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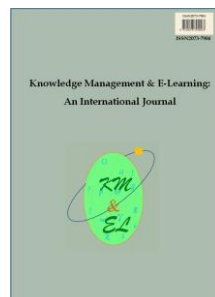
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The framework of building indigenous technological innovation capabilities: A conceptual study focused on Saudi Arabia

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Abstract: This conceptual article aims to contribute to the literature by identifying and analyzing the four-stage model of building indigenous technological innovation capabilities in developing countries, particularly in Middle Eastern countries. In addition, this article explores factors affecting the environment and actors in the indigenous technological innovation capabilities

process and applies the indigenous technological innovation capabilities-building model to the Saudi Arabian context. The research question guiding this study is: What are the key factors and challenges in indigenous technological innovation capability building for Saudi Arabia, and how do they influence Middle Eastern firms? We propose a four-stage model of indigenous technological innovation capability building in developing countries, particularly Saudi Arabia. The model comprises four stages: technology initiation, technology imitation, technological improvement, and technological innovation. Finally, this study concludes with theoretical contributions and future work.

Keywords: Technological innovation; Indigenous innovation; Middle Eastern countries; Saudi Arabia

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1. Introduction

Technological innovation in the advanced and developing world has grown rapidly in the last few decades, and it seems that this growth trend will continue (Ali, 2021). With the evolution of economies from agriculture to industry-based in developing countries, technological advancement and development through industrialization have become increasingly inevitable (Chen & Lee, 2020; Ganda, 2019). Similarly, the management of

technological innovation is becoming important for competitive advantage and sustainable development (Algarni et al., 2023; Ali, 2021). Indigenous technological innovation capability building has emerged in recent years as a new development agenda not only in developing countries - Brazil, Russia, India, and China (BRIC), and Vietnam, Indonesia, South Africa, Turkey, and Argentina (VISTA), as well as Mexico, the Philippines, Thailand, and Malaysia (Kihombo et al., 2021; Yao et al., 2020)—but also in Middle Eastern countries such as Kuwait, the United Arab Emirates (UAE), Jordan, Lebanon, Morocco, Oman, Qatar, Iran, and Saudi Arabia (Chen et al., 2021; Habibi & Zabardast, 2020). Technology management is an inevitable issue in high-end technological and innovation organizations. Today, most innovations are limited to advanced countries, such as the U.S, Europe, Korea, and Japan, while developing and Middle Eastern countries, still have a long way to go (Park et al. 2011). The innovation and technology management environment in Middle Eastern countries is by nature problematic, characterized by poor business models, high unemployment, political instability, governance conditions, low education level, lack of world-class research universities and institutions, high military and security spending, an underdeveloped and mediocre physical infrastructure, ineffective public sector, and lack of solid technology based on trained human resources (Haabazoka, 2019; Pigato et al., 2020). Problems at the strategic level in Middle Eastern countries have restricted the development of technological management and innovation. For small and medium enterprises in countries with limited resources and relatively low national comparative advantage, economic development, science and technology policy, innovation, and technology management are much more difficult (Distanont & Khongmalai, 2020; Tu & Wu, 2021).

Against this background, this conceptual study attempts to analyze the indigenous technological innovation capabilities environment in Saudi Arabia, a Middle Eastern country. These arguments raise the following research question: What are the main factors affecting this environment, actors in the indigenous technological innovation capabilities process, and the application of the indigenous technological innovation capabilities-building model to this environment? To answer the research question, this study proposes a conceptual framework for analyzing and improving indigenous technological innovation capabilities in developing countries, particularly in Middle Eastern countries such as Saudi Arabia. Therefore, this study examines the overall environment of indigenous technological innovation capabilities in Middle Eastern countries. The following research question was incorporated, in accordance with the study objectives: 1) What are the key factors and challenges in indigenous technological innovation capability building for Saudi Arabia, and how do they influence Middle Eastern firms? Based on the current literature, there appears to be no significant information or studies highlighting the current state of indigenous technological innovation capabilities in Saudi Arabia. This study contributes to the literature on indigenous technological innovation capabilities in Saudi Arabia, as there is little literature examining indigenous technological innovation capabilities in the Middle East in general, and Saudi Arabia in particular.

The remainder of this paper is organized as follows. Section 2 describes the development stages of Saudi Arabia, based on its geographical location and global competitive index. In Section 3, we provide a conceptual definition of indigenous technology. The context of related work is discussed in section 4, and in section 5, the factors that improve technological innovation among Saudi firms are discussed. In Section 6, we present our analytical framework to strengthen the indigenous technological innovation capabilities of Saudi Arabia. Section 7 discusses implications, theoretical contributions, limitations, and directions for future research.

2. Theoretical background

2.1. Indigenous technological innovation

The concept of indigenous technological innovation is more appropriate in developing countries in general, and in Middle Eastern countries in particular. In most developing Middle Eastern countries, technological innovation is based on imitation and improvement of technology imported from advanced countries (Algarni et al., 2023; Ali, 2021). Developing nations have mostly improved their technology through the imitation, improvement, adaptation, or transformation of technology imported from developed nations (Ali, 2021). The term “technology” is a broad concept, some conceive it as patents, trademarks, or licenses, some conceive it as techniques, advertising, management, and manufacturing while some conceive it in terms of products, tools, equipment, or machinery (Hosseini et al., 2021; Lema et al., 2021). It is the integration of human know-how, equipment (tools, machinery, building, process, technological know-how, and technical skills), and knowledge about equipment, marketing, management, and organizational know-how. In today’s highly competitive globalized and technological advancement, firms or countries with obsolete technology, poor management, old ways of thinking, and obsolescent production processes cannot exist. Technological capability refers to the ability to effectively use technological knowledge in production, engineering, and innovation processes (Oke & Fernandes, 2020). Indigenous technological innovation is a firm’s ability to effectively use technological knowledge to use, adapt, change, and create new technology through imitation, improvement, and innovation (Kim et al., 1989). Indigenous technological innovation capabilities refer to technological innovation for local people and are developed by the local people (Kusumastuti et al., 2022). Indigenization means making technologies appropriate for the situations in which they are to be applied (Chen & Lee, 2020; Sun et al., 2021). Technology is developed for the local people, keeping in mind their specific needs, requirements, economic and political systems, social and cultural backgrounds, and regional and working environments. Indigenous technological innovation capabilities relate to local initiatives using local techniques and methods and indigenous knowledge, which are often non-documented and held by local people. These technologies fit the local environment and meet the specific needs and requirements of the local communities. Indigenous technological innovation capabilities can also be defined as technologies employed by the native inhabitants of a country, which constitute an important part of its cultural heritage and should therefore be protected against exploitation by industrialized countries (World Bank, 2021).

2.2. Related work

The concept of indigenous technological innovation capabilities is not appropriate for developing countries, the BRIC, and VISTA, but for Middle Eastern countries as well (Habibi & Zabardast, 2020). Several methods have been proposed for this purpose. These studies comprise conceptual concepts, theories, cases, models, frameworks, and empirical analyses (Chen & Lee, 2020; Cheng et al., 2021; Hosseini et al., 2021; Kihombo et al., 2021; Lema et al., 2021). This study only discusses the studies related to its theme (i.e., Almalki et al., 2013; Amirat & Zaidi, 2020; Li et al., 2022; Kim, 1997a,b; Kim, 1998; Kim, 1999; Park et al., 2011). The pattern and nature of technological innovation in developing Middle Eastern countries are different from those in developed countries (Li et al., 2022). Middle Eastern countries have improved their technology by imitating, adapting, and transforming it from that of developed countries. Most indigenous technological innovation capabilities in developed countries are based on scientific or

applied research, but in developing Middle Eastern countries, technological innovation comes from the imitation, improvement, and innovation of imported technology. Such indigenous technological innovation capabilities process is referred to as 3-I Strategy or 3-I Pattern which stands for imitation, improvement, and innovation (Chen et al., 2021).

Technological innovation and imitation capabilities constitute feasible approaches to enhancing competitive advantage in the global market. The capability to imitate is a distinctive strength of the firm, and a crucial approach towards developing business model technologies before moving on to the subsequent stages of technological innovation and growth. Imitating capability remains a popular tactic for firms (Zhou 2006). Developing processes and learning practices is essential for firms that aim to encourage innovation capabilities (Grant, 2010). The literature contends that learning processes contribute to a greater number of indigenous innovations. Individuals must acquire contemporary knowledge and disseminate knowledge within the organization to continually improve innovation (Jiménez-Jiménez & Sanz-Valle, 2011). Several studies have concluded that organizational learning has a beneficial relationship with innovation, consistent with previous arguments. For instance, previous studies have found a mediating role for organizational learning between external collaboration and innovation (Martínez-Costa et al., 2019), a positive relationship between learning and related processes and innovation processes (Valaei et al., 2017), a positive influence of organizational learning capabilities on technological innovation (Gomes & Wojahn, 2017), and a positive relationship between imitating capability and technological innovation (Zhou, 2006).

Several studies have proposed that process innovation in firms in developed countries follows product innovation (Xie et al., 2019). Li et al. (2022) suggest that in developing countries the process of innovation is more crucial than product innovation at the early stage. To strengthen indigenous technological innovation activities in developing Middle Eastern countries, other researchers have proposed a total innovation management (TIM) system that requires the alignment of deliberate indigenous technological innovation capabilities strategies with business strategy (Aslam et al., 2020). The systematic implementation of the TIM system would help Middle Eastern firms sustain new advanced technological innovation capabilities, engage in a winning technological path, and give rise to a set of non-conventional indicators to examine the technological capabilities of developing Middle Eastern firms. Porter's (2003) model proposes that a nation's development comprises three stages: (1) factor driven, (2) efficiency driven, and (3) innovation driven. The Global Risk Report integrated Porter's model of the development stages into 12 pillars of country competitiveness and two transition stages, as shown in Fig. 1. In the first stage, a country's economy is factor-driven and competes with natural resources and unskilled workers (Porter, 2003). At this stage, country competitiveness is based on pillars 1, 2, 3, and 4, as shown in Fig. 1.

2.3. Development stages in Saudi Arabia

Since its first recognition as an independent sovereign state under Abd Al-Aziz's domain in 1927 (Wynbrandt, 2010), Saudi Arabia has not recognized the importance of technology management, which is key to the sustainable development of a country's industrial development (Almalki et al., 2013). Saudi Arabia is a middle-eastern country located in Southwest Asia and the largest Arabian country. The geostrategic location of Saudi Arabia makes it a marketplace with possibilities, bordering the Red Sea, Persian Gulf, Bahrain, Qatar, and UAE on the East, Oman and Yemen on the South, Kuwait and Iraq on the Northeast, and Jordan in the North. It started with a pure cattle farming

economy, but its industrial wing soon gathered momentum and Saudi Arabia soon became a role model world over. Among the various sectors of the economy, the petroleum export sector has grown rapidly, reaching 42% of GDP, approximately 87% of budget revenue, and 90% of total export earnings in 2020 (Amirat & Zaidi, 2020). This exceptionally strong growth positioned Saudi Arabia as the fastest-growing economy in the Middle East. Fig. 2 shows the increasing growth in GDP per capita of Saudi Arabia from 1980 to 2021 compared to other Middle Eastern countries. The GDP of Saudi Arabia in 2021 was US\$ 833.54 billion, the GDP per capita was US\$ 18,695.94 and GDP (PPP) as a percentage share of the world total was US\$ 0.37 with a total population of 35.9 million (World Bank, 2021).

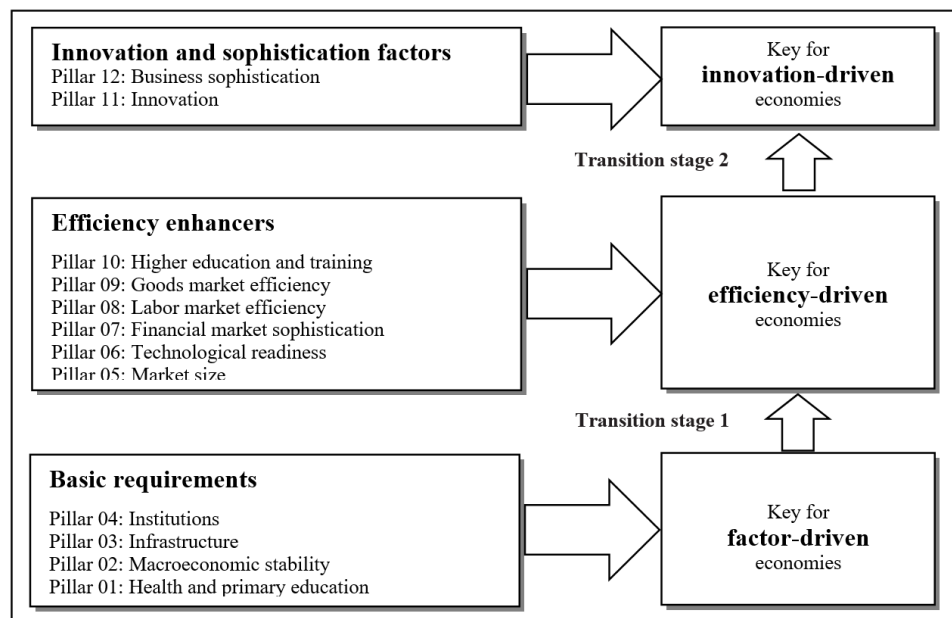


Fig. 1. Development stages: 12 pillars of competitiveness

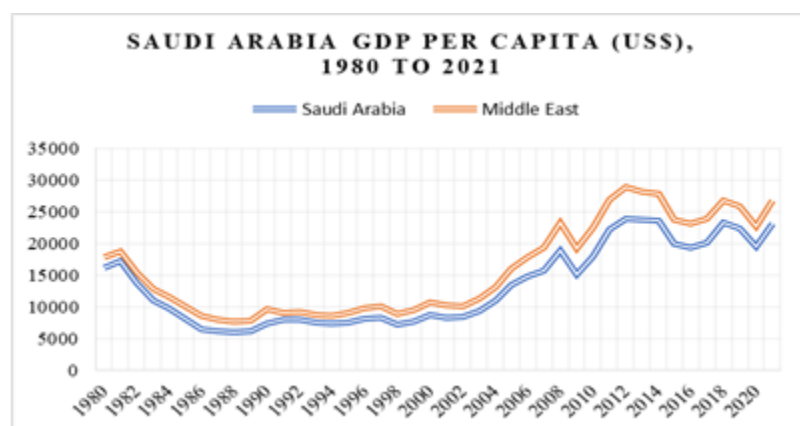


Fig. 2. Saudi Arabia's GDP per capita (US\$), 1980 to 2021

Emerging economies, which are at the vanguard of technological transformation, have witnessed significant increases in their technological capabilities. In certain sectors, they outperform their industrialized counterparts. For example, China experienced an enormous spike in the number of patent applications since 2000. Conversely, Technological innovation is expensive, hazardous, and route specific. This could provide developing nations such as Saudi Arabia with a justification for depending on the acquisition of foreign technologies to advance their technological capabilities. Most countries' advancements in productivity can be attributed in a significant way to imported technologies globally. In fact, most innovation activities occur in a select group of industrialized countries, mainly the US, Japan, and some EU nations. Thus, the global transmission of technology is essential for economic growth. If foreign technology is easily propagated and adopted, technologically deficient countries may advance ahead of other countries by promptly acquiring and implementing cutting-edge technological innovations (Chen et al., 2021; Vural, 2021).

Using numerous transmission methods, technology may advance between companies in Saudi Arabia as well as across nations and regions (Stoneman & Battisti, 2010). Among them are (i) the transmission of merchandise through worldwide trade; (ii) the flow of funding using foreign direct investment both inward and outward; (iii) the relocation of individuals through immigration, travelling, and educational exchanges of laborers and students; (iv) worldwide academic partnership; (v) the dissemination of autonomous knowledge using the media and Internet; and (vi) incorporation into worldwide value chains to reap benefits from foreign technology transmitted in the supply chain. Thus, Saudi firms can benefit from global research transmission at all stages of the technological innovation process. The effective incorporation of fresh external insights into the innovation process is becoming more essential as firms become more diverse in terms of technology.

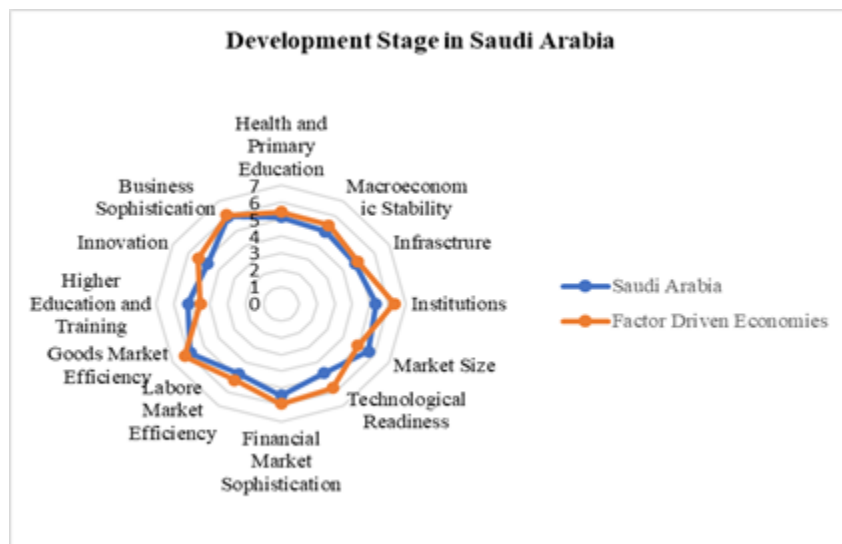


Fig. 3. Development stage in Saudi Arabia

The global competitiveness index (GCI) of Saudi Arabia is shocking. The GCI of Saudi Arabia fell from 36 (out of 140 countries) in 2021 to 27 (out of 134 countries) in 2008 (World Economic Forum, 2022). The country weakened across most of its GCI. Fig. 3 shows the average scores of the 12 pillars (see Fig. 3) for a total score of seven:

institution (5.32), infrastructure (4.78), microeconomic environment (4.94), health and primary education (5.12), higher education and training (5.20), efficient goods markets (5.86), labor market efficiency (4.78), financial markets (5.43), technological readiness (4.76), market size (5.65), business sophistication (5.93), and innovation (4.76). These figures confirm that Saudi Arabia must take serious action against many basic, efficient, and innovation-driven factors, as shown in Fig. 3.

It is safe to say that Saudi Arabia needs great effort to attract new technologies, but the technological environment needs to be explored. Researchers in the field are required to develop more science and technology strategies for Saudi Arabia, since it is still in the factor-driven phase (World Economic Forum, 2022). Like other developing and Middle Eastern countries, Saudi Arabia also needs to consider how to accelerate indigenous technological innovation capability and reduce its dependability on foreign technology.

2.4. Factors influencing indigenous technological innovation in Saudi Arabia

As a factor-driven economy, indigenous technological innovation capabilities in Saudi Arabia are influenced by several factors. The indigenous technological innovation capabilities environment in developing Middle Eastern countries is by nature poor government conditions, education, business model, technological readiness, management of technology, infrastructure, lack of finances, entrepreneurship, government interest in science and technology policy, and R&D (Asghar et al., 2021). As ITI is related to several complex factors, this study has identified several factors that affect the improvement of indigenous technological innovation capabilities in Saudi Arabia. These factors were derived and identified from previous literature related to indigenous technological innovation capabilities (Ali et al., 2009; Aubert, 2005; Sull et al., 2004) as follows:

2.4.1. Chief technology managers (CTM's)

Firms in Saudi Arabia still require technology executives and managers. Such firms often fail to develop local technological infrastructure and environments to assimilate imported technology (Habibi & Zabardast, 2020). Moreover, most engineers who graduate from developed countries apply their knowledge to local firms. These engineers have no idea how to approach local firms. It is expected that the concept of technology managers in Saudi Arabia will be highly appreciated. These managers must simultaneously have an interdisciplinary knowledge background of management, technology, engineering, and information technology (IT) at the same time. They can play different roles in organizational innovation and technology management (Mikalef et al., 2019), where technological improvements are based on indigenous requirements. Like other functional managers, technology managers are also crucial for high-end ITI in developing Middle Eastern countries, and Saudi Arabia is no exception.

2.4.2. Educational institutions

Quality higher education and training are crucial for dealing with any kind of technology. Continuous human resource development plays a significant role in the production and selection of appropriate technologies. In Saudi Arabia, the rank of both primary and higher education is 37 out of 139, while average scores are 5.12 and 5.2 respectively with a total score of 7.0 (World Economic Forum, 2022). Education and training are

significant barriers to the management of indigenous technological innovation. In Saudi Arabia, establishing a clear relationship between education and technology requires further effort. However, this process requires a systematic approach. Basic literacy is required during the early industrial phase. However, more technical and professional skills are required in the post-industrial phase. What is the source of a new idea or technology, one of them being educational institutions? In Saudi Arabia, the establishment of an environment where academics can share their research efforts with entrepreneurs is needed, and a commercialized approach should be searched for innovations and emerging technologies.

2.4.3. *Infrastructure*

Appropriate economic and social infrastructure is a critical necessity to ensure productivity and growth in today's highly competitive markets. The poor condition of infrastructure in Saudi Arabia is also a core issue for improving indigenous technological innovation capabilities. Infrastructure such as roads, railroads, ports, air transport, electricity supply, fixed telephone lines, and mobile users, and technological readiness such as firm-level technology absorption, FDI and technology transfer, and Internet broadband and bandwidth users need to be appropriately developed in Saudi Arabia to meet the challenges and requirements of indigenous technological innovation capabilities. Saudi Arabia's infrastructure has improved significantly in recent years, but the Kingdom may still require further technological innovation (Alaqeel & Suryanarayanan, 2019).

2.4.4. *Government supports*

The case of many industrialized countries, such as Japan, Korea, China, Taiwan, Singapore, Malaysia, and Singapore, shows that the government's role in developing indigenous technological innovation capabilities is very significant. Indigenous technological innovation is an activity that occurs under certain institutions and social, cultural, and political environments that are mostly controlled by the government (Chen & Lee, 2020; Cheng et al., 2021). In Saudi Arabia, many institutions in the public sector have been established to promote indigenous technological innovation capabilities; however, more appropriate policies are strategic levels are needed to identify the emerging areas of indigenous technological innovation capabilities and offer incentives to cover the identified gaps in indigenous technological innovation capabilities.

2.4.5. *Research and development (R&D) investment*

R&D investment in Saudi Arabia is less as compared with other middle eastern countries, UAE's investment in R&D, for instance, was US\$ 4.3 billion in 2020 as compared to Saudi Arabia's investment of US\$ 1.8 billion (World Bank, 2021). R&D institutions are crucial for indigenous technological innovation capabilities. The appropriate allocation of R&D investment, technological resources, and coordination between internal and external R&D results in a high level of indigenous technological innovation capabilities (Chen et al., 2021). In addition, developing linkages with educational institutions, research centers, and firms is necessary to improve indigenous technological innovation capabilities. Establishing an appropriate R&D structure is a dire need to improve indigenous technological innovation capabilities in Saudi Arabia. Research activities, such as basic and applied research and experimental development, need to be adapted to local needs and capabilities (Alam et al., 2019; Alam & Murad, 2020).

2.4.6. *Entrepreneurship*

Economists view entrepreneurship as a combination of innovation and risk-taking (Llanos-Contreras et al., 2020; Williams et al., 2021), while others view entrepreneurship and innovation as the most powerful engines of economic growth and progress. Entrepreneurship plays a pivotal role in technological innovation (Kihombo et al., 2021). New ideas can only be commercialized through entrepreneurship. In Saudi Arabia, the government has to revisit its policy on entrepreneurship, which needs to be encouraged at the individual, firm, and country levels. Indigenous technological innovation capability is the capability to create new products and services, whereas entrepreneurship is the capability to apply it to commercial ends.

2.4.7. *Financial institutions*

Innovation is an expensive activity (Sullivan, 2005), and financial resources are required to initiate, direct, and sustain it. In a middle-eastern country such as Saudi Arabia, it becomes more crucial to finance indigenous technological innovation capabilities. ITI demands high investments, and firms in developing Middle Eastern countries are not ready to initiate such projects. Previous studies have discussed the relationship between innovation and finance in the context of micro-and macroeconomics (Blach et al., 2020; Effiom & Edet, 2022). The financial system in Saudi Arabia has grown substantially (Oladapo et al., 2022), but linking indigenous technological innovation capabilities with financial institutions is a challenge. This factor greatly influences indigenous technological innovation capabilities, and further research is needed to determine how finance plays its role more effectively and efficiently.

3. **Proposed framework**

This section presents a framework analysis showing how the indigenous technological innovation capabilities process may initiate, improve, adapt, and create innovative processes, products, services, or technology. As mentioned earlier, due to the lack of environmental stability, social and economic systems, coordination, and linkage development among educational institutions and the business world, technological infrastructure, technological capabilities, upgradation of knowledge and skills in the context of the country's specific technical and financial institutions, R&D, financial institutions, poor entrepreneurship, and technological innovation process are Saudi Arabia needs to pay much more attention. Considering the technological environment in Saudi Arabia, it is safe to suggest an indigenous technological innovation capabilities framework, as shown in Fig. 4. This framework is based on parenting and extensive research (Ali & Park, 2013; Kim, 1997a,b; Kim, 1998; Kim, 1999; Park et al., 2011). The details of the framework are as follows.

3.1. *Stage I: Technology initiation*

Like other Middle Eastern countries, Saudi Arabia has failed to develop indigenous technological innovation capabilities. In the early stages of technology development, multinational firms in developed countries are a major source of technological initiation in Middle Eastern countries, and Saudi Arabia is no exception. These firms are reluctant to share technology and knowledge with the local firms. Such a situation creates “creative crisis destruction” in which local firms enter Stage I. As shown in Fig. 4 that “imported technology from abroad” is the antecedent of technology initiation. At this stage, the

initiation of the indigenous technological innovation capability process is crucial. This may also refer to the technology identification stage, but no technology has yet been acquired. Firms search, discover, identify, and initiate technology acquisition. Technology needs assessment must be carried out among end users, including educational institutions, R&D centers, and firms. Developing Middle Eastern countries then search for where they may find the required technology. Thus, they may look forward to firms in developed countries. The complexity of the technology determines how it is acquired. Technology with high complexity and availability may need to be purchased. Technology with high complexity and low availability can be acquired through reverse research, development, and engineering (RD&E). Technology with low complexity and high availability may be acquired through payments or indigenous R&D efforts, while technology with low complexity and low availability may be acquired through indigenous R&D efforts. It is important to ensure that the technology acquired abroad meets the needs and requirements of the local environment and end users. It is also important to assess the complexity of the identified technology if it can be easily maintained and repaired by the local people. The available resources in Saudi Arabia and their expertise suggest that Saudi Arabia must depend on other technologies. The government's role is crucial in developing a better relationship with developed countries. Initiating indigenous technological innovation capabilities at this stage, Saudi Arabia needs to focus on the good functioning of public and private institutions (pillar 1), appropriate infrastructure (pillar 2), a stable macroeconomic framework (pillar 3), and a healthy and literate workforce (pillar 4; World Economic Forum, 2022).

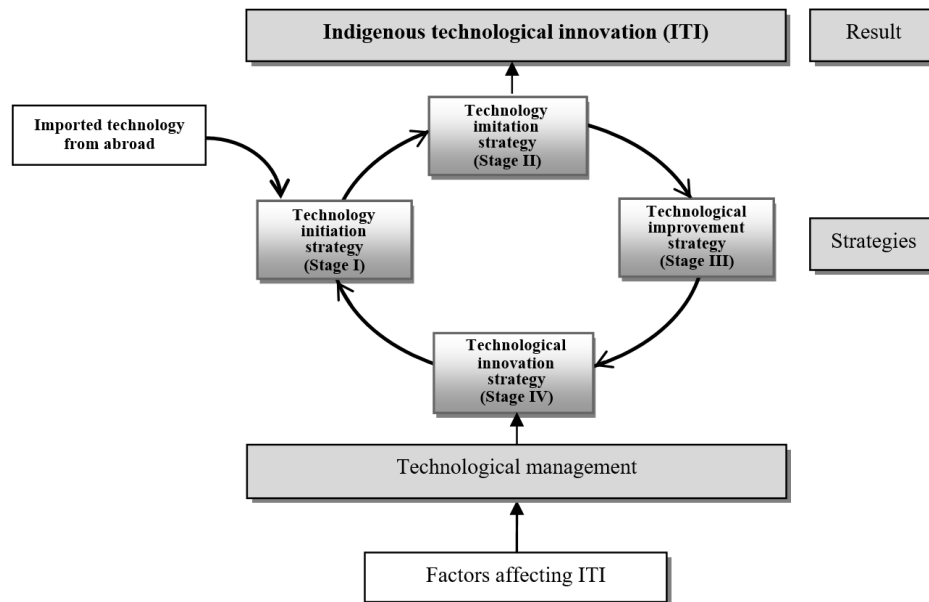


Fig. 4. Indigenous technological innovation capabilities building framework

3.2. Stage II: Technology imitation

The second stage is technology imitation. Firms in Saudi Arabia lack the ability to meet current local needs and requirements. Various firms have no detailed ideas about the technology they need. They also have no detailed idea of the kind of technology being bought and what will be the consequences of its application (Hosseini et al., 2021; Lema

et al., 2021). Firms face challenges because of the unavailability of parts and skilled mechanics for the maintenance of imported technology. As a result, they fail to develop indigenous technological innovation capabilities for the assimilation of imported technology. Firms must depend on imported technologies. At this stage, local experts are unable to develop their technology. In Saudi Arabia, the quality of local expertise is low, and they need to follow duplicate imitation (Alaqeel & Suryanarayanan, 2019; Almalki et al., 2013). Firms may acquire foreign technologies and assimilate imported ones. Initially, firms pursue imitation and establish indigenous technological innovation capabilities through reverse engineering and the implementation of imported “packaged” technology from advanced countries. Owing to the high complexity and availability of technology, firms may simply buy the technology and implement it. This may allow firms in Saudi Arabia to improve their local expertise to prepare them for the next stage. At this stage, firms still need to focus on strengthening institutions (pillar 1), quality of higher education (pillar 1 and pillar 5), appropriate infrastructure (pillar 2), stability of markets (pillar 3 and pillar 7), and a healthy and literate workforce (pillar 4; World Economic Forum, 2022).

3.3. Stage III: Technological improvement

The third stage is technology improvement, which refers to modifying and improving imported technologies. Most developing Middle Eastern countries have adapted technologies developed in developed countries. Firms in Saudi Arabia may modify and improve such technologies to make them more suitable for use in specific working environments. These changes may occur in response to new or modified surroundings. Such modifications and adjustments may be in the technology structure, mechanics, and process, or in use to make it more suitable for use in the local environment. Owing to these differences, the technology developed in developed countries cannot be easily applied in developing Middle Eastern countries, and firms need proper technology improvement strategies. In Saudi Arabia, firms’ technological improvement is relevant to the modern industrial sector of their economies and aims to improve and adapt modern technologies to the needs of their indigenous markets (Chen & Lee, 2020; Sun et al., 2021). These technologies include low-tech industries, such as food processing and textiles, and clothing to high-tech industries, such as pharmaceuticals, automotive, and even computers. With respect to these technologies, this stage involves improving and modifying existing products to meet the needs of the indigenous markets. It also involves adapting the existing process technologies suitable for indigenous resource endowments and climate change, and improving the technology delivery system and organizational structure suitable to the indigenous social, cultural, and political environment. At this stage, firms in Saudi Arabia need to focus on higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labor markets (pillar 7), sophisticated financial markets (pillar 8), a large domestic or foreign market (pillar 9), and the ability to harness the benefits of existing technologies (pillar 10). At this stage, Saudi Arabia needs to focus on higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labor markets (pillar 7), sophisticated financial markets (pillar 8), a large domestic or foreign market (pillar 9), and the ability to harness the benefits of existing technologies (pillar 10; World Economic Forum, 2022).

3.4. Stage IV: Technological innovation

The fourth and final stage in improving indigenous technological innovation capabilities in Saudi Arabia is technological innovation. This stage makes firms fully capable of

generating their technology by using their indigenous technology, learning capabilities, and R&D efforts. During this stage, firms become capable of refining, broadening, and leveraging existing technologies and competencies, and creating new technology and competency by integrating imitated and improved technology (Zahra & George, 2002). Firms become competent to innovate without assistance from firms in developed countries once they borrow technology. This results in firms that imitate technology becoming innovative and leading companies to generate their own indigenous technological innovation capabilities. Technology development in this stage may not be commercialized at the global level, but these become new sources of indigenous technological innovation capabilities at the national level. The real problem is to identify, objectify, and patent these innovations and then commercialize them at the national level. Finally, as countries move into the technology innovation stage, firms must focus on continuous innovation to produce new and different goods using the most sophisticated production processes (pillar 11) and compete with new and unique products through innovation (pillar 12; World Economic Forum, 2022).

3.5. Process of content analysis

Content analysis was used to analyze the qualitative data collected in this study. Content analysis is an effective method to deconstruct any subject, particularly when combined with normal quantitative research methodologies. This method enables the analysis of data in a systematic and objective manner, focusing on identifying patterns, themes, and relationships within the data (Krippendorff, 2018). During content analysis, we attempted to determine the wider context of how individuals perceive and perform. This study adopted the following steps to analyze data using the content method approach: (1) Collected previous research materials related to indigenous technological innovation for evaluation in order to produce the content for this study, (2) developed a predetermined list of categories from developed and developing countries about technological innovation; (3) decided on the frequency of a concept, which means we determined the number of times the concept indigenous technological innovation was mentioned in previous studies, (4) created coding rules for technological innovation to distinguish among different concepts; (5) ignored the irrelevant information collected from previous literature in this study, and finally (6) analyzed the findings of this study, provided theoretical contributions, and drew conclusions.

4. Theoretical contributions

This study contributes to the literature in multiple ways by utilizing theories of organizational design and knowledge management. First, it considers the structure of organizations as a possible precursor to indigenous technological innovation capabilities. It then establishes a uni- and bi-modal connection between the structural variables and indigenous technological innovation capabilities. Further, the study establishes an association between the structural variables and indigenous technological innovation capabilities and a two-stage model consisting of a conceptual stage and an implementation stage. Finally, this study suggests a uni- and bi-modal relationship between organizational structure and indigenous technological innovation capabilities.

This literature review discusses the uni- and bi-modal relationships between organizational structure and indigenous technological innovation capabilities. There is a conceptual correlation between these four structural factors and the ability of developing countries to innovate technologically. Multiple components of these factors affect the

initiation and implementation phases of a multivariate framework. Prior studies have discussed indigenous technological innovation capability interaction from the perspective of structure in a deterministic context. Previous research suggests that an organization's structure should change as it develops its capacity for indigenous technological innovation capabilities in different phases (Park et al., 2011b). Therefore, a functional structure that prioritizes distributed decision-making, flexibility and adaptability, effective organizational communications, and elaborate dignified regulations is preferable in the early stages (Slevin & Covin, 1997). Subsequently, while implementing strategies, a mechanistic structure (with distributed decision-making, rigid adherence to clearly specified regulations, absolute control on communication channels, and carefully orchestrated reporting and workflow interactions; Slevin & Covin, 1997) is preferable. Nonetheless, the significance of organizational learning in the development of indigenous technological innovation capabilities has been neglected in this conceptual framework. The organizational type should determine whether exploratory and exploitative learning play a moderating or independent role in the association between an organization and its indigenous technological innovation capabilities (Pierce & Delbecq, 1977). For instance, it is ambiguous how uni- and bi-modal exploratory and exploitative learning moderate the association between organizational structure and indigenous technological innovation capabilities.

To define behavior and impact the efficiency and effectiveness of indigenous technological innovation capabilities, organizational structure shapes patterns, and the frequency of interactions among members of the organization; designates venues for decision-making; and requires adherence to systematic specific guidelines, rules, practices, directions, and collaboration in undertaking organizational functions associated with indigenous technological innovation capabilities. How knowledge is structured, how knowledge management practices are integrated, and how deeply knowledge management techniques are ingrained in day-to-day operational activities influence the efficiency and efficacy of organizational innovation and performance (Zheng et al., 2010).

Analyzing the depth and breadth of knowledge and competence that contribute to indigenous technological innovation capabilities further influences this aspect of indigenous technological innovation. Reduced costs and the ability to provide distinct products and services are favored because of the process's diversified knowledge and skills (Damanpour & Schneider, 2006; Damanpour, 1991, 1996). Having a formalized structure in place to coordinate and connect the actions of various actors within the organization can be useful for fostering the growth of indigenous technological innovation capabilities.

5. Conclusions, limitations, and recommendations for future research

Building indigenous technological innovation capabilities is a new development agenda for any developing Middle Eastern country (Chen & Lee, 2020), including Saudi Arabia. This paper explores indigenous technological innovation in the context of developing countries in general and Middle Eastern countries in particular, using it for the case of Saudi Arabia. This study attempts to identify the key factors and challenges in building indigenous technological innovation capability in Saudi Arabia, which requires thorough investigation. The experiences of developing Middle Eastern countries show that they also have strong potential for innovation and technology management. Indigenous technological innovation capabilities in Saudi Arabia are still poor and in their early stages, so they can learn from the experiences of other Middle Eastern countries. Keeping in mind the resources available and from the experiences of developing Middle Eastern

countries, four stages of the indigenous technological innovation capabilities process model are proposed to improve indigenous technological innovation capabilities in Saudi Arabia. It is believed that this study will contribute in a timely manner to the indigenous technological innovation capability-building literature in Middle Eastern countries, particularly Saudi Arabia. Little literature examines indigenous technological innovation capability building in Saudi Arabia. Future considerations for research involved the empirical study of generalizability and how each actor, as shown in Fig. 4, can contribute to the indigenous technological innovation capabilities environment in developing Middle Eastern countries and in Saudi Arabia.

Finally, because of its emphasis on Saudi Arabia and the application of qualitative content analysis, this study has the following limitations. The validity of the proposed framework was substantiated by qualitative latent content analysis. Consequently, the framework requires quantitative research to ensure its generalizability across sectors and nations with homogeneous developmental structures in Saudi Arabia. Policymakers and managers in emerging economies, along with those in the Middle East, will reveal their implications in fostering indigenous technological innovation capabilities to be particularly instructive. Organizations in the developing Middle East and elsewhere can gain useful information from corporations' experiences in more technologically advanced countries. The indigenous technological innovation capabilities of newcomers or followers hampered by a resource shortage and specialized knowledge can be brought up to speed through a mechanism of initiation, imitation, improvement, and innovation. Second, the latent content analysis method is appropriate but less trustworthy. Finally, there is a chance of sample bias because this study used existing materials generated for various functions and has been published by various authors. The authors strategize to use their observations to conduct a research study and indicate both internal and external factors that influence technological learning and indigenous technology innovation capability at the organizational level from the middle-eastern perspective. Furthermore, scientific data can be utilized to formulate hypotheses, demonstrate associations between key variables, and identify the factors that can ultimately improve the framework across stages (Fig. 4), from which scholars, executives, and policymakers may derive implications.

Author Statement

The authors declare that there is no conflict of interest.

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