatives, and projects that will deliver the stated fiscal and economic goals, such as diversity, stability, and stimulation processes (Figure 6).

Figure 6: Saudi Arabia Budget (2019).
Source: Ministry of Finance, Saudi Arabia, 2019.



Finally, there is a close relationship between education and economic growth in any economy. Given that an educated population is a productive workforce, and higher productivity equals higher economic gains, the education sector appeared as one of the sectors improving with the pace of economic transformation. Therefore, it is vital that there are untiring efforts for learning, as well as distance learning, so that by 2030 there is a trained workforce that consists of 500,000 government employees. It is compulsory that all ministries and government institutes generate a high level of human capital by adopting effective measures. In this context, the government has upgraded its hiring standards to acquire talented workers as decision makers and future leaders. This can help the Saudi economy to become knowledge-based, which can result in long-term and sustainable economic growth. This aspect was also quantified by Jawadi and Ftiti (2019), who suggested that these measures will help to achieve the Vision 2030 expectations and will lead to a future diversification path for the Saudi economy.

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