

## Article

# Nexus of Innovation Network, Digital Innovation and Frugal Innovation towards Innovation Performance: Investigation of Energy Firms

Abdelmohsen A. Nassani <sup>1</sup>, Crenguta Sinisi <sup>2</sup>, Loredana Paunescu <sup>3</sup>, Zahid Yousaf <sup>4,\*</sup>, Mohamed Haffar <sup>5</sup> and Ahmad Kabbani <sup>6</sup>

<sup>1</sup> Department of Management, College of Business Administration, King Saud University, P.O. Box 71115, Riyadh 11587, Saudi Arabia; nassani@ksu.edu.sa

<sup>2</sup> Department of Management and Business Administration, University of Pitesti, 110040 Pitesti, Romania; crengutaileana77@gmail.com

<sup>3</sup> Department of Cybernetics, University of Petrol & Gas, 100680 Ploiesti, Romania; loredana.paunescu@yahoo.com

<sup>4</sup> Higher Education Department, Government College of Management Sciences, Mansehra 23100, Pakistan

<sup>5</sup> Department of Management, Birmingham Business School, Birmingham B15 2TY, UK; m.haffar@bham.ac.uk

<sup>6</sup> Business Administration Department, Cordoba Private University, Aleppo 15310, Syria; ahmadkabbani@cpu.edu.sy

\* Correspondence: muhammadzahid.yusuf@gmail.com

**Abstract:** The present research aims to find how firms achieve innovation performance through innovation networks. This study also explores the mediating role of digital innovation and the moderating role of frugal innovation. Quantitative research design is used for data collection and analysis. To analyze the study's hypotheses we select the energy firms which aim to attain innovation performance. An indirect effect with Sobel test was used to check mediation analysis. The results proved that the innovation performance of energy firms is predicted by innovation networks. Our findings proved that digital innovation acts as a mediator between innovation networks and innovation performance links. Our results also show that frugal innovation strengthens the interplay between innovation networks and innovation performance links. This study highlights how energy firms can stabilize innovation performance through the combined influence of innovation networks, digital innovation and frugal innovation. The managers of energy firms should prefer innovation networks to update their knowledge about the upcoming/latest procedures to achieve innovation performance. Moreover, the role of digital innovation in the current digital world is also very important, and the present study used it as mediator.

**Keywords:** energy firms; innovation network; digital innovation; frugal innovation; innovation performance



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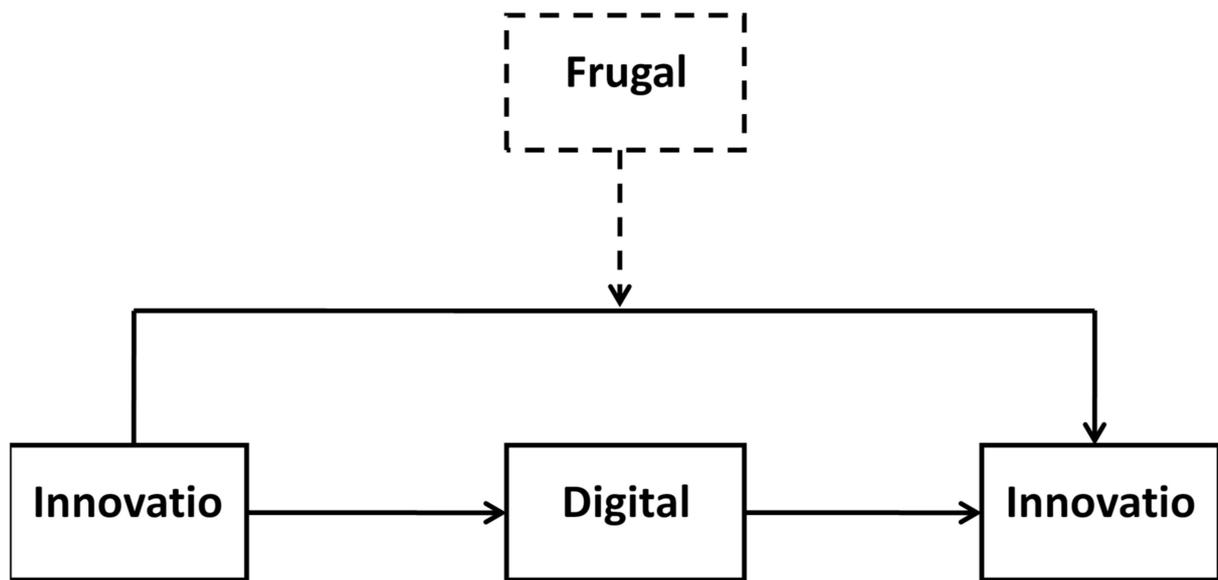


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## 1. Introduction

In the current digital-economy, the concept of innovation performance has been largely explored by innovation researchers to generate competitiveness for all types of firms [1]. Energy firms mainly depend on the constant and significant role of innovation networks to acquire innovation performance. At the same time, digital innovation is also documented as the formation of an advanced method for undertaking economic operations by means of new digital internet technologies to attain the purpose of innovation performance [2,3]. The innovation networks are considered a rapidly emerging-phenomenon for energy firms to increase their innovation performance [4,5]. The innovation technologies in marketing, product development and various strategies have contributed considerably to changing the businesses prototype of different firms such as energy firms [6]. Prior studies merely carried out research and investigated the prerequisites that can determine the growth of innovation performance in energy firms [5,7]. Moreover, research studies overlooked numerous vital factors that accelerate and enhance innovation performance inside energy firms so far.

Previous researchers barely highlight innovation performance and its determinants in manufacturing firms [8,9], acquiring firms [10] and low technology firms [11], but do not enlighten as to the achievement of innovation performance in energy firms. The accomplishment of enhanced innovation performance for energy firms is a complex and tricky job, and there is also an enormous need to use strong innovation networks [8]. Several preceding studies have been conducted on energy firms, but they focused on variables such as financial performance or environmental performance, which helps to boost and improve firm performance, although in prior studies innovation networks are not discussed as a mechanism that boosts the innovation performance of energy firms in Saudi Arabia [12]. This study contributes through offering an innovation performance model for energy firms. Our study model is unique, as we used three different variables, namely innovation networks as an independent variable, frugal innovation as a moderator of the association between innovation networks and innovation performance and digital innovation as a mediator between them. The purpose of our study is not to describe only the effects of innovation networks on innovation performance, but also to explain the accelerating outcomes of digital innovation and innovation performance through support of innovation networks. In this study, we empirically test their influence and outcomes into improved innovation performance. Therefore, the aim of our study is to improve and boost the innovation performance of energy firms in the Arab world. The digital economy submits all economic operations and activities that are based upon digitized internet-related information and knowledge [13]. The outcomes of the digital economy in business enterprises are frequent, and this modified change of focus is particularly profound in energy firms [14]. After the emergence of advanced digital technologies, the temperament of business activities in the 21st century around the world has been transformed [15]. Delivery of services through the use of digital technologies requires innovation networks for the implementation of innovative business models [8]. Innovation networks drastically change the procedure and results of innovation performance due to their ontology and their particular nature [13]. The change activated by innovation networks is mostly different from those changes activated through traditional means and information-technologies because it used advance means to process and also gather huge amounts of information [15]. The innovation network has become a fundamental part of the novel business model that put its print on digital innovation and innovation performance [16]. The innovation network accelerates the process of innovation via mobilizing and integrating internet technologies and human resources [17]. Several researchers have proposed that firms face various huge problems for running and adapting to digital change due to a lack of innovative resources and capabilities. The innovation network ensures integration and the transformation of digital-technologies for digital innovation and innovation performance [16]. Therefore, innovation networks play a vital role in digital innovation towards novel business models. Moreover, innovation networks help in offering the right direction for achieving innovation performance, and this mechanism is more authentic via digital innovation [18]. Previous researchers have suggested different features that are outcomes of innovation networks, and at the same moment, they certainly influence innovation performance. One main outcome of innovation networks is digital innovation that sequentially affects innovation performance. Thus, in our research we draw attention to this gap and investigate the mediation effect of digital innovation between innovation networks and innovation performance. In this study, we theorize that innovation networks sustain the modification of the resources of an organization with rising technologies, which eventually determine the improvement of the innovation performance [12]. This research also recognized the moderating role of frugal innovation between innovation networks and innovation performance. The paper arrangement is designed in this way. The second section contains literature review findings concerning innovation networks and innovation performance. The next section shows the methodology and data analysis. The final section comprises a discussion, an examination of implications and a conclusion, along-with limitations and future directions. Figure 1 shows the theoretical framework of this study.



**Figure 1.** Theoretical Framework.

## 2. Literature Review

### 2.1. Innovation Network and Innovation Performance

An innovation network includes informal and formal associations that exist among organizations, and this linkage can be used to acquire reports, system knowledge, implicit knowledge and software to enhance innovation performance [19]. Innovation networks make it easier for organizations to get needed resources and information for improving innovation performance [20]. The structural attributes of an innovation network will have an effect on integration, utilization and absorption of knowledge into an organization, therefore affecting the innovation performance of the firm [21]. Firms can transform and take in a huge amount of implicit and invisible knowledge via innovation networks, by maintaining adaptability to rapid changes that are important for enhancing innovation performance [10]. Innovation networks enable firms to adapt advanced innovation capabilities by effective gathering of new knowledge to improve innovation performance [22]. They provide platforms to firms for innovative knowledge learning and accept rapid changes to increase new knowledge and the innovation performance of firms [23].

**Hypothesis 1 (H1).** *Innovation network and innovation performance is positively associated.*

### 2.2. Digital Innovation as Mediator

Innovation networks help firms to acquire more information, new methods, knowledge and ideas through digital innovation regarding increasing their innovation performance [24]. They facilitate firms in knowledge acquisition for the development of new products and quick adaptation to new emerging digital innovation technology trends, as well as mobilization of their resources to improve innovation performance [25]. Innovation networks know how to increase opportunities for technological interactions and thinking collisions among organizations, which can greatly augment the development of digital innovation in firms, which eventually leads to improved innovation performance [22]. Innovation networks allow organizations to continuously obtain technologically innovative knowledge and information via digital innovation and merge this information with internal knowledge, generating many new ideas and concepts of product development in the organization for enhancing innovation performance [26]. However, digital innovation acts as a bridge between innovation networks and innovation performance. Digital innovation facilitates the use of existing resources and adoption of new market trends by firms to structure new products and improve existing ones [27]. Innovation networks provide

a large amount of technical and technological knowledge for the attainment of digital innovation in firms to increase and enhance innovation performance [28].

**Hypothesis 2 (H2).** *Innovation network and innovation performance is mediated by digital innovation.*

### 2.3. Frugal Innovation as Moderator

Frugal innovation is related to the resources of an organization that are organized in such a way as to provide an uncertain environment for firms to perform their activities in transformed patterns and to move forward and become innovative [29]. Frugal innovation contributes to fulfilling the demands of customers who are unable to approach the existing products and services [30]. Previous studies have been enlightening regarding the progressive function of innovation networks in the enhancement of frugal innovation [31]. Frugal innovation adds to the strength of the link between innovation networks and innovation performance. Innovation networks perform a considerable role and facilitate the implementation of innovation activities that eventually enhance innovation performance [32]. Frugal innovations support organizations to engage in successful advance innovative activities, which speed up their services, underserve their customers and augment their innovation performance [33,34].

**Hypothesis 3 (H3).** *Frugal innovation plays a moderating role between innovation networks and innovation performance.*

## 3. Methodology

### 3.1. Data Collection

A cross-sectional research design was used and data were collected once and at a specific time. We initially contacted 205 energy firms, among which 117 SMEs responded to participate, and we distributed 475 questionnaires (1 to 5 questionnaires in each firm). However, the final collection of responses that were usable for analysis produced only 387. The respondents include owners, operational managers, quality managers and IT officers. The research was conducted between September 2021 and December 2021. We followed the general principles of ethics and sent a cover letter explaining our research purpose. We ensured participants' secrecy and data confidentiality. Table 1 shows respondents details.

**Table 1.** Characteristics of Survey Sample ( $n = 387$ ).

Work Experience (Years)	Business Age (Years)
1 to 525 (6.45%)	1 to 595 (46.34%)
6 to 1095 (24.54%)	6 to 1010 (4.87%)
11 to 15,112 (28.94%)	11 to 1558 (28.29%)
16 to 2028 (7.23%)	16 to 229 (14.14%)
More than 20,127 (32.81%)	More than 2013 (6.34%)

### 3.2. Measurement

The information regarding the independent variable (innovation network), the mediating variable (digital innovation), the moderating variable (frugal innovation) and the dependent variable (Innovation Performance) was acquired from managers and owners of the various SMEs.

#### 3.2.1. Digital Platform

The digital platform was measured through an 8-item scale, which is adapted to the prior designed scale [35].

### 3.2.2. Innovation Network

For the measurement of innovation networks, a 5-item scale from a previous work was used [36].

### 3.2.3. Innovation Performance

For the measurement of innovation performance, a 7-item scale was used [37].

### 3.2.4. Frugal Innovation

The moderating role of frugal innovation was measured through 9 items [38].

### 3.2.5. Controls

Age, educational level and field experience of the respondents was controlled for to gain a good understanding of the relationship between innovation networks, innovation performance and digital platforms.

## 4. Analysis

### Measurement Scale

SPSS 21 software was utilized to examine the data. According to [39], the variables' validity was tested by CFA. The model was fitted to the data by the process of structural equation modeling [40] was used for checking the mediation effect of DI, while to examine the moderation effect, multiple moderated regression analysis was utilized. A four-factor model proved fitness ( $\chi^2 = 1056.42$ ,  $df = 470$ ;  $\chi^2/df = 2.248$ ;  $RMSEA = 0.05$ ;  $CFI = 0.93$ ;  $GFI = 0.92$ ).

Discriminant and convergent validity (CR) was also checked. The AVE procedures were examined to test the convergent validity. According to [41], this technique was utilized to test the discriminant validity. Table 2 shows that all values are confirmed and CR and AVE were higher than the cutoff points, i.e., CR was greater than 0.70, AVE was greater than 0.50 and CR was greater than the average variance extracted.

**Table 2.** Results of Alpha, CR and AVE.

Variable Detail	FL	T-Value	Alpha	CR	AVE
Innovation Network			0.83	0.92	0.73
IN-1	0.83	15.46			
IN-2	0.77	15.36			
IN-3	0.82	14.55			
IN-4	0.76	14.54			
IN-5	0.82	13.21			
Digital Innovation			0.86	0.94	0.72
DI-1	0.78	15.42			
DI-2	0.82	15.55			
DI-3	0.76	14.31			
Frugal Innovation			0.84	0.96	0.74
FI-1	0.82	15.45			
FI-2	0.78	14.55			
FI-3	0.86	13.56			
FI-4	0.78	15.54			
FI-5	0.76	14.22			
FI-6	0.81	13.52			
FI-7	0.85	14.56			
FI-8	0.75	15.42			
FI-9	0.73	14.53			
Innovative Performance			0.82	0.93	0.76
InnP-1	0.82	15.77			
InnP-2	0.78	14.52			
InnP-3					
InnP-4	0.86	13.67			
InnP-5	0.75	14.21			

Table 3 presents the value of correlation, standard deviations and means value. Innovation networks are positively associated with innovative performance ( $r = 0.26$ ). Digital innovation is positively associated with IP ( $r = 34$ ). Furthermore, frugal innovation is positively associated with innovation performance ( $r = 36$ ).

**Table 3.** Descriptive.

Variable	Mean	SD	Alpha	1	2	3	4	5	6	7	8
1 Bus-Age	3.05	1.04	0.82	1.00							
2 Bus-Size	1.26	0.44	0.85	0.116 **	1.00						
3 Experience	1.86	0.41	0.83	0.215 **	0.86 *	1.00					
4 Education	1.62	0.56	0.80	−0.03	0.07	1.00	1.00				
5 Innovation Network	3.74	0.47	0.87	−0.02	−0.18	0.01	−0.10	1.00			
6 Digital Innovation	3.43	0.56	0.85	0.04	−0.05	0.093 *	−0.02	0.164 **	1.00		
7 Frugal Innovation	3.62	0.72	0.83	−0.09	−0.15	−0.04	0.085 *	0.347 **	0.347 **	1.00	
8 Innovative Performance	0.23	0.45	0.84	0.03	−0.12	−0.05	−0.12	0.260 *	0.349 **	0.365 **	1.00

Note: \* = 0.01; \*\* = 0.05.

To check the research hypothesis, Structural equation modeling was utilized. Table 4 shows that IN predicts IP ( $B = 0.16$ ,  $p = 0.000$ ). The results proved that innovation networks set basic foundations for knowledge integration and the newest information. These novelties confirm innovation performance among energy firms through the creation of innovation networks.

**Table 4.** Direct effect Emotional Intelligence on Innovative Performance.

Model Detail	Hypothesis Detail	Beta Value	F	T	Sig	Remarks
Model #1	IN → IP	0.16	15.065	0.148	0.000	Accepted

To check the mediating effect of digital innovation between innovation networks and innovative performance, the analysis outlined in [42] was used. Path ‘ab’ shows the results of indirect effects in the last section of Table 5. Indirect effect results shows that DI acts as a mediator (Beta = 0.16, Low = 0.1242 to Up = 0.2685). A normal test was also conducted to check the mediation effect of DI. Thus, H2 was proved, and it is proved that the link between IN and IP is mediated through DI. IN is a direction that enables firms to use digital technologies and all the latest IT-based information. Moreover, digital innovations become more prosperous through the newest knowledge provided by innovation networks. This digitalization/innovation confirms IP among energy firms.

**Table 5.** Mediator Digital Innovation.

Paths Description	Beta	T-Value	SE	Sig		
Innovation Network to Digital Innovation (Path a)	0.348	7.453	0.042	0.000		
Digital Innovation to Innovation Performance (Path b)	0.246	7.236	0.052	0.000		
Innovation Network to Innovation Performance (Path c)	0.324	3.652	0.067	0.000		
Innovation Network to Innovation Performance (Path c')	0.158	1.432	0.066	0.148		
Model: $R^2 = 0.1222$ ; $F = 31.7321$ ; $p = 0.000$						
<b>Bootstrap with indirect effect “ab path”</b>						
Model Detail	Data	Boot	SE	Lower	Upper	Sig
IN-DI-IP	0.164	0.145	0.42	0.1242	0.2685	0.0000

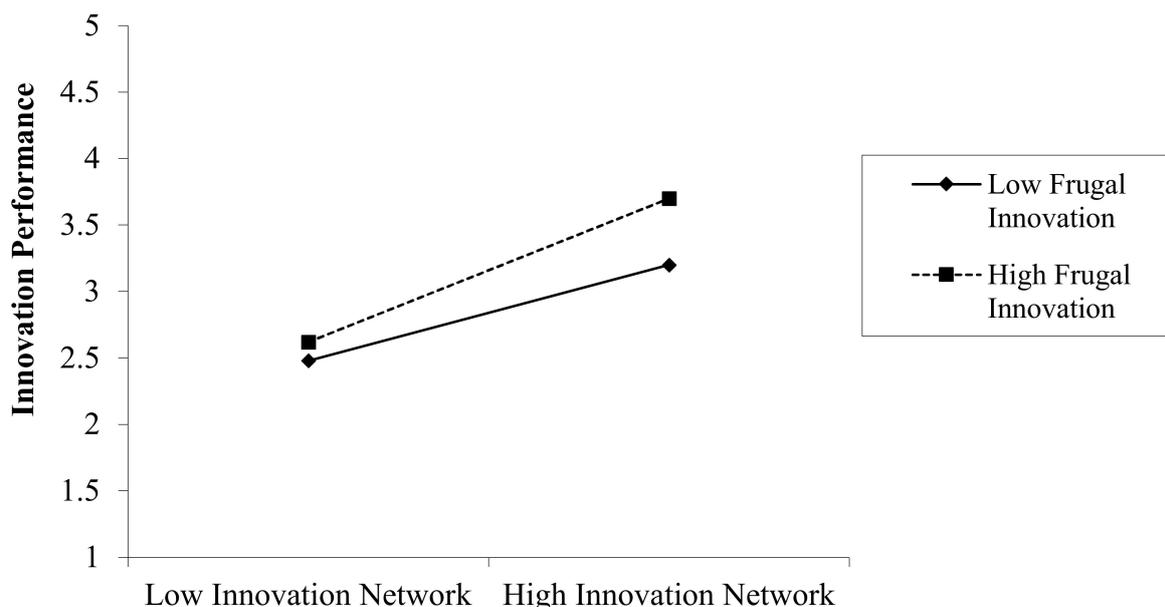
H3 suggests that frugal innovation plays a moderator role in the connection between innovation networks and innovation performance. To investigate H3, we used multiple-moderated regression. Control variables were added in the first step, and in the second step, an innovation network and FI (IN \* FI) were added. Finally, in the third step, a relationship between IN and FI was entered, and all values presented the significant impact of IN and FI on IP, shown in Table 6. The results show that the combined effect of IN-FI (Beta = 0.26,  $p \leq 0.05$ ) on IP is positive ( $p =$  less than 0.05). The results also proved that FI strengthens the relationship between IN and IP; therefore, H3 is proved. Although the direct impact of IN on IP is positive, the role of FI is very important to strengthen this effect. Frugal innovation enables firms to cope with challenges in a cost-saving manner, which helps energy firms to achieve IP through IN in a more enthusiastic way.

**Table 6.** Moderating role of the Frugal Innovation.

Detail	IP					
	Beta	T Value	Beta	T Value	Beta	T Value
Step-1						
Bus-Age	0.06	0.22	0.01	1.32	0.01	0.24
Bus-Size	0.08	0.22	0.13	0.86	0.13	0.76
Education	0.13	0.4	0.10	0.12	1.03	1.42
Experience	0.15	0.24	0.14	0.94	0.05	0.14
Step 2						
IN			0.34 *	7.96	0.36 *	3.62
FI			0.28 *	5.56	0.34 *	4.58
Step 3						
IN*FI					0.26 **	2.26
F		5.17 **		16.56 *		16.56 *
R2		0.04		0.26		0.27
R2				0.22		0.01

Note: \* =  $p < 0.001$ , \*\*  $p < 0.05$ .

A simple slope test was conducted to check the collaboration span IN-FI at two distinguished levels of FI in Figure 2.



**Figure 2.** Moderating Role of Frugal Innovation.

## 5. Discussion

Innovation networks are the most important factor in facilitating firms in the development and sharing of information and knowledge inside and outside the organization, which consecutively improves innovation performance. This study explores the importance of innovation performance on the firm performance and declares three hypotheses to examine the outcomes of innovation networks, digital innovation and frugal innovation in innovation performance. The H1 of this research shows the direct linkage between innovation networks and innovation performance. The empirically tested outcome of hypothesis 1 shows that innovation networks have a positive critical role in the promotion of innovation performance. The findings of H1 support prior studies that claimed that innovation networks make it easier for organizations to get needed resources and information for improving innovation performance [20]. The structural attribute of innovation-networks will have an effect on the integration, utilization and absorption of knowledge into organizations, thereby affecting the innovation performance of firms [21]. Firms can transform and take in a huge amount of implicit and invisible knowledge via innovation networks by adapting to rapid changes that are important for enhancing innovation performance [10]. The outcomes of H1 are consistent with the previous literature, which shows that innovation networks are the precondition for the improvement of innovation performance. H2 of this research suggests the mediating role of digital innovation in the association between innovation networks and innovation performance. The H2 findings corroborate the idea that a businesses can obtain strategic monetary and non-monetary advantages with the help of innovation networks and can share information and technology applications by means of digital innovation, which leads towards enhanced innovation performance. Prior research studies have also suggested that innovation networks know how to increase opportunities for technological interactions and thinking collisions among organizations that can greatly augment the development of digital innovation in firms, which eventually leads to improved innovation performance [22]. However, digital innovation acts as a bridge between innovation networks and innovation performance. Innovation networks allow organizations to continuously obtain technologically innovative knowledge and information via digital innovation and to merge this information with internal knowledge, generating many new ideas and concepts of product development in organizations for enhancing innovation performance [26]. The findings of H2 support the prior studies and show that successful innovation networks provide unpredictable benefits to firms through the mediating role of digital innovation, which increases and improves innovation performance. The H3 of our research adds to the knowledge in the growing field of innovation of how frugal innovation moderates in the relation between IN-IP links. The results of the research support the idea that frugal innovation has a key ability that helps it to improve innovation performance. The findings demonstrate that frugal innovation contributes to fulfilling the demands of customers who are unable to approach existing luxury products and services [30]. Previous studies enlighten the progressive function of innovation networks in the enhancement of frugal innovation [31]. Frugal innovation adds to the strength of the link between innovation networks and innovation performance. Innovation networks perform a considerable role and facilitate the implementation of innovation activities that eventually enhance innovation performance [32]. The findings of the H3 are consistent and support the prior research studies' outcomes.

## 6. Conclusions

This study suggests some important implications for management to put into practice. First, our research proposed that innovation networks can improve innovation activities inside firms through the help of digital innovation, via a focus on mobilization and the integration of existing technological and human resources. Second, this research suggests that innovation networks are a pre-condition for and an influential predictor of digital innovation. In short, to boost levels of innovation performance, enterprises have to focus on the development of improved innovation networks that will assist them to increase

their capability towards innovation performance. This study contributes to the theory that in the domain of innovation networks, digital innovation determines innovation performance. There are limited studies focusing on how innovation networks enhance innovation performance. This study investigates the mechanism of innovation performance improvement through innovation networks. Secondly, this study creates an innovation performance framework for businesses, which clarifies how a combination of various factors such as innovation networks, frugal innovation and digital innovation can positively influence innovation performance. The third input of our study refers to the examination of innovation networks for the improvement of digital innovation. This research focuses on this gap concerning innovation networks as a pre-condition for digital innovation and innovation performance. In this study, we examined and made support for the mediating effects of digital innovation on innovation performance. Few studies have focused on and investigated the role of digital innovation as a powerful indicator behind innovation performance. As an outcome of innovation networks, digital innovation has a main impact on innovation performance. The current study confirms that digital innovation mediates between innovation networks and innovation performance.

#### *Limitations and Future Research*

Current studies have several limitations that provide insights for future research. Firstly, the findings of this study are limited to energy firms in the Arab world, and therefore future research may be conducted in other industries and countries. Furthermore, the findings cannot be generalized for all industries as they are based on one industry sample. Secondly, this research study emphasizes the positive outcomes of the variables, although depending on the project and how it is organized, they may lead to negative outcomes. In this viewpoint, future research may be conducted about how to deal with such negative impacts and how to avoid them. Lastly, this study shows the mediating role of digital innovation in the association between innovation networks and innovation performance. Digital innovation provides certain imperative benefits to firms, such as easy access to information and the sharing and receiving of knowledge from surroundings. In future studies, this variable may be replaced with a more interesting construct that provides more flourishing benefits in different functional areas of businesses.

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**Data Availability Statement:** Data will be provided on request.

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