

Impact of emerging technologies on economic diversification: the case of Saudi Arabia

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Abstract

Purpose – The main purpose of this paper is to examine the performance of Saudi Vision 2030 and its impact on economic diversification. This study highlights the importance of economic diversification in building capacity for a resilient and productive economy. It evaluates the outcomes of government policy initiatives on various sectors of the economy.

Design/methodology/approach – This study adopts a theoretical and descriptive approach. It makes use of data collected from a variety of sources to analyze and highlight the progress of Saudi Vision 2030 in diversifying the economy and reducing the country's dependence on a limited number of commodities. The sources of data include government reports, academic publications and statistical databases. By analyzing information from these sources, the study aims to shed light on the initiatives and outcomes associated with Saudi Vision 2030, providing insights into the effectiveness of the strategies implemented to achieve economic diversification.

Findings – The study adds value to existing literature by providing updated information on the outcomes of Vision 2030. It highlights the tangible progress made in various non-oil sectors and the overall impact on the Saudi economy. This updated data is crucial for researchers, policymakers and stakeholders to understand the effectiveness of Vision 2030 and to make informed decisions for future initiatives.

Originality/value – The paper features the effectiveness of government policy in promoting economic diversification and establishing a supportive business environment, which are crucial for rapid socioeconomic transformation. Policy-makers, researchers and students can make use of the findings of this research to enhance their knowledge and understanding of the Saudi Vision 2030. The outcomes provided can help in refining strategies, updating educational curricula and guiding future research to align with the objectives of Vision 2030.

Keywords Economic diversification, Industry 4.0, Vision 2030, Capabilities, Sustainable development

Paper type Research article

Introduction

Economic diversification involves expanding the range of productive sectors in an economy that heavily relies on the production and export of a limited number of commodities. This process broadens the economy's capacity to produce a variety of goods and services, thereby reducing commodity concentration in trade and sustaining economic growth. A high degree of trade concentration makes the economy vulnerable to external shocks, leading to market disruptions and financial instability.

To mitigate the risks associated with uncertainty about future changes in global markets, effective strategies need to be implemented to enable the economy to absorb external shocks and minimize the risk of high dependency. Such measures must be backed by investment in productive capabilities to empower the economy, build production capacity, and diversify output. As a resource-rich country, Saudi Arabia has the potential to reallocate resources towards production in non-energy sectors to reduce the share of energy in total trade and stabilize income. Vision 2030, launched in 2016, aims to reinvent development by investing in emerging technologies, including artificial intelligence, renewable energy, robotics,



nanotechnology, the Internet of Things (IoT), and digital services to enhance productive capabilities and promote integration into the 21st-century economy.

In recent decades, globalization has led to greater financial and economic instability due to liberalization and privatization, which have increased economic interdependencies among nations. Energy-producing countries, in particular, have faced significant price and income volatility because their monetary and fiscal policies are often insufficient to mitigate the risks associated with the fluctuation of commodity prices in global markets. Economies that rely on a limited range of export commodities, such as oil-producing countries, are especially vulnerable to changes in external forces. Economic diversification, therefore, enables the economy to produce high-quality products that diversify income sources and reduce financial dependency on a limited number of export commodities.

This paper highlights the critical role of economic diversification in mitigating economic dependency and enhancing financial stability. The research examines recent efforts by Saudi Arabia and other Gulf countries to diversify their economies and reduce reliance on global markets for development financing. For decades, economic growth in these nations has been driven by export revenues from energy resources, with minimal investment in other productive sectors. This lack of diversification has led to increased financial instability and diminished investor confidence in the economy's ability to sustain growth and support future development. Fluctuations in global energy demand often impact the export earnings of countries heavily reliant on a limited range of commodities. For instance, in 2022, oil exports constituted approximately 80% of Saudi Arabia's export income, accounting for about 40% of its GDP. This paper utilizes data from international institutions to assess the impact of diversification policies on the economy of Saudi Arabia.

Saudi Arabia vision 2030

Among the GCC countries, Saudi Arabia has the largest economy, ranked 21st globally. In 2023, Saudi Arabia's GDP exceeded one trillion US dollars, reflecting the country's progress in building productive capabilities for economic diversification and reducing dependency on the energy sector. The oil sector remains a key driver of development, contributing about 45% to real GDP, 75% to government expenditures, and 70% to export earnings. Therefore, diversification is critical for strengthening the economy's ability to broaden the range of productive activities and promote sustainable growth. Shifting from a high dependency on a limited number of commodities for exports could create new opportunities for innovation, technology transfer, and industrialization. Moreover, the oil sector is capital intensive and it is unable to absorb the large number of young Saudis joining the labor force. Thus, economic diversification should be encouraged to create new job opportunities and sustain future development (IMF, 2019; Al-Roubaie, 2018b).

Over the past several decades, economic development in Saudi Arabia has been shaped by revenues from the production and export of crude oil, with little attempt to diversify output and reduce economic vulnerability. The country is the largest exporter of oil, with reserves estimated at 20% of the world total, establishing it as a leader in energy production for decades to come. However, instability in export earnings and uncertainty about future energy demand make the country vulnerable to global financial crises, disrupting the government's ability to promote economic growth and plan for the future. To address these challenges and restore confidence in the local economy, Saudi Arabia embarked on a new development path to diversify outputs and accelerate the transformation into a modern society benefiting from the 21st-century economy.

In 2016, Saudi Arabia launched Vision 2030 as a strategic pathway to transform the Kingdom's economy into a knowledge-based economy driven by digital technologies. Vision 2030 aims not only to reduce the country's dependency on oil and gas but also to enable the Saudi economy to compete in global markets and participate in global value chains. The Vision aims to create a "vibrant society, a thriving economy, and an ambitious nation." (Alarabiya

News, May 2021). It recognizes economic diversification as a key driver towards achieving these objectives through the development of manufacturing, promoting tourism, and fostering a healthy business environment that motivates both private and foreign firms to contribute to economic diversification and enhance the Kingdom's capabilities, making it more innovative, creative, and productive. By focusing on diversification, the Vision offers greater opportunities for young people and women to participate in the economy and create a better future for all citizens of the Kingdom (Al-Roubaier *et al.*, 2020).

Integration into global markets will allow local enterprises to benefit from technology transfer, knowledge absorption, skills acquisition, and innovation diffusion, stimulating linkages and supporting economic diversification. Saudi Arabia needs to integrate entrepreneurship and innovation into the educational system to inspire economic diversification and create new opportunities for businesses that contribute to technological innovation and job creation. By integrating entrepreneurship and innovation into the school curriculum, the educational system can provide students with the knowledge and skills needed to support economic diversification through the creation of new products and markets. Saudi Arabia can successfully implement its long-term development strategy if it fosters appropriate technology for local needs. The effectiveness of such strategies will depend on providing digital services, including internet connectivity, to bridge the digital divide and increase access to global markets. This enhances collaboration by bringing together public and private enterprises to share knowledge and maximize technological benefits to productive capacity and output diversity. Improving the Kingdom's capabilities through investment in human capital, digital technologies, and infrastructure will speed up the transformation process and build a resilient economy capable of increasing sectoral productivity and reducing dependency. The aim of Vision 2030 is to promote inclusive development, providing equal opportunities for all citizens and ensuring that basic services, including health and education, are affordable, thereby building a vibrant and productive society.

Saudi Arabia's initiatives to pursue economic diversification under Vision 2030 are evident in various activities, including investments in renewable energy, human capital, tourism, manufacturing, and services. Diversifying the energy mix is crucial for reducing the Kingdom's dependency on petroleum production and exports, as well as ensuring long-term sustainable economic growth. Under Vision 2030, Saudi Arabia aims to meet 50% of its electricity needs from renewables by 2030, thereby cutting carbon emissions and reducing dependency on conventional energy sources. In addition to its abundant solar energy, Saudi Arabia is investing in wind energy to diversify the energy mix and mitigate the risk of cyclical changes in global market demand for conventional energy (Arab News, October 20, 2024).

Vision 2030 aims to increase the country's capacity to absorb knowledge, acquire skills, and diffuse innovation. Restructuring productivity through the creation of new knowledge and development of new technologies contributes to rapid socio-economic transformation. Saudi Arabia has the resources to strengthen productive capabilities and utilize emerging technologies, including artificial intelligence, robotics, renewable energy, and nanotechnology, to participate in the new economy and benefit from the Fourth Industrial Revolution. It is projected that in the next five years, nearly a quarter of all jobs and 44% of workers' skills will face disruption due to factors such as geoeconomics, technology, and the green transition. This requires placing people at the core of technological and economic shifts, aiming to foster progress and ensure that individuals are equipped to thrive (World Economic Forum, 2023).

The ambitious NEOM project exemplifies Saudi Arabia's commitment to diversifying its economy and reducing reliance on non-renewable resources. This initiative aims to sustain future economic trends and enhance the country's economic management capabilities. Additionally, Saudi Arabia is investing in education and training to develop a knowledgeable and skilled workforce essential for adapting to emerging technologies. Investment in education enhances diversification capabilities, fosters innovation, and generates new knowledge. To implement the NEOM project, the government is estimated to spend \$24.7

billion on technology, the highest in the world (Alarabiya News, March 30, 2022). This creates new opportunities for resources to shift to higher productivity sectors, including manufacturing production, which advances localization in the technology sector as a key driver for economic diversification and global integration. Knowledge localization is critical for economic diversification and the adaptation of new technologies that impact the productive structure. It lays the foundation for successful diversification that involves the emergence of new productive sectors requiring demand for local inputs, including labor, capital, and natural resources. In particular, it acquires new skills and knowledge that can be used to adopt new technologies and support capacity building. However, efforts at economic diversification could be more successful if knowledge localization increases demand for technology transfer and innovation diffusion, creating new opportunities for local businesses to engage in market activities and contribute to knowledge creation and technology diffusion. Economic diversification can further support re-orienting economies towards more knowledge-based and innovation-led activities. Without a strong and localized knowledge system of their own, Gulf countries will continue to depend on international markets as consumers of knowledge and technology (United Nations, 2014).

The completion of the NEOM project will enable Saudi Arabia to create a vibrant business environment that encourages local enterprises to leverage the opportunities of the Fourth Industrial Revolution (Al-Roubaier *et al.*, 2020). The project aspires to become a global hub for innovation and entrepreneurship, providing opportunities for both local and foreign firms to invest in smart technologies and develop new technologies. Essentially, the project's goal is to foster a new culture of innovation and creativity, adapting and integrating emerging technologies into local conditions. NEOM underscores Saudi Arabia's commitment to creating a new society driven by an innovative and creative economy, which will not only influence future socio-economic trends in the country but also have significant implications for the Gulf region and beyond.

The role of the public sector in the process of diversification is pivotal for reducing the risk of market disruption by providing the necessary skills, investing in research and development, and introducing regulatory frameworks to encourage international linkages and support global integration. Vision 2030 will have a major impact on transforming the Saudi economy into a highly diversified productive structure capable of creating new opportunities for adapting emerging technologies and providing incentives for local enterprises to participate in the new economy driven by the technologies of the Fourth Industrial Revolution. Implementing Vision 2030 ensures financial stability by increasing the share of the non-energy sector in total government revenues and empowering local enterprises to cultivate the benefits of diversification and invest in new projects. Such rapid structural transformation could significantly impact job creation, especially for young people and women, contributing to development and building capacity for a digital society.

Strengthening the diversification process underscores the importance of building productive capacity. This involves ensuring adequate physical infrastructure, a skilled labor force, access to finance, stimulating macroeconomic policies, and creating a conducive business environment attractive to both domestic entrepreneurs and foreign direct investment. The government's role is critical in accelerating diversification and providing the necessary incentives for technological innovation and market competitiveness. However, government initiatives to transform the economy into a sustainable, resilient system capable of absorbing global shocks and market disruptions will depend on improving productive capabilities and the ability of the productive system to create linkages that foster economic growth.

Recent trends indicate that Saudi Arabia's non-oil economic activity accounted for 50% of the country's GDP, valued at \$453 billion in 2023. According to Al-Arabiya News, "The Kingdom has pursued rapid diversification across three pivotal fronts: enhancing trade diversity to elevate the share of non-oil trade, boosting the value-added of exports and expanding trade partnerships; pursuing government revenue diversification through VAT and other broad-based tax measures; and broadening production horizons to reduce reliance on

oil-centric industries” (Al-Arabiya News, April 8, [2024](#)). In 2022, the main non-oil export items included “chemical and allied industry products,” which comprised 35.8% of non-oil exports, and “plastic and associated articles; rubber and related articles,” which accounted for 28.3% of non-oil exports ([Lloyds Bank, 2024](#)). As a share of total GDP, commodity exports declined from 41.1% in 2012–2014 to 23.4% in 2019–2021. The share of energy exports in total exports by commodity group also declined from 81.2% in 2012–2014 to 69.4% in 2019–2021 (Saudi Arabia, 2024).

There is a need for changes in educational policy to incorporate new requirements for emerging technologies, including digital skills, soft skills, and training to enhance labor capabilities in line with market needs for digital literacy and ICT applications. Universities in Saudi Arabia should promote the study of science, engineering, and technical subjects to support Vision 2030 by increasing the stock of human capital and equipping graduates with adequate digital competencies and technical skills for problem-solving and productivity growth. Digital technologies could contribute to economic diversification by fundamentally changing the structure of production, providing enterprises with the opportunity to start up and contribute to the process of rapid transformation. ([Al-Roubaie, 2019](#)) Investment in digital technologies enhances individual and group capabilities to become more creative and productive by facilitating the diffusion of technologies, creating new knowledge, and developing new products. Thus, investment in digital literacy, smart energy, transportation, social networking, and services ensures reliable facilities to address the challenges facing the country and reap the benefits of the Fourth Industrial Revolution. Social networks can share knowledge and know-how to transform inventions into innovations, inspiring entrepreneurs and investors to adapt smart technologies and diversify productivity.

Economic diversification

Economic diversification plays a critical role in promoting transformation and supporting policies to reduce dependency on a limited number of commodities. It broadens the productive capacity of the economy to produce goods and services, which stimulates the creation of linkages and encourages investment in the domestic market. Improvements in productivity across various sectors strengthen market flexibility, enabling the economy to absorb external shocks and increasing its potential to generate new knowledge, products, and technologies applicable to local needs. Thus diversification through higher technological capabilities, commodity dependent countries, such as Saudi Arabia, can reduce financial and economic vulnerabilities. In other words, economic diversification can be achieved through investment in technological upgrading and innovation to strengthen productivity growth in the manufacturing sector.

Countries in the GCC region rely heavily on earnings from the production and export of energy, mainly oil and gas, to finance development and improve the quality of life of their citizens. Government expenditure in these countries finances development through investment in education, health, infrastructure, transportation, and various other productive projects. However, the ability of the government to finance these projects is largely affected by the instability of export earnings, which account for a large percentage of government revenues and expenditure. A diversified economy would unlock job-creating growth, increase resilience to oil price volatility, and improve the country’s prospects for future generations ([IMF, 2016](#)).

The Saudi Vision 2030 emphasizes the importance of economic diversification in building productive capacity, rethinking development, and reducing dependency on global markets. The Vision offers an ambitious plan to transform Saudi society into a modern state characterized by equal opportunities, allowing all citizens to participate in building the new society and share the benefits of the new economy. However, the preferred diversification pathways will promote the private sector, boost local content, and produce higher value-added exports, making the economy more self-sufficient and less dependent on revenues from the

basic oil and gas sector. Among other things, quality infrastructure aims at building capacities across sectors of the economy to encourage the adaptation of smart technologies in manufacturing production and industrial development (Havrlant and Darandary, 2021).

Economic diversification helps create a more stable economy, strengthens the fundamentals for rapid economic growth, and sustains development. It increases confidence in market activities and is crucial for investment allocations by both local and foreign firms. According to the United Nations, “Economic diversification is considered a key element of economic development in which a country moves to a less concentrated, more varied production and trade structure. Lack of economic diversification is associated with increased economic vulnerability, such that external shocks can undermine the development process” (World Trade Organization, 2019, p. 30). A country is defined as resource-dependent if over 60% of its export value consists of natural resources and the ratio of natural resource exports to GDP is above 10%. Saudi Arabia is classified as a commodity-dependent nation, with about 70% of its export earnings attributed to the production and export of energy, mainly oil (Mohammed bin Rashid School of Government, 2024).

Economic diversification can be defined as the transition from a dependency on traditional sectors, such as agriculture and mining, to a variety of sectors and high-quality services (IMF, 2024). In other words, countries lacking diversified productivity are subject to external shocks, which undermine their ability to manage vulnerabilities and reduce the risk of financial crises. This is the case for most energy-producing countries, including Saudi Arabia. Due to their dependence on income generated from sales in global markets, they often experience such shocks because of a lack of economic diversification. A non-diversified economic structure weakens the economy and hinders its ability to promote economic stability and sustain growth. In contrast, a diversified economy has greater leverage to manage external shocks and restore confidence in market activities. Therefore, economic diversification empowers the economy to sustain growth and strengthens the fundamentals for building capacity for development.

Although financial dependency on energy production and exports varies among countries, in those with high dependency, the share of oil revenues in total fiscal expenditures and income is high, which does not support long-term financial stability and economic sustainability. Minimizing the risk of financial shocks and strengthening investors’ confidence entails building capacity to reduce dependency on traditional sectors and increasing the share of manufacturing in total output. In the case of GCC countries, including Saudi Arabia, the non-oil sector remains too small to generate enough stimulus and encourage non-traditional sectors to participate in the market economy (IMF, 2016). Economic diversification can be defined as the transition from a dependency on traditional sectors, such as agriculture and mining, to a variety of sectors and high-quality services (IMF, 2024). In other words, countries lacking diversified productivity are subject to external shocks, which undermine their ability to manage vulnerabilities and reduce the risk of financial crises. This is the case for most energy-producing countries, including Saudi Arabia. Due to their dependence on income generated from sales in global markets, they often experience such shocks because of a lack of economic diversification. A non-diversified economic structure weakens the economy and hinders its ability to promote economic stability and sustain growth. In contrast, a diversified economy has greater leverage to manage external shocks and restore confidence in market activities. Therefore, economic diversification empowers the economy to sustain growth and strengthens the fundamentals for building capacity for development.

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Countries with high dependency on non-renewable resources, including the Gulf countries, must diversify their revenue streams by building up sovereign wealth funds and avoiding projects that require ongoing government support or subsidies (Kabbani and Ben Mimoune, 2021, p. 21). Ultimately, the success of economic diversification will depend on the effectiveness of government support programs and policies concerning the utilization of productive resources and the incentive regime for promoting investment in non-traditional sectors of the economy. A close relationship with the private sector enables the government to select and implement diversification strategies that are more effective for building productive capacity and fostering industrialization. Partnership and collaboration with the private sector facilitate inclusive growth and enhance the economy's capabilities to become more innovative, creative, and productive.

The development of productive capabilities is important for understanding economic diversification. Capabilities such as technologies, ideas, skills, knowledge, infrastructure, and natural resources empower the local economy to produce diversified products that enhance productive capacity and stimulate sectoral growth. Productive capacity is defined as the "productive resources, entrepreneurial capabilities, and production linkages which together determine the capacity of a country to produce goods and services and enable it to grow and develop" (UNCTAD, 2021, p. 61; Al-Roubaie, 2018a). In the meantime, productive capabilities determine the ability of a country to produce goods and services that can be exported to increase competitiveness and participate in the global economy.

In 2023, the Ministry of Planning announced that the non-oil sectors accounted for 50% of the GDP, reflecting significant progress in economic diversification. This implies that the productive capacity of the Saudi economy is shifting from high dependency on primary products towards the production of high-quality goods and services. It is an expression of structural transformation, allowing the economy to shift from low productive capacity to more sophisticated products, including manufacturing production. Therefore, diversification is an important initiative to foster economic transformation and promote sustainable development.

As a highly diversified country with substantial natural and human resources, Saudi Arabia can invest in boosting productive capabilities by utilizing both local and external resources. This approach promotes horizontal and vertical diversification, broadens the productive structure, and reduces high dependency on the energy sector. Balancing external and internal capabilities could enable the economy to progress through various stages of development, not only reducing dependency but also accelerating integration into the new economy and benefiting from 21st-century technologies.

The new economy offers opportunities for countries like Saudi Arabia to diversify productive capacity through investment in high-quality products and services. An effective strategy, as outlined in Vision 2030, would allow the country to participate in the new economy by adapting new technologies to local conditions. Technologies empower the economy to absorb knowledge, acquire skills, narrow the digital divide, and increase collaboration beyond borders, thereby reaping the benefits of global markets. Additionally, technology enhances the capacity for industrialization and manufacturing production, which is essential for structural transformation and productivity growth.

Table 1 presents several measures of economic diversification. The data includes indicators of economic dependency in the Gulf Cooperation Council (GCC) countries. According to these indices, GCC countries are still lagging in diversifying their productive structures and sustaining future growth. However, recent trends indicate that strategies to boost production in non-energy sectors have been successful in ensuring sustainable growth and reducing dependency.

For instance, in the Global Innovation Index 2024, Saudi Arabia ranked 47th, consolidating its position in the top 50. This reflects the economy's ability to progress and generate innovative activities. The 2024 index highlights four key issues as indicators of economic progress driven by diversification: science and innovation investment, technological progress, technology adoption, and the socioeconomic impact of innovation. Saudi Arabia appears to

Table 1. Indicators of economic performance in GCC countries

Country	Diversification index	Concentration index	Economic complexity index	Frontier technologies readiness index	Global innovation index	Productive capacities index
Saudi Arabia	90.5	0.591	0.62	0.65	33.9	56.9
Bahrain	93.7	0.354	0.45	0.58	42.8	60.7
Qatar	88.7	0.426	−0.38	0.55	32.9	63.6
Oman	87.7	0.340	−0.16	0.57	27.1	56.0
UAE	95.7	0.289	0.12	0.74	42.8	63.5
Kuwait	86.2	0.318	0.33	0.64	28.1	54.5

Note(s): Economic complexity Index [The Atlas of Economic Complexity \(harvard.edu\)](#)

UNCTADSTAT Concentration Index and diversification index [ConcentDiversIndices \(unctad.org\)](#)

Complexity Ranking (2022) [ECI Rankings \(HS96\) | The Observatory of Economic Complexity \(oec.world\)](#)

UNCTAD, Productive Capacity Index 2nd Generation, 2023 [Productive Capacities Index: 2nd Generation - Enhanced Statistical and Methodological Approach with Results \(unctad.org\)](#)

World Intellectual Property Organizations (WIPO) Global Innovation Index, 17th Edition, 2024 file:///C:/Users/AU-289/Documents/Global%20Innovation%20Index%202024_WEB2.pdf

Source(s): The author

have made significant progress in these areas, moving up into the top 50 rankings among nations. In 2022, Saudi Arabia was ranked 35th most complex economy out of 133 countries, number 17 economy in the world in terms of GDP, and 37th in terms of GDP per capita, according to the Economic Complexity Index (ECI) ([OECToday, 2022](#)).

Over the past few years, the Saudi economy has been growing at an average rate of 1.6%, reflecting its transformation through technological innovation, economic diversification, and global integration. According to the Global Diversification Index, the Middle East and North Africa (MENA) region made progress from 2007 to 2019 by increasing the share of manufactured exports as a percentage of total exports from 35.8% to 42.9%. Additionally, these countries increased the share of medium and high technology exports in total manufactured exports from 25% to 36.9% during the same period. Concurrently, the share of fuel exports in total GDP dropped from 47% to 35.8% (The Global Diversification Index 2022).

The Market Concentration Index of exports measures the degree of export market concentration, ranging from zero to one. A value closer to zero indicates that all countries export an equal share, whereas a value of one indicates that only one country exports all products. For Saudi Arabia, an index of 0.591 suggests that the country shares its exports with a large number of other countries. This also indicates a low level of knowledge in these exports, as measured by an Economic Complexity Index of 0.62. Low knowledge content implies that the country exports ubiquitous products that are equally produced by several other countries ([UNCTADSTAT, 2018](#)).

On the other hand, the Frontier Technologies Readiness Index ranks countries on a scale from 0 to 1, with the United States receiving the highest score of 1. All Gulf countries scored above the average of 0.50 on this index, with Saudi Arabia receiving a score of 0.65. This score indicates that the country is on the right track regarding frontier technologies readiness, reflecting the seriousness of policy initiatives to move the economy into a new frontier driven by smart technologies ([UNCTAD, 2023](#)).

The Economic Complexity Index (ECI) classifies countries based on the diversity and competitiveness of their output in global markets, as well as the ubiquity of these products, measured by the number of countries that produce them. The least complex countries have low product diversity, with many other countries producing and exporting similar products. In

other words, these countries export a small number of ubiquitous products. For instance, countries such as Japan, South Korea, and Germany rank highly on the ECI because they produce unique and sophisticated products that only a few countries can manufacture. “Economic complexity, therefore, is expressed in the composition of a country’s productive output and reflects the structures that emerge to hold and combine knowledge” (Hausmann *et al.*, 2022, page 18).

In this context, the ECI can be used as an indicator of a country’s level of prosperity, as measured by the amount of knowledge embedded in its diversified products. This also highlights that the prosperity levels in Gulf countries are not necessarily due to the knowledge embedded in their exports, but rather the high income earned from exporting energy resources.

Smart technologies and economic diversification

The Fourth Industrial Revolution, also known as Industry 4.0, builds on the Third Industrial Revolution by digitizing the economy through advanced technologies such as AI, robotics, automation, the Internet of Things, and big data. These technologies are transforming productive activities, leading to market redistribution, unemployment, and rapid technological advancements. Industry 4.0 signifies a new era of integrating smart technologies into manufacturing, transforming economies into digital, physical, and biological systems. This revolution not only creates new opportunities for productivity growth and economic diversification but also causes market disruption and income inequalities both among and within nations. The term was first coined by Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, who explained the impact of emerging technologies on economies, industries, and societies. Industry 4.0 primarily focuses on manufacturing production, with digital technologies representing the core process of creating smart factories (Al-Roubaier *et al.*, 2020).

Saudi Arabia has the potential to leverage these smart technologies to diversify its economy and reduce its dependency on the energy sector. However, participating in the Fourth Industrial Revolution requires building technical, scientific, managerial, and human capital capabilities to strengthen market stability and adapt to technological changes. Continuous training of workers is essential to ensure enterprises can adjust to technological advancements and market changes. Skilling and reskilling workers are crucial for helping modern enterprises not only adapt to technological changes but also compete in global markets. Investing in these technologies empowers the country to create knowledge and diffuse innovation, which are foundational for building a knowledge-based economy driven by smart technologies. Saudi Arabia has the potential to catch up with industrialized nations by investing in emerging technologies and creating a resilient business environment that incentivizes knowledge creation and technological development. These technologies enable the economy to bypass several stages of development, relying on digitally driven communication and electronic systems that increase connectivity and facilitate access to physical resources.

Technologies of the Fourth Industrial Revolution can significantly enhance economic capabilities by increasing access to global knowledge, skills, finance, and technology. At this stage of development, Saudi Arabia can leverage existing knowledge and technologies from around the world to build productive capacity for diversification and expedite integration into global markets. Adapting existing technologies supports rapid transformation towards promoting indigenous development that is more applicable to local conditions. Both horizontal and vertical diversification can benefit from the deployment of emerging technologies, stimulating linkages and building capacity for development. Saudi Arabia has the financial, technical, and human capital resources to support rapid vertical and horizontal diversification, empowering the economy to leapfrog and speeding up the process of global integration. Investing in emerging technologies not only reduces the cost of development but also strengthens the fundamentals for building capacity for a diversified economy and sustainable growth. Additionally, smart technologies enhance economic complexity,

strengthening local capabilities to create new knowledge and diffuse innovation to support sustainable growth. Technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotics, and big data can significantly boost the productivity of small and medium enterprises (SMEs). These advancements enable SMEs to compete more effectively in the market by providing greater access to information and opportunities to expand their offerings to global markets. In Saudi Arabia, SMEs can be encouraged to supply services to large businesses and participate in global value chains. This involvement will foster linkages that stimulate market activities, enhance economic diversification, and bridge development gaps.

Fostering SMEs should be given high priority in the Saudi Vision to widen the productive capacity of the economy and diversify output. SMEs empower economic diversification through global linkages, creativity, and innovation, which contribute to job creation, market competitiveness, technology transfer, and structural transformation. The existence of a conducive business environment, largely shaped by the government, is critical for private sector incentives to invest in new projects and build productive capacity for economic diversification. The government needs to support enterprises by providing domestic credit, access to global markets, and digital skills.

Collaboration between local and international tech communities is pivotal in propelling Saudi Arabia towards realizing its ambitious transformation agenda. International collaborations bring in new technologies and innovative practices, fostering a robust local innovation ecosystem. These collaborations enable Saudi tech entities to access global markets, attract investors, and connect with mentors, thereby accelerating Saudi Arabia's ambitions to become a leading digital economy and enhancing its competitiveness on the world stage. To accelerate the process of joining the Fourth Industrial Revolution, Saudi Arabia established the Center for the Fourth Industrial Revolution (C4IR) with the aim to "accelerate the development and implementation of governance principles, policies, and protocols of emerging technology to best serve the Kingdom's vision for economic diversification and technological innovation." (C4IR, 2024).

The human factor is crucial for future development. Therefore, investment in education not only promotes creativity and innovation but also increases competition and facilitates integration into global markets (Al-Roubaie, 2019). Recently, Saudi universities have made substantial gains in international rankings, reflecting their progress in closing knowledge and skill gaps. To accelerate the diversification process, specialized skills and training are required to upgrade and adapt emerging technologies to local conditions. Universities play a vital role in skills acquisition and labor training, as well as in developing new methods, creating new knowledge, and providing solutions for problem-solving. Universities need to rethink curricula and teaching methods to equip students with the skills that meet the demands of the new economy, including creativity, digital literacy, problem-solving, critical thinking, and socio-economic skills. The need for skills in advanced technologies, including AI, robotics, and big data, is essential for reducing skill gaps and increasing market flexibility to respond quickly to market changes. Similarly, building digital infrastructure facilitates economic diversification by providing access to global markets. The basic idea is that connectivity and social networking make it much easier for knowledge to be shared, enabling business enterprises to diversify productivity and support rapid transformation.

In recent years, Saudi Arabia has been actively addressing significant challenges to close the skills and digital gaps and endorse effective strategies for transitioning into a diversified economy driven by smart technologies. The government is introducing several programs to improve skill capabilities and vocational training. For example, the partnership with IBM aims to upskill 100,000 young Saudis over five years, focusing on emerging technologies. Skill capabilities are needed for adopting existing technologies and creating new ones applicable to local conditions. For Saudi Arabia, it is important to develop the capacity to adapt and modify technologies to speed up the process of diversification and increase global competitiveness. Building digital skills and addressing the connectivity gap will increase the economy's capabilities, especially SMEs, to adopt new technologies and support knowledge localization.

Similarly, universities such as King Abdullah University of Science and Technology (KAUST) and King Abdulaziz City for Science and Technology (KACST) are among the leading educational institutions providing research centers for advanced training. These institutions aim to foster innovation and support the Kingdom's initiatives towards rapid economic diversification. Recently, the Ministry of Human Resources and Social Development launched the "Professional Verification" program to ensure that Saudi workers have adequate skills to meet market demand for skilled labor. According to the program, workers coming from outside the Kingdom will be examined by international examination centers in their home country before their arrival ([Human Resources and Social Development, 2023](#)).

Aramco's Fourth Industrial Revolution (4IR) Center is another significant initiative aimed at enhancing workers' skills and capabilities for integrating advanced technologies into the company's operations. The Center is implementing Aramco's strategy to digitally transform its operations by adopting Fourth Industrial Revolution technologies, including artificial intelligence (AI), the Internet of Things (IoT), robotics, and big data. The Center collects vast amounts of data to develop innovative solutions that enhance productivity and increase operational performance. To this end, Aramco advances knowledge management to facilitate knowledge sharing by creating a collaborative environment where workers and top management work closely to develop digital solutions and strengthen the adaptation of emerging technologies into the company's operations. This will increase the company capabilities to become a global leader in the production and export of petroleum and petroleum products ([Energy Industry Review, 2019](#)).

Pursuing an effective strategy for diversification through Fourth Industrial Revolution technologies, Saudi Arabia must overcome several challenges, including closing the digital divide, building infrastructure, establishing regulatory and policy frameworks, investing in human capital, and creating an enabling environment. The effectiveness of these measures depends largely on the ability of both public and private sectors to overcome these challenges and undertake decisions to implement programs for adopting emerging technologies into local conditions. Such an environment should not only encourage investment in smart technologies but also adapt to organizational changes and cultural shifts such as mindset, continuous learning, and market demand.

Technological innovation is critical for economic diversification, global competitiveness, and sustainable growth. Saudi Arabia can enhance innovation capabilities through the ability to explore new technological combinations by embracing the concept of incremental innovation and innovation without research ([WIPO, 2024](#)). Innovation can be achieved by introducing new products, new technology, and discovering new markets that enable the economy to increase productivity and promote diversification. This implies that innovation depends not only on research and development but also on the quality of the educational system, the existence of inventive mechanisms, the supply of finance, and the institutional framework of the state ([Balzat, 2006](#)). These determinants can increase the learning capabilities of individuals and organizations to modify and diffuse new technologies, create productive knowledge, and diversify the economic structure. Collaboration and linkages with others, which Vision 2030 recognizes as a driver of rapid transformation, will contribute to both horizontal and vertical diversification processes.

Initiatives for rapid economic transition in Saudi Arabia focus on partnerships and international collaboration to encourage technology transfer, knowledge absorption, skill acquisition, and information dissemination. These programs enable the Kingdom to make informed decisions about selecting technologies suitable for the local environment. By doing so, Saudi Arabia is making substantial efforts to close the digital divide, address skill gaps, and empower the economy to adapt to new technologies. Furthermore, international collaboration enables Saudi Arabia to acquire new technologies and disseminate innovations, accelerating economic diversification and speeding up the transformation into a digital economy. "The

countries best placed to move to smart production are those with stronger manufacturing industries and higher levels of skill” (UN, 2023, p. 66).

The country needs to strengthen the fundamentals for inclusive development to encourage participation and provide integrated linkages that ensure access to global knowledge, build appropriate infrastructure, enhance digital literacy, and create an enabling business environment. The private sector, including SMEs, represents an important force behind manufacturing production and industrial development, which countries like Saudi Arabia need to encourage to empower local firms to adapt to emerging technologies, create job opportunities, and participate in the new economy. However, implementing these projects will require long-term government support to ensure appropriate policy development capable of introducing effective strategies for managing current resources and building capacity for suitable technologies. The country has numerous opportunities for local, regional, and global collaboration to share knowledge and exchange experiences for adopting technologies that enhance sectoral productivity and ensure long-term sustainability.

Vision 2030 recognizes the contribution of small and medium-sized enterprises in promoting economic growth, creating jobs, supporting innovation, and boosting exports. To achieve this goal, the government has established the SMEs Authority to encourage young entrepreneurs with business-friendly regulations, easier access to funding, international partnerships, and a greater share of national procurement and government bids. In this age of the internet and connectivity, economic diversification facilitates knowledge absorption and innovation diffusion, empowering economies to build capacity for participation in the Fourth Industrial Revolution through the adaptation of smart technologies and integration into global markets. The use of smart technologies can lead to greater automation and more innovation, accelerating the process of catching up with industrialized countries. SMEs can benefit from social networking to facilitate knowledge acquisition and technology transfer to enhance local capabilities and contribute to building capacity for productivity in non-oil sectors (Al-Roubaie, 2019).

In the fields of technology and innovation, Saudi Arabia has been making substantial efforts to increase investment in research and development, build digital infrastructure, and enhance the country’s capabilities in smart technologies, including artificial intelligence and robotics. As a commitment to future sustainability, the government has decided to allocate 2.5% of GDP to research and development by the year 2040 to support innovation and the creation of new knowledge. This will help the Kingdom enhance market flexibility and adapt to changes in technology. In research and development, which is critical for building capacity for innovation and creation of new technologies, Saudi Arabia has committed to become a global leader “with an annual investment of 2.5% of GDP in 2040. This will diversify and add 60 billion Saudi Riyals (\$16 billion) to the economy in 2040 while creating high-value jobs in science and technology.” (UmmAlQura, October 22, 2024).

The Saudi Data and Artificial Intelligence Authority is set to provide support for local enterprises by setting standards for digital transformation, ensuring that local businesses continue to deliver high-quality products and find solutions to challenges facing the economy due to market changes and technological advancements. These projects are part of Saudi Vision 2030, which aims to build capacity for smart technologies and establish Saudi Arabia as a leader in scientific applications and technological advancement in the Middle East. These initiatives contribute to reducing dependence on the energy sector by supporting a more diversified economic structure through technological advancement, knowledge creation, and innovation. High dependency on the production of oil and gas resources and other unsustainable products is expected to increase future economic vulnerability. Therefore, focusing on promoting diversification to increase value-added and enhance the quality of technological innovation will sustain development by creating a balance between present and future consumption. In Saudi Arabia, there is much to be gained from diversification by addressing important challenges such as water management, food security, renewable energy, environmental protection, and development sustainability.

Saudi Arabia and other Gulf countries need to address serious macroeconomic challenges, including unemployment and inflation, and provide incentives for the private sector to participate in the new economy by encouraging investment in smart technologies. They should support private enterprises by reducing regulations, building infrastructure, providing funding, and strengthening global connectivity to encourage participation in international markets and promote competitiveness. Not only creating an enabling environment encourages domestic firms adapting new technologies, but also provides incentives for foreign firms to invest in the local economy. The Saudi economy can benefit from foreign direct investment to acquire new technologies, new knowledge, and vocational skills which are essentials for building productive capacity and diversifying output. Investment by foreign firms in the non-oil sector accelerates diversification by creating linkages that stimulate productivity growth and increase competitiveness. In other words, through the transfer of emerging technologies, local firms gain access to Fourth Industrial Revolution technologies, facilitating integration into the new economy and strengthening the foundation for building a digital society. Digitization enhances inclusion, providing new opportunities for individuals, corporations, and public institutions to participate in Vision 2030 and support diversification.

Conclusion

In 2016, Saudi Arabia launched Vision 2030, aiming to restructure the Kingdom's economy by diversifying its productive structure and increasing the share of non-energy sectors in total output. A high degree of trade concentration makes the economy vulnerable to external shocks driven by the instability of commodity prices and changes in global demand and supply for energy. Vision 2030 emphasizes the need for reinventing development through investment in human capital, knowledge creation, technology diffusion, and innovation. The Vision provides inclusive and equal opportunities for the Kingdom's nationals to participate and contribute to the process of socio-economic transformation.

The government is taking serious steps towards strengthening the fundamentals for rapid transformation by investing in human capital, digital literacy, infrastructure, and creating a vibrant business environment attractive to both local and foreign investment. Saudi Arabia recognizes the need to reduce the volatility and uncertainty of energy prices in global markets to advance technological innovation and sustain economic growth. The government is not only striving to reorient the Kingdom's economy towards a technology-driven model but also to become a key player in shaping socio-economic transformation in the 21st century. As a major energy producer, Saudi Arabia will continue to play a significant role on the global stage by finding solutions to global challenges such as climate change, renewable energy, sustainable development, and peace and security.

Economic diversification is a strategy to reduce dependency on the production and export of a limited number of commodities. This aims to diversify income sources to mitigate the risk of price fluctuations and changes in demand and supply in global markets. In other words, diversification seeks to enhance economic performance to achieve financial stability and build resilience against external shocks. Successful diversification, however, will require effective strategies to create enabling conditions and promote building productive capacity in non-energy sectors. To embark on strong diversification, governments need to undertake several policy measures, including digital transformation, investment in human capital, building infrastructure, knowledge creation, and innovation dissemination. Vision 2030 focuses on building productive capacity that enables the economy to diversify production, create jobs, sustain development, and participate in global markets. The Vision underscores the need for structural reforms to reduce dependence on a narrow economic base and accelerate the process of transformation to catch up with industrialized countries.

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