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The Impact of Information and Communication Technologies on Competitiveness: Evidence from MENA Countries

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Abstract: Information and communication technologies (ICTs) have recently emerged as a snowballing phenomenon that orient competitiveness strategies. They are vital and critical aspect for countries to not only improve their global competitiveness, but they also accomplish long-term growth. Latest developments in the Middle East and North African (MENA) countries render the region to be an appealing case study. This study aims at investigating the impact of ICTs in supporting the competitiveness in a sample of (13) countries in the MENA region during the period from 2010 to 2021. To accomplish this purpose, the study employs an econometric model that utilizes the dynamic Generalized Method of Moments (GMM) estimator. Moreover, the results are confirmed by implementing two models. The first model measured ICTs by an indicator which is networked readiness index (NRI). The second model measured ICTs by individuals using the internet (IUI) and the competitiveness in both models was measured by global competitiveness index (GCI). The findings indicated that networked readiness index (NRI) and individuals using the internet (IUI) have a significant and positive impact on the competitiveness in MENA countries. The study recommended that countries in the MENA region should inevitably accelerate the procedures of developing ICTs and support the ICT infrastructure in order to increase their competitiveness.

Keywords: ICTs, Competitiveness, GMM, MENA

1. Introduction

It has become increasingly evident that information and communication technologies (ICTs) are becoming more and more critical for countries' economic development [1]. ICTs interlink with several parts of life, offering individuals new, simpler, and quicker means of communication, networking, accessing knowledge and learning and then raising their standard of living.

ICTs further evolved as an integrated solution for improving competitiveness [2]. Competitiveness is a vital element of a country's success and prosperity as it fosters growth, innovation, and increases productivity and efficiency [3].

At present, MENA countries have tremendously grown and significantly shifted their economies toward knowledge- and technological-based economies. Previously, MENA countries are inherently dependent on oil revenues as a major chunk of their income. Nevertheless, this dependence makes the region vulnerable to fluctuations in oil prices. To avoid the impact of oil price oscillations on their growth rates and budget deficits, MENA countries sought to transform their economies from an energy-based economy to a knowledge-based one [4]. MENA countries possess all the necessary infrastructure to transform into a digital and ICT-driven future. Precisely, they own a huge, well-educated population of young people who have adopted modern technology broadly. As a result, ICT equipment, such as computers and cellphones are widely used [5]. MENA countries have a diverse technological advancement in ICTs because of

their different levels of development [6].

Despite the importance of ICTs for competitiveness, their impact on MENA economies' competitiveness has not been sufficiently studied in the literature. Consequently, the study aims at investigating how ICTs affect MENA countries' economies and competitiveness levels. In order to achieve this objective, the study implemented an empirical model and applied the GMM dynamic panel method on a sample of MENA countries. Based on the findings of the study, policymakers in MENA countries can better align their digitalization goals with their competitiveness goals.

The study contributes to this literature field in several manners: firstly, unlike the previous literature which heavily concentrated on the impact of ICTs on competitiveness in European countries. This study focused on MENA countries in which both ICTs and competitiveness are critical. Secondly, previous research expresses the ICTs impact on competitiveness using descriptive methods, but this study employed the GMM method in investigating this relationship. Thirdly, the independent variable that is employed in quantifying the ICTs is the NRI. Prior literature usually measures the ICT using fixed telephone subscriptions per 100 inhabitants (TEL), mobile cellular subscriptions per 100 inhabitants (MOB), Internet users per 100 inhabitants (INT) and fixed broadband subscriptions per 100 inhabitants. Thus, using NRI will capture broader ICT dimensions and hence increase the policy relevance and study outcomes. Moreover, the study employs another variable in proxying the ICTs namely individuals using the internet (IUI) in order to confirm the relationship between ICTs and competitiveness in MENA countries.

In what follows, the study will show the level of ICTs and competitiveness in the (13) MENA countries during the period (2010-2021). The following table 1 shows the ICTs levels of the selected MENA countries measured by networked readiness index (NRI). As shown in table 1, Qatar, UAE, Bahrain, Saudi Arabia, Israel, Jordan Oman and Tunisia had the highest degree of ICTs while Egypt, Iran, Lebanon, Morocco and Algeria had the lowest ICTs degree. The table further illustrates that the index declined overtime in almost all the sampled countries, emphasizing the low digital readiness of the region.

Additionally, the index, on average, span between 35-77 for all countries between 2010-2021, which was well below the NRI global average. Despite the countries' efforts in transforming their economies to technology-based ones, much more still to be done in multiple aspects, particularly infrastructure and regulatory frameworks.

Table 1. *Networked Readiness Index in MENA Countries.*

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Qatar	71	70	69	73	75	73	74	74	69	64	61	62
UAE	69	68	68	72	74	76	76	74	70	66	64	65
Bahrain	66	68	70	69	69	70	73	71	65	59	58	58
Saudi Arabia	63	65	66	69	68	67	69	68	62	57	58	57
Israel	69	72	75	77	78	77	77	77	74	71	70	70
Oman	61	61	62	64	65	64	61	63	58	53	55	54
Jordan	57	58	60	60	62	61	60	61	55	49	48	48
Tunisia	62	60	59	56	54	56	56	54	48	42	41	42
Egypt	54	54	54	54	53	51	53	52	46	41	43	42
Iran	49	48	48	49	49	51	53	52	48	44	44	44
Lebanon	50	50	50	51	52	50	54	52	47	41	41	41
Morocco	51	50	51	66	52	56	56	54	55	37	40	39
Algeria	45	44	43	40	43	44	46	45	40	35	35	35

Source: Measuring Information Society Reports (multiple updates)

The previous table shows MENA countries that had the highest degree of NRI in contrast, MENA countries that had the lowest degree of NRI during that period. This indicates the former had a solid infrastructure which supports the ICTs in contrast, others had obsolete infrastructure.

The following table 2 shows the ICTs levels proxied by individuals using the internet (% of population). In a similar manner, Qatar, UAE, Bahrain, Saudi Arabia, Israel, Morocco, Lebanon and Oman experienced the highest degree of ICTs while Jordan, Tunisia, Egypt, Iran had the lowest levels throughout the study period. Despite having the lowest levels, Egypt, Iran and Algeria internet penetration had consistently grown during this period.

Table 2. *Individuals Using the Internet in MENA Countries (% of population).*

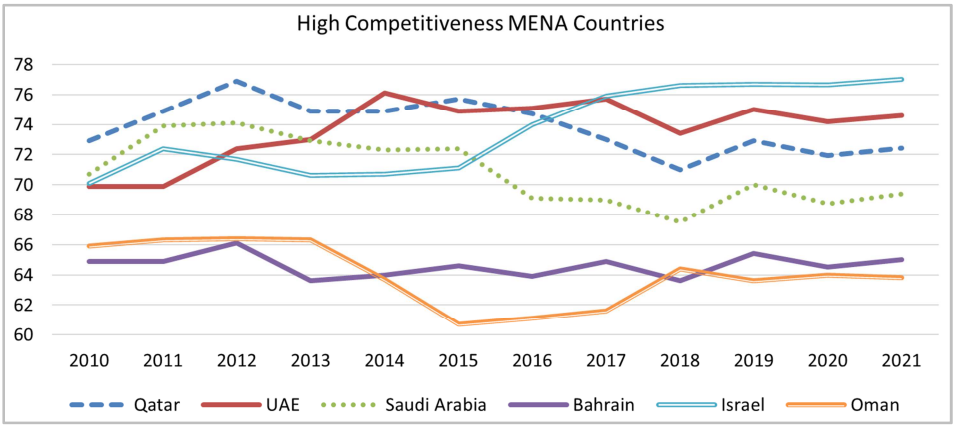
Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Qatar	69	69	69	85	92	93	95	97	99.7	99.6	99.6	99.7
UAE	68	78	84.9	88	90	91	91	95	99	99	99	99
Bahrain	55	77	88	90	91	93	98	96	99	99.7	99	99
Saudi Arabia	41	48	54	61	65	70	75	94	93	96	95	95
Israel	68	69	71	70	75	77	80	82	84	87	85	86
Morocco	52	46	55	56	57	57	58	62	65	74	70	72
Lebanon	44	52	61	71	73	74	76	78	77	78	77	79
Oman	36	48	60	67	70	74	77	80	86	92	89	91
Jordan	27	35	37	41	46	60	62	67	65	66	65	65

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Tunisia	37	39	41	44	46	47	50	56	64	67	65	66
Egypt	22	26	26	29	34	38	41	45	47	57	52	55
Iran	16	19	23	30	39	45	53	64	70	67	69	68
Algeria	12.5	15	18	23	30	38	43	48	49	48	49	49

Source: World bank (multiple updates)

The following figures 1 and 2 show the evolution of competitiveness in MENA countries during the period (2010-2021) for high and low competitive countries respectively. Analogously, the competitiveness had slightly increased in both counties' groups. High competitiveness countries had a range from 63 to 77, while low competitiveness countries had a range from 53 to 67. High competitiveness countries were Qatar, UAE, Saudi Arabia, Bahrain, Oman and Israel. UAE had the highest degree of competitiveness; Qatar was the second country that had high degree of competitiveness and Saudi Arabia was the third country.

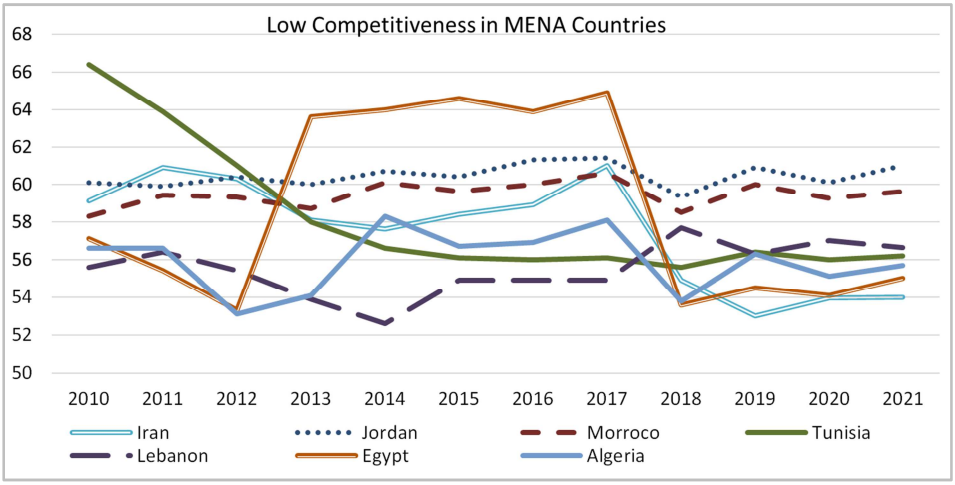
The competitiveness in UAE had increased from 2010 until 2014. In 2015 it slightly decreased and then returned to increase again in 2016 and 2017. In 2018, it also decreased and then increased in 2019. In 2020, it slightly decreased and then increased in 2021. The competitiveness in Qatar increased from 2010 until 2012. In 2013 and 2014, it slightly decreased. In 2015, it returned to increase. In 2016, 2017 and 2018 it decreased. In 2019, it increased. In 2020, it slightly decreased and then returned to increase in 2021. The competitiveness in Saudi Arabia increased from 2010 until 2012. In 2013 and 2014, it slightly decreased. In 2015, it returned to increase. In 2016, 2017 and 2018 it decreased. In 2019, it increased and in 2020, it decreased and then increased in 2021.



Source: constructed by the author based on World Economic Forum (WEF)

Figure 1. *High Competitiveness in MENA countries.*

The following figure shows the low competitiveness countries which are Iran, Jordan, Morocco, Tunisia, Lebanon, Egypt and Algeria.



Source: constructed by the author based on World Economic Forum (WEF)

Figure 2. *Low Competitiveness in MENA countries.*

The preceding tables and figures clearly show that countries with high ICTs experienced high levels of competitiveness, implying the existence of a positive linkage between ICTs and competitiveness in MENA region.

The rest of this study is structured as follows: section two, Literature review, section three, Empirical study, section four, Findings and discussion, section five, Conclusion eventually section six includes Policy recommendations.

2. Literature Review

2.1. Theoretical Background

Theoretical literature distinguishes between two forms of the competitiveness: price competitiveness and non-price or structural competitiveness.

Price competitiveness: is based only on price. This type of competitiveness does not explain all the other determinants of an economy's competitiveness because it does not interpret how an economy may effectively retain its competitiveness apart from the price component [7-9]. The biggest criticism against the examination of a country's competitiveness by prices related to its interpretations. When it declines, it may result in increased manufacturing cost or an enhancement of the standard of the exported goods.

Structural competitiveness: denotes to the economic capacity that distinguishes the competitors through measures other than the price. In order to meet the challenge raised at the investigation of price competitiveness, developers of non-price competitiveness have asserted for the investigation of structural competitiveness which includes structural elements such as product sufficiency provided to customers, technology, innovation and advancement, quality control, funding for infrastructure and any other variables going to enhance an economy's competitive position, with the ultimate goal of elevating the population living standards. In order to account for all the dimensions of competitiveness, the World Bank has recommended analyzing countries' competitiveness using an indication called GCI. It considers all drivers which are price and structural [10-12].

Before reviewing the literature about the ICTs impact on competitiveness, the study indicates some theories on the ICTs -competitiveness relationship.

Joseph Schumpeter: Who emphasized on the importance of the entrepreneurship as a competitiveness element, concluded that the competitiveness is an outcome or a consequence of inequalities that encourage innovation and technological advancement [13].

Numerous scholars argued that the true competitive power of US rested on technological capabilities not on capital availability. This resulted in the 1960s neo-technological trade theories, which focused on the significance of cross-country disparities in technological capabilities and their influence on competitiveness [14-16].

The Neo-Technological Approach: Has an idea of a model of two-country, which the first is much inventive than the other (it has a technological advantage or leadership), while the other (the technological lagging) depends much more on emulation. Technological developments arise in the dominant country, which has a prolonged monopoly for a period of time. Nevertheless, the technological lagging will eventually learn how to cope with all these technological capabilities, and competitiveness among the two countries will emerge. In general, the income levels in the dominant country will be greater. The amount of the income disparity based on the extent of the technological divide or on the period required for the lagging country to emulate the innovations [14].

Porter Diamond Model (1990): Focused on four factors affect a country's competitiveness. This model distinguished between basic or primary factors, which are natural resources, and advanced factors, which are know-how technology, that is more important for competitive advantage, while the significance of factor endowments can be returned to traditional or classical trade theories [8].

To conclude, international trade theory has evolved away from focusing solely on cost-price disparities and has shifted its focus to other aspects such as technology or innovation. As a result, supporters of many theories sought to explain observed changes in international competitiveness, such as globalization, and FDI and its role in transfer technology and even technology itself and innovation [17].

2.2. Descriptive Literature

Most studies have the descriptive method for instance, Bierut, & Pawlak, 2016 [17], Psychoyios & Dotsis, 2018 [18], Peña-Vinces, 2009 [19], Kostoska, & Mitrevski, 2008 [20], Stolyarova, et al., 2020 [21] and Istomina, et al., 2020 [22] concluded that ICTs have a favorable role in enhancement and supporting the competitiveness and became essential component for every economy and when a country's competitiveness is examined, a variety of measures are considered, including the international share rate, productivity, employment, and technological level [23].

Technological advancements lead to price reductions of ICTs goods and services providing a significant incentive to replace other forms of capital and labor with ICTs equipment [24].

Moreover, ICTs have a vital influence in a country's global competitiveness and ICT maturity can achieve high scores on the global competitiveness scale by using two-wheel models [25]. Through analyzing the global competitiveness index (GCI), it is concluded that at both the macroeconomic and microeconomic levels, technology and innovation have a significant impact on the competitiveness. It is apparent that ICTs and innovations are extremely crucial for a country's competitiveness [26].

United Arab Emirates accomplished enormous success in terms of technological capability and helped them to increase its competitiveness as evaluated by GCI [27]. Furthermore, it is important to keep in mind that one of the primary difficulties and critical prerequisites for boosting the

competitiveness of Mexico and Poland remains fostering innovation and technology [28].

Furthermore, the impact of ICTs on the competitiveness in Latin America was investigated and determined if there were substantial disparities in the GCI's adoption and implementation of ICTs component. It is concluded that one group of nations was making great progress in ICTs, while another was moving more slowly. ICTs implementation is not the only factor that influences international competitiveness, but its impact was considerable. Chile received a high consideration in the Latin American area due to its degree of competitiveness and ICTs implementation. Chile, as a nation may be considered as a positive model for the rest of Latin America to replicate [29].

2.3. Empirical Literature

The second type of literature focused on the empirical studies. For instance, Yunis, et al., 2011 [30] investigated the influence of ICT maturation in achieving global competitiveness at the national- level. They also examined the socioeconomic and technological elements that are most likely to be connected to ICT maturation, as measured by an index which is NRI, and then evaluated their significance in propelling global competitiveness between the years 2003 and 2007. The number of countries was 93. Countries were classified using cluster analysis. Structural equation modelling was implemented to verify the fitting of a model investigating these variables. They concluded that firstly, ICT had a considerable influence in advancing the global competitiveness of a country, with a greater association in strong readiness nations than that in weak readiness ones. Secondly, ICT maturation was discovered as a mediator among ICT efficiency and R&D investments from the one side, and worldwide competitiveness from the other side.

Simionescu, et al., 2021 [31] investigated the key competitiveness factors in the 28 countries in the European Union. They extended Cobb-Douglas function with others competitiveness indicators in a panel data from 2004 to 2018 and then implemented MG and CCEMG estimators. They emphasized the importance of innovation and technology, human capital and FDI in supporting the competitiveness in the European economies. It is concluded that individuals' innovative capabilities boosted the productivity. Capital investment also supported the expansion of the economy. Human capital could also impact on the international technology acceptability by integrating new instruments. They also explained two measures that indicated the competitiveness of the European countries. First, the composite indicator GCI and the second measure is GDP per capita, which was commonly seen as a good indicator of a country's well-being and welfare.

Boikova, et al., 2021 [32] investigated the competitiveness performance factors that influence the growth of European economies, as well as to distinguish EU countries clusters based on the effects of these factors. It used the IBM SPSS Statistics software package to undergo cross-sectional data analysis for EU countries to determine which competitiveness factors could be further taken advantage for the estimation of their relationship with economic growth. They implemented factor analysis which is a statistical technique was used to investigate the competitiveness determinants that are important for European economies. They used data for 28 EU countries for 2017, 2018, and 2019. They concluded that the most important factors for competitiveness are Macroeconomic Stability, R&D and Digitalization, FDI, and Trade Openness.

Zoroja, 2015 [33] investigated the influence of ICTs on European nations' overall competitiveness. He employed a panel regression analysis to examine the impact of ICTs on the competitiveness in the European countries. Furthermore, statistics from the European dataset Eurostat and the global competitiveness report are gathered during a five-year period (2007-2011). It is concluded that ICT had a substantial influence on European nations' global competitiveness. In addition to ICTs had the largest influence on the GCI and the efficiency enhancers sub-index. It was also revealed that ICTs had a small influence on the sub-indices of basic requirements in addition to innovation and sophisticated.

Zoroja & Bach, 2016 [1] examined how ICT impacted the competitiveness of the European countries through four categories which were: e-learning, personal usage of the Internet, e-commerce, and e-government. Two-stage analysis were used to achieve this purpose. Throughout K-means clustering analyses that were performed to classify European nations within reasonable categories for the year 2011 based on their ICT usage. Using the global competitiveness report, established groups are evaluated and compared applying ANOVA analysis based on their competitiveness indices. It is concluded that ICT had a great and significant impact on the competitiveness in these countries.

Neffati, 2015 [34] outlined the empirical framework of ICT, innovations and development as well as their consequences on the competitiveness process in Euro-Mediterranean countries from 2007 to 2012. He highlighted the role of ICT diffusion as a major indication of a country's competitiveness, along with concerns connected to the development of productivity and facilitating innovation. GCI had been used as just a dependent indicator, while ICT-development index (IDI) and global innovation index (GII) were used as independent variables. Linear regression and the ordinary least square (OLS) technique had been used. It is found that ICT development and innovation had a substantial impact on the global competitiveness of Euro-Mediterranean nations.

Constantinescu, 2017 [35] investigated the effect of ICT development on the global competitiveness. It used a linear model with the ordinary least square method (OLS) for the IDI besides GII as independent variables on the GCI as a dependent variable and that for 35 countries in the Euro-Mediterranean region from 2012 to 2015. The results indicated that the coefficient of correlation which is R-squared between the independent variables and the dependent variable shows a significant explanatory capacity, particularly for the EU-15 which equaled 0.94. So, it is concluded that of ICT affected positively the competitiveness in EU-15 countries.

3. Empirical Study

3.1. The Model Building

The model based on Delgado, et al., 2012 [36] framework that measure the competitiveness by distinguishing the impact of the macroeconomic and microeconomic factors on the competitiveness.

$$C_{it} = \alpha_0 + \beta_1 MIC_{it} + \beta_2 MAC_{it} + \varepsilon_{it} \quad (1)$$

Where C_{it} is the competitiveness, $\beta_1 MIC_{it}$ is the microeconomic factors that affect competitiveness, $\beta_2 MAC_{it}$ is the macroeconomic factors that affect competitiveness, ε_{it} is the error term. Macroeconomic competitiveness is separated into two major dimensions: firstly, social infrastructure and political institutions (SIPI) [12, 37-40]. Secondly, there is monetary and fiscal policy (MFP), which comprises fiscally sustainable strategies as well as debts and inflation rules for controlling both short and long-term variations in the economic activities [41]. Then the equation will be:

$$MAC_{it} = SIPI_{it} + MFP_{it} \quad (2)$$

$$C_{it} = \alpha_0 + \beta_1 MIC_{it} + \beta_2 SIPI_{it} + \beta_3 MFP_{it} + \varepsilon_{it} \quad (3)$$

Where $\beta_2 SIPI_{it}$ is the social infrastructure and political institutions, and $\beta_3 MFP_{it}$ is the monetary and fiscal policies which are the two basic elements of macroeconomic indicators that affect competitiveness. According to the micro-economic competitiveness is concerned with aspects of the regional business. Porter was one of the first to emphasize the importance of microeconomic determinants in influencing the productivity and national development [8]. A substantial number of evidence research now highlights the importance of micro-economic variables and activities in nation's economic competitiveness [42, 9, 43].

The two major aspects of micro-economic competitiveness (MICRO) are the appearance of corporate operations and strategy (COS) and the efficiency of the national business environment (NBE) [8]. Then the equation will be:

$$MIC_{it} = COS_{it} + NBE_{it} \quad (4)$$

$$C_{it} = \alpha_0 + \beta_1 COS_{it} + \beta_2 NBE_{it} + \beta_3 SIPI_{it} + \beta_4 MFP_{it} + \varepsilon_{it} \quad (5)$$

Where $\beta_1 \ COS_{it}$ is the sophistication of company operations and strategy, the $\beta_2 \ NBE_{it}$ is the quality and efficiency of the national business environment. The NBE is separated into four elements: factor conditions, demand conditions, strategy and rivalry context, in addition to supporting and linked industries includes the state of cluster development. Then the equation will be:

$$NBE_{it} = FC_{it} + DC_{it} + CSR_{it} + SRI_{it} \quad (6)$$

$$C_{it} = \alpha_{it} + \beta_1 COS_{it} + \beta_2 FC_{it} + \beta_3 DC_{it} + \beta_4 CSR_{it} + \beta_5 SRI_{it} + \beta_6 SIPI_{it} + \beta_7 MFP_{it} + \varepsilon_{it} \quad (7)$$

Where $\beta_2 \ FC_{it}$ is the factor conditions, $\beta_3 \ DC_{it}$ is the demand conditions, $\beta_4 CSR_{it}$ is context for strategy and rivalry and $\beta_5 SRI_{it}$ is supporting and related industries. Porter's model consolidated these and other aspects of NBE into a coherent and unified framework [8]. These four sectors, together with the role of government and chance had become known as the Diamond model and in the assessment of the economic competitiveness, this model is widely applied. In order to investigate the influence of ICTs on the competitiveness in MENA countries, the dependent variable which is competitiveness is expressed by the GCI, then the equation will be:

$$GCI_{it} = \alpha_0 + \beta_1 COS_{it} + \beta_2 FC_{it} + \beta_3 DC_{it} + \beta_4 CSR_{it} + \beta_5 SRI_{it} + \beta_6 SIPI_{it} + \beta_7 MFP_{it} + \varepsilon_{it} \quad (8)$$

3.2. Data and Variables

To examine the impact of ICTs on competitiveness, the study used panel data for (13) MENA countries which are: Algeria, Bahrain, Egypt, Iran, Israel, Jordan, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia and United Arab Emirates (UAE). The choice of these countries depends on the availability of data.

The dependent variable is GCI, which is used as a proxy for competitiveness. Economists use a variety of measurements to assess the economy's competitiveness. It should be recognized that each indication is determined based on the study's topic. Following Rusu & Roman, 2018 [44], Neffati, 2015 [34], Arredondo-Trapero, et al., 2020 [29] and Zoroja, 2015 [33] the study used GCI as a proxy for competitiveness.

Following Kirkman, et al., 2002 [45], Yunis, et al., 2011 [30] and Soldić-Aleksić & Stankić, 2015 [46] the study used NRI as a proxy for ICTs. Following Hamilton, 2010 [47], Močnik & Širec, 2010 [48] and Hodrob, et al., 2016 [49] the study used IUI as another proxy for ICTs. Also, in line with empirical studies, the study used three control variables. Following Sigue, 2020 [10] and Dima, et al., 2018 [50] Real GDP per capita was used and it is expected to influence positively on it. Following Rusu & Roman, 2018 [44] and Sigue, 2020 [10] inflation was used. The impact of inflation is a controversial topic. According to some studies, inflation has a positive influence such as Dornbusch, et al., 1996 [51]. While on the other side, various studies indicated that the impact of inflation is distinguished by a non-linear relation such as Fischer, 1993 [41] and Kremer, et al., 2013 [52]. The anticipated sign is obscure and confusing. Following Kharlamova & Vertelieva, 2013 [53] exports was used, and the anticipated sign is positive.

Note: Until 2017, NRI and GCI had a range from 0 to 10 and then their ranges are from 0 to 100. So, the data was unified according to the range from 0 to 100.

Table 3 shows the variables measurements and definitions. Table 4 shows the descriptive statistics of variables. The table shows the mean, median, standard deviation, minimum value, maximum value, and the total number of observations of all variables. The statistics report that the average value of GCI in the selected sample of MENA countries is 4.145 with a minimum value of 3.962 and a maximum value of 4.343. The mean value of NRI is 4.037 with a minimum and maximum

value of 3.559 and 4.348, respectively. The mean value of IUI is 4.101 with a minimum value of 2.525 and maximum value of 4.602. The mean, minimum, and maximum values of RGDPPC are 4.505, 2.356 and 6.546 respectively. Then, the mean, minimum, and maximum values of EXP are 24.728, 23.131 and 26.718 respectively. Finally, the average value of INF 3.363 with a minimum value of 0.139 and a maximum value of 4.120.

Table 3. *Variables measurements and definitions.*

Abb.	Variable and Measurement	Source
GCI	Global competitiveness index. It is a proxy for competitiveness.	World Economic Forum (WEF) Reports
NRI	Networked readiness index. It is a proxy for ICTs which is a proxy for factor conditions in the diamond model and proxy for SIPI which is a dimension of macroeconomic factors that affect the competitiveness.	Information Society Reports
IUI	Individuals using the internet. It is a proxy for ICTs which is a proxy for factor conditions in the diamond model and proxy for SIPI which is a dimension of macroeconomic factors that affect the competitiveness.	World Bank
RGDPPC	Real GDP per capita. It is a proxy for demand conditions and firm strategy, structure and rivalry which are factors that affect competitiveness in the diamond model.	World Bank
EXP	Exports. It is a proxy for demand conditions and firm strategy, structure and rivalry which are factors in the diamond model.	World Bank
INF	Inflation. It is a proxy for the government role or policies which refers to one of components in the diamond model.	World Bank

Note: Abb. stands for Abbreviation

Table 4. *Descriptive Statistics: LGCI, LNRI, LIUI, LRGDPPC, LEXP, LINF.*

Variables	Mean	Median	St. Dev	Minimum	Maximum	Obs.
LGCI	4.145752	4.116595	0.112072	3.962716	4.343805	156
LNRI	4.037446	4.050214	0.199134	3.559625	4.348987	156
LIUI	4.101119	4.203306	0.434696	2.525729	4.602181	156
LRGDPPC	4.505167	4.181064	1.186671	2.356164	6.546485	156
LEXP	24.72883	24.51575	1.010212	23.13132	26.71814	156
LINF	3.363303	3.366948	0.383141	0.139041	4.120133	156

3.3. Estimation

To investigate the impact of ICTs on competitiveness by using panel data, the study used NRI, IUI as proxies for ICTs. The study applied a dynamic GMM estimator. As two steps should be applied: traditional panel data method such as Pooled OLS regression, Fixed Effects (FE) regression and Random Effects (RE) regression. Lastly, using dynamic GMM estimator. The dynamic panel's selection is mostly governed by the notion that previous competitiveness can have a beneficial impact on future competitiveness. Competitiveness, as Porter, 1990 [8] conceded, is not inherited but rather developed with time. Considering all these factors into consideration, the empirical dynamic panel reported to display and assumes the following form:

$$GCI_{it} = \alpha + \beta X_{it} \quad (9)$$

Where, GCI_{it} is the competitiveness of MENA countries and α, is the intercept. The X_{it} is the explanatory variables that affect the competitiveness. In line with the literature, ICTs is evaluated by an indicator which is NRI so, the equation will be:

$$GCI_{it} = \alpha + \beta_1 NRI_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (10)$$

Where GCI_{it} refers to the competitiveness as measured by the global competitiveness index of country i in year t, NRI_{it} is the Networked readiness index which refers to ICTs that affects GCI (competitiveness proxy) and it is the core independent variable, X_{it} is the other independent variables, ε_{it} is the error term. Several elements are expected to impact the economy's overall competitiveness, according to the economic literature. The following are the most frequently applied in the analyses:

$$GCI_{it} = \alpha + \beta_1 NRI_{it} + \beta_2 GDP_{it} + \beta_3 Exports_{it} + \beta_4 Inf_{it} + \varepsilon_{it} \quad (11)$$

All variables are in natural logs, then the equation will be:

$$Log(GCI_{it}) = \alpha + \beta_1 \log(NRI_{it}) + \beta_2 \log(GDP_{it}) + \beta_3 \log(Exports_{it}) + \beta_4 \log(Inf_{it}) + \varepsilon_{it} \quad (12)$$

Dynamic panel regression model will be implemented to evaluate the impact of ICTs on the competitiveness. In the following equation GCI is interpreted depends on a group of exogenous variables.

$$GCI_{it} = \alpha GCI_{i,t-1} + \beta X_{it} + \varepsilon_{it} \quad (13)$$

$$\varepsilon_{it} = u_{it} + V_{it} \quad (14)$$

X_{it} is an exogenous regressors vector, α and β are vectors of coefficients. The error term ε_{it} has two orthogonal components which are: u_i (fixed effects), and V_{it} (idiosyncratic shocks).

The following equation is the equation of the GMM method with fixed approach:

$$Y_{it} = Y_{it-1} + \sum_{i=1}^{k} \beta_i X_{it} + \delta_t + \mu_i + \varepsilon_{it} \quad (15)$$

Where Y_{it} is the logarithm of competitiveness (GCI), Y_{it-1} is the dynamics of competitiveness, X_{it} represents a vector of explanatory variables, δ_t is the time fixed effect, μ_i represents a cross sectional fixed effect, ε_{it} is the error term, i and t represent country and time period respectively.

In line with the literature, ICTs is evaluated by an indicator which is individuals using the internet (IUI) so, the equation will be:

$$GCI_{it} = \alpha + \beta_1 IUI_{it} + \beta_2 GDP_{it} + \beta_3 Exports_{it} + \beta_4 Inf_{it} + \varepsilon_{it} \quad (16)$$

All variables are in natural logs, then the equation will be:

$$Log(GCI_{it}) = \alpha + \beta_1 \log(IUI_{it}) + \beta_2 \log(GDP_{it}) + \beta_3 \log(Exports_{it}) + \beta_4 \log(Inf_{it}) + \varepsilon_{it} \quad (17)$$

Before GMM method was applied, Pooled, Fixed and Random OLS, were implemented and their results were biased and inaccurate so, GMM model was used.

Table 5 represents the impact of ICTs on GCI in MENA countries measuring ICTs using NRI by GMM results. Table 6 represents the impact of ICTs on GCI in MENA countries measuring ICTs using IUI by GMM results.

The results in table 5 and table 6 show the values of the J-statistic and their P-values is more than 0.05 Therefore, the null hypothesis was accepted which indicates the validity of instruments and the well-specification of the model.

In table 5, step (1) is the simplest and contains the core independent variable, which is the NRI. Other three steps have gradually added control variables, so the influence of each variable can be obtained.

Column (1) shows a step (1) which includes GCI as the dependent variable, and it is a function of log NRI. The result shows that the estimated coefficient of log (NRI) is 0.118522 and it is associated with a positive and significant (significant at 1%) relationship with competitiveness (GCI). This result is compatible with the economic theory, is in line with empirical studies and carries the expected sign.

In column (2), Log (RGDPPC) was added as additional control variable. Thus, Log (GCI) became a function of Log (NRI) and Log (RGDPPC). The estimated coefficient of Log (NRI) and Log (RGDPPC) is 0.082870 and 0.120295 respectively (significant at 1%). The result shows that log (NRI) and log (RGDPPC) have a significant and positive impact on GCI.

In column (3), Log (EXP) was added as another additional control variable. Thus, Log (GCI) became a function of Log (NRI), Log (RGDPPC) and Log (EXP). The estimated coefficient of Log (NRI), Log (RGDPPC) and Log (EXP) are 0.192256, 0.084498, 0.102809 respectively (significant at 1%). The result confirms the positive and significant association between Log (NRI), Log (RGDPPC), Log (EXP) and competitiveness (GCI).

In column (4), Log (INF) was added as another additional control variable. Thus, Log (GCI) became a function of Log (NRI), Log (RGDPPC), Log (EXP) and Log (INF). The estimated coefficient of Log (NRI), Log (RGDPPC) and Log (EXP) are 0.225051, 0.053689, 0.064681, respectively (significant at 1%). The estimated coefficient of Log (INF) is -0.000737 and it has insignificant impact on competitiveness (GCI).

Table 5. *The impact of ICTs on GCI in MENA countries measuring ICTs using NRI by GMM results.*

Variables	(1)	(2)	(3)	(4)
Log (NRI)	0.118522*** (71.38078)	0.082870*** (4.787937)	0.192256*** (3.948216)	0.225051*** (6.027800)
Log (RGDPPC)		0.120295*** (3.874317)	0.084498*** (1.921719)	0.053689*** (5.096011)
Log (EXP)			0.102809*** (3.040258)	0.064681*** (6.443233)
Log (INF)				-0.000737 (-0.057816)
Number of Obs.	117	117	117	104
J-statistic	7.133489	8.107593	4.616955	12.32788
P-value	0.415115	0.230326	0.464389	0.137163
Instrument rank	21	21	21	13

* Significant at 10%, ** Significant at 5%, *** Significant at 1%

Table 6. *The impact of ICTs on GCI in MENA countries measuring ICTs using IUI by GMM results.*

Variables	(1)	(2)	(3)	(4)
Log (IUI)	0.234270*** (2.730429)	0.248913*** (5.137096)	0.111428*** (9.837032)	0.123900*** (6.672522)
Log (RGDPPC)		0.672580*** (13.30675)	0.268818*** (9.391248)	0.272188*** (9.347170)
Log (EXP)			0.045730*** (3.305814)	0.053474*** (3.547764)
Log (INF)				-0.001065 (-0.138541)
Number of Obs.	104	117	130	130
J-statistic	5.776658	7.856055	2.297699	1.936048
P-value	0.448668	0.248840	0.806605	0.747520
Instrument rank	8	21	21	21

Note: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

In table 6, column (1) shows a step (1) which includes GCI as the dependent variable, and it is a function of log IUI. The result shows that the estimated coefficient of log (IUI) is 0.234270 and it is associated with a positive and significant (significant at 1%) relationship with competitiveness (GCI). This result is compatible with the economic theory, is in line

with empirical studies and shows that the estimated coefficient of log (IUI) carries the expected sign. Column (2), Log (RGDPPC) was added as additional control variable. Thus, Log (GCI) became a function of Log (IUI) and Log (RGDPPC). The estimated coefficient of Log (IUI) and Log (RGDPPC) is 0.248913 and 0.672580 respectively (significant at 1%), confirming the positive and significant relationship between IUI, RGDPPC and GCI.

Column (3), Log (EXP) was added as another additional control variable. Thus, Log (GCI) became a function of Log (IUI), Log (RGDPPC) and Log (EXP). The estimated coefficient of Log (IUI), Log (RGDPPC) and Log (EXP) are 0.111428, 0.268818, 0.045730 respectively (significant at 1%). The result confirms the positive and significant association between Log (IUI), Log (RGDPPC), Log (EXP) and competitiveness (GCI). Column (4), Log (INF) was added as another additional control variable. Thus, Log (GCI) became a function of Log (IUI), Log (RGDPPC), Log (EXP) and Log (INF). The estimated coefficient of Log (IUI), Log (RGDPPC) and Log (EXP) are 0.123900, 0.272188, 0.053474, respectively (significant at 1%). The estimated coefficient of Log (INF) is 0.001065 and it has insignificant impact on competitiveness (GCI).

3.4. Robustness Check

GMM used fixed method and log of variables to account for possible endogeneity, and for standard error white cross section was used because of the problem of heteroskedasticity, so, it provides robust estimates without heteroskedasticity, endogeneity and first order autocorrelation. The estimators would be consistent, efficient, and asymptotically normal. Lagged independent and exogenous variables are used as instrumental variables to eliminate the correlation between the error term and the dependent variable.

Instruments validity is confirmed by the Hansen J- statistic and corresponding P-values. The values in the parentheses reflect the absolute values of the t-statistic. Because the log for each variable is used so, the coefficient of independent variables represented as an elasticity between the independent variables and the dependent variable. Independent variables were added gradually, and the magnitude values didn't change by a large amount which that confirm the model efficiency.

Hausman test was applied for orthogonality of the random effects and the regressors. The null hypothesis is that the individual-specific effect and the regressors are uncorrelated. Its alternative hypothesis is that a correlation exists between the individual- specific effect and regressors. This means that if the test shows a nonsignificant P-value, indicating that correlation does not exist, it means that the random effects model is the preferred regression and if the test estimates a statistically significant P-value, the fixed effects model is the preferred regression.

So fixed effect model is better, since the results reject the null hypothesis. Omitted variables in fixed effect and random effect regressions can bias the results because omitted variables are correlated with the errors. The fixed effect model is useful when omitted variables are time-invariant (fixed or constant) and correlated with errors, while random effect model provided unbiased estimates only when there no omitted variables, or such variables are uncorrelated with errors. However, the existence of some omitted variables in a random model will produce some biasness.

When the "Hausman Test" was implemented, the p-value was less than 0.05 and this means that fixed effect model is appropriate model than the random effect model.

4. Findings and Discussion

The empirical findings of this study are supported by different literature review for instance, it is concluded that ICTs measured by NRI has a positive impact on the competitiveness measured by GCI and this result is in line with the results of Yunis, et al., 2011 [30] and Soldić-Aleksić & Stankić, 2015 [46].

Also, the study concluded that ICTs measured by IUI has a positive impact on the competitiveness and this result is in line with the results of Hamilton, 2010 [47], Močnik & Širec, 2010 [48] and Hodrob, et al. 2016 [49]. The results of control variables also are in line with literature review. For instance, Real GDP per capita has a significant and positive impact on competitiveness and this result is in line with the results of Sigue, 2020 [10] and Dima, et al., 2018 [50]. According to exports, it has a significant and positive impact on competitiveness and this result is in line with the results of Kharlamova & Vertelieva, 2013 [53]. Inflation has insignificant impact on competitiveness, and it is in line with the results of Fischer, 1993 [41] and Kremer, et al., 2013 [52].

From the previous GMM results it is found that ICTs measuring by NRI have a positively significant impact on the competitiveness in MENA countries. In step (1) when NRI increases by 1%, the GCI increases by 11.8%. In step (2) when NRI increases by 1%, the GCI increases by 8.28%. In step (3) when NRI increases by 1%, GCI increases by 19.23%. In step (4) when NRI increases by 1% GCI increases by 22.51%.

Also, ICTs measuring by IUI have a positively significant impact on the competitiveness in MENA countries. In step (1) when IUI increases by 1%, GCI increases by 23.43%. In step (2) when IUI increases by 1% GCI increases by 24.89%. In step (3) when IUI increases by 1%, GCI increases 11.14%. In step (4) when IUI increases by 1%GCI increases by 12.39%.

RGDPPC in the estimation which measured ICTs by NRI has a significant and positive impact on competitiveness. In step (2) its coefficient is 0.120295 (significant at 1%) which means when RGDPPC increased by 1%, GCI increases by 12.02%. In the step (3) its coefficient is 0.084498 (significant at 1%) which means when RGDPPC increased by 1%, GCI increases by 8.4%. In step (4) its coefficient is 0.053689 (significant at 1%) which means when RGDPPC increased by 1%, GCI increases by 5.3%. on the other hand, RGDPPC in the estimation which measured ICTs by IUI has a significant and positive impact on competitiveness. In the step (2) its coefficient is 0.672580 (significant at 1%) which means when RGDPPC increased by 1%, GCI increases by 67.2%. In the step (3) its coefficient is 0.268818 (significant at 1%) which

means when RGDPPC increased by 1%, GCI increases 26.8%. In the step (4) its coefficient is 0.272188 (significant at 1%) which means when RGDPPC increased by 1%, GCI increases by 27.2%.

Exports in the estimation which measured ICTs by NRI has a significant and positive impact on competitiveness. In step (3) its coefficient is 0.102809 (significant at 1%) which means when exports increased by 1%, GCI increases by 10.2%. In step (4) its coefficient is 0.064681 (significant at 1%) which means when exports increased by 1%, GCI increases by 6.4%. on the other hand, exports in the estimation which measured ICTs by IUI has a significant and positive impact on competitiveness. In step (3) its coefficient is 0.045730 (significant at 1%) which means when exports increased by 1%, GCI increases by 4.5%. In step (4) its coefficient is 0.053474 (significant at 1%) which means when exports increased by 1%, GCI increases by 5.3%.

Inflation in the estimation which measured ICTs by NRI has insignificant impact on competitiveness. In step (4) its coefficient is -0.000737. On the other hand, in the estimation which measured ICTs by IUI has also insignificant impact on competitiveness. In step (4) its coefficient is -0.001065.

5. Conclusion

The study investigates the ICTs impact on competitiveness for a panel of (13) MENA countries during a period from 2010 to 2021. The competitiveness has long been a subject of thorny debate in literature. Precisely, there is no consensus between scholars on either its definition, description or measurement. Generally, there are two types of competitiveness namely, price and structural competitiveness. This study outlined how to account for these two types of competitiveness by employing and measuring it by global competitiveness index (GCI).

After the implementation of the GMM estimation and measuring ICTs by two indicators which are networked readiness index and individuals using the internet, it is concluded that NRI, IUI in addition to other control variables which are RGDPPC and Exports affect significantly and positively the overall competitiveness (GCI) in MENA countries, while the only independent variable which is inflation is insignificant and does not affect it.

6. Policy Recommendations

The findings of this study have some economic policy consequences and implications. Countries in the MENA region should inevitably accelerate the procedures of developing ICTs and support the ICT infrastructure in order to increase their competitiveness and become more competitive. Due to the strong association between ICTs and competitiveness, the study suggests that MENA countries should take care in the following:

1. ICT infrastructure: The lack of suitable ICT infrastructure has limited the country's supply of effective ICT services. The government's policy should support infrastructure including the encouragement of software development, the advancement of local production and manufacturing of ICT equipment and accessories and providing different incentives to promote ICT infrastructure.
2. Education: In order to provide training and attract students to new ICTs employment opportunities, educational investments seem to be necessary and needed. Greater funding for professional development for educators is also required. In addition to schools should promote general digital literacy by including fundamental technology training and skills in the core curriculum.
3. Competitive subsidies: Bargaining to grant financial subsidies to technology providers or developers can encourage private investment by minimizing the startup risk. To obtain money, technology suppliers must satisfy performance goals, which drive compliance. Furthermore, subsidies might be tailored to social or economic concerns, such as enhancing rural internet connection.
4. Private funding guarantees: Governments can establish loan guarantee programs, such as those found in Europe, in order to encourage and stimulate private lenders to support technological developments.

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