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The Impact of Information and Communication Technologies on International Trade: The Case of MENA Countries

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Abstract: Given the importance of international trade, we empirically investigate the impact of information and communication technologies on the exports, imports, and total trade of five service items by using a panel data for 19 MENA countries from 2005 to 2019. Unlike most previous studies, we use the Information and Communication Technologies Development Index, which is a composite index that combines 11 indicators that include the access, use, and skill aspects of the technology. The results are as follows: the Information and Communication Technologies Development Index has a negative and statistically significant effect on exports of information technology services, and a positive and statistically significant effect on imports and total trade in financial services. Furthermore, we found also that the Information and Communication Technologies access sub-index has a significant effect on total trade in information technology services and transport. For the Information and Communication Technologies use sub-index, its effect on imports of travel services and exports of both travel and information technology services is significant. It also has a significant positive effect on total trade in travel and information technology services. As for the Information and Communication Technologies skills sub-index, the results show that it has significant positive effects on total trade in IT services and travel, and a negative significant effect on transport. These results provide interesting policy insights for information and communication technologies development and the growth of services trade for policy makers.

Keywords: system generalized method of moments (GMM-S); information and communication technologies (ICTs); e-commerce; international trade

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1. Introduction

The information and communication technologies (ICTs) revolution, which, over the last decade, has led to a rapid expansion in the digitization of the economy, is particularly important for boosting trade worldwide, and especially in MENA countries. It improved the prospects of the global markets for a growing number of companies, and has already offered them new opportunities created by improved electronic connections and a greater consumer propensity to shop online.

While it is true that there is a "digital divide" linked to highly disparate performances both within and across countries, and even sub-regions, in an area whose boundaries are more often blurred, the fact remains that, overall, the ICT sector in the region has seen undeniable progress over the last few decades[1]. Even so, in most MENA countries, the digital economy only accounts for between 1% and 8% of GDP, even in markets where e-commerce is gaining popularity, such as the United Arab Emirates (UAE), Saudi Arabia, and Egypt (World Bank 2018). Similarly, despite the widespread availability of Internet connections and digital devices in the region, these tools are primarily used to access social media rather than to create new businesses or new sources of employment. If the current trend tends to widen inequalities between most regions of the world and many MENA countries, it is because multiple obstacles are preventing the latter from embarking on

the path of the digital economy and e-commerce. Indeed, access to an inadequate ICT infrastructure, relatively low literacy levels, the dominance of a state-owned monopoly over the telecommunications sector, the absence of a favorable legal and regulatory framework, and lack of digitally skilled personnel are some of the major obstacles to the emergence of the digital economy in the region in general, and in the public sector in particular. This is especially true in rural areas (OECD 2017).

It should be noted within this research that, in the past few years, the questions concerning the recent rise of ICTs and the expansion of international trade have gained significant interest since they are at the heart of the global economic debate and development. The stakes raised by this debate would be paramount because while international trade and investment in ICTs are widely recognized as key drivers of economic integration, global growth, and prosperity, they also raise concerns about their redistributive effect in the context of growing inequality (OECD 2017).

This paper contributes to the empirical literature on the effect of ICT on international trade. While the empirical studies on this subject have expanded to cover mainstream global samples (Freund and Weinhold 2004), such an extension misses MENA countries. Notably, there is a significant lack of econometric research on the adoption of ICT in this region. And this study comes to fill this gap in many ways. Indeed, compared with earlier studies, this paper contributes to the trade literature in four ways. First, the novelty of this work is that, to the best of the authors' knowledge, we are the first to examine the impact of ICT on international trade for a group of MENA countries selected based on the availability of ICT data, with the latest data spanning from 2005 to 2019. Second, it contributes to the understanding of the ICT effects on trade in the period of greatest Internet diffusion for MENA countries (2005 to 2019). Third, according to a review of the literature, this is the first systematic GMM-S empirical analysis that relates ICT to trade in the MENA region. Fourth, in contrast to most previous studies, in this paper, we use an aggregate measure of ICT named an ICT development index (IDI), which is a composite index combining 11 indicators grouped by three sub-indices—access, usage, and skills—and we also explore how these sub-indices separately affect services trade differently. Likewise, supplementing and strengthening the MENA library with modern standard studies, especially with regard to dynamic panel data, is considered a qualitative addition to the MENA library and the economic researcher.

Thus, this study aligns itself with the existing body of literature primarily highlighting the positive impacts of ICTs on international trade. However, it narrows its focus to a more specific context: international trade in services in the MENA region. Based on the foregoing, the objective of this empirical study is to address the following research problem: how does the diffusion of ICT affect international trade in the group of MENA countries during the period 2005–2019? Therefore, we have to test the following main hypothesis: an increase in ICT has a positive impact on international trade in the MENA region. To achieve this, we study: (1) the effects of ICT on service exports, (2) the effects of ICT on service imports, and, finally, (3) the effects of ICT on total trade (imports + exports) in services.

More precisely, the paper investigates the impact of ICT on exports, imports, and total trade in services for 19 MENA countries. And we can summarize the results obtained overall as follows. By using IDI, a composite index of ICT, the paper finds that ICT negatively impacts exports of IT services and positively impacts the imports and total trade of financial services. The sub-indices of ICT have differing impacts on IT, travel, and total trade in services.

The rest of the paper is organized as follows. Section 1 reviews the theoretical and empirical literature on the relationship between ICT development and international trade in services. Section 2 discusses the data and methodology used for our empirical research based on dynamic panel data estimated by the GMM-S technique over the 2005–2019 period. Our model is particularly inspired by the study of (Freund and Weinhold 2002, 2004; Choi 2010; Liu and Nath 2013; Nath and Liu 2017). The aim is to study the impact of the most important variables highlighted in the economics literature on the separate

evolution of cross-border services transactions, namely imports, exports, and total trade (imports + exports) in services. Our main hypothesis is that the evolution of international trade volume in services is influenced by specific technological and macroeconomic factors. The results of the model are reported and discussed in Section 3. Section 4 discusses the robustness tests. Finally, some recommendations are proposed in the conclusion.

2. The Impact of ICT on International Trade: Literature Review

The exponential process of economic globalization over the last few decades has come alongside a growth in international trade, and, in particular, global e-commerce, fueled by the ongoing rapid evolution of ICTs and the meteoric growth of their most important manifestation, the Internet. This suggests a strong correlation between these two variables[2]. While ICTs are often cited as a factor that has disrupted business models and amplified international e-commerce, it is important to stress that the results of some empirical studies that highlighted these potentially positive effects remain, however, sometimes inconclusive (Mattes et al. 2012)[3]. Addressing this issue essentially amounts to focusing on the question of the impact of ICTs on reducing the costs of trade transactions (Kere and Zongo 2023). Indeed, the main assumption that the rise of ICT offers new opportunities for the development of international trade is motivated by a number of potential benefits. First, digital technologies considerably facilitate the rapid, decentralized processing of information. In doing so, they significantly reduce transaction costs, particularly across borders, by enabling potential consumers, for example, to find out about and compare the different prices and features of a wider range of products more easily and more quickly—thus reducing friction and uncertainty. As a result, consumers could purchase goods and services available online in competing markets at lower prices (Duch-Brown et al. 2017; UNCTAD 2023). Moreover, ICTs provide these economic agents with an advantage stemming from the lower costs of searching for, transmitting, storing, and sharing information. From a company's point of view, such an advantage directly and positively affects both its decision to engage in international trade (its extensive margin) and to increase its exports and imports (its intensive margin) (Mattes et al. 2012). Second, the effective use of ICTs—which should come with investment in intangible assets such as skills and organizational change—is a source of productivity gains that particularly benefit companies in the service sector (Stiroh 2002; OECD 2003; Jorgenson et al. 2008; Van Ark et al. 2008). Empirical studies have shown that productivity growth for companies is most often accompanied by gains in market share (Melitz 2003). ICTs can also indirectly help companies to increase their sales thanks to their potential to lower the fixed costs of conducting business. Finally, and this is by far an issue that has been debated for some time in the economics literature, the increased use of ICTs accentuates network effects (and economies of scale). Service quality depends on the extent of the network, i.e., the number of users (Katz and Shapiro 1985). While network effects already exist in the "classic" economy, the "new" (digital) economy can promote them (OECD 2003). In this regard, the potentially positive effect of ICTs on trade can be expected to be greater when different trading partners actually use these technologies intensively (Mattes et al. 2012).

Nonetheless, it should be stressed that the use of ICTs essentially covers trade in digital services, which can be broadly divided into two categories according to the place and role of these technologies: on the one hand, services that directly involve the production and/or use of ICTs, known as ICT services (or ICT-based services), and on the other, services in which ICTs play an indirect or a secondary role, known as non-ICT services[4]. There are several channels through which ICTs can have a positive impact on trade in the first category of services. ICTs, for example, play a key role in the increasing geographical fragmentation of global value chains (GVCs) brought about by industrial relocation and the international division of production processes (Apte and Mason 1995). Indeed, by using ICTs, companies can more effectively exchange information online over long distances, both within a single country and internationally (Primo Braga 1996), communicate just-in-time with both potential customers and suppliers, and thereby provide services efficiently and

rapidly. Similarly, thanks to outsourcing and offshoring, these services can be provided by companies that are now reaping the benefits of the competitive dynamics taking place in the digital age, and, additionally, more often offer lower prices online than those offered by traditional distribution channels[5]. Therefore, not only are ICTs a vehicle for service provision, but their growth can also have a positive impact on trade flows. Indeed, access to ICTs, their widespread use, and their large-scale application can foster the development of ICT-based service industries (essentially IT services), and thus lead companies to participate in international trade in order to benefit from the competitive advantages conferred by their specialization in this industrial activity. It should also be pointed out that, for the same reasons mentioned above, ICTs can also have an impact on trade in non-ICT services (such as construction, transport, travel services, etc.)[6]. However, the potential impact of ICT on trade in (different) services can be expected to vary according to the penetration rate of these technologies and the efficiency with which they are used within each business service activity.

3. Econometric Study and Methodology

In this section, we explain the econometric methods used in the study, such as the system generalized method of moments (GMM-S).

3.1. Empirical Model and Data Source

From a methodological point of view, we choose to evaluate the contribution of the ICT sector to the growth of international e-commerce in services. However, in order to estimate the contribution of this sector, and unlike most previous studies, we use a broad, aggregated measure of ICT development that combines three pillars of technology, namely access, use, and ICT skills[7], denoted as IDI thereafter. In addition to our variable of interest, we also select other independent variables likely to impact international trade in services, which are highlighted by most recent empirical studies devoted to this topic. The construction of our econometric model and the selection of variables have been adapted to the MENA region based on pertinent empirical results obtained through different estimation methods. This paper is thus an overview inspired by several models, mainly from Clarke and Wallsten (2006) and Nath and Liu (2017), without nevertheless reproducing any specific model. We therefore use a panel regression model whose structural form is as follows:

$$\log Trade^{J}_{i,t} = \propto_i + \beta' IDI_{i,t} + \gamma' \log Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

For country i and period t, $Trade^{J}_{i,t}$ is the dependent variable representing the volume of trade in service j represented either by exports, imports, or total trade in that service during year t; $IDI_{i,t}$ denotes the ICT development index (IDI)[8]; $X_{i,t}$ represents the vector of control variables; α_i is the unobservable specific effect of country i; $\varepsilon_{i,t}$ is the error term for unobserved variables, and is assumed to be independent and identically distributed (iid), with $E(\varepsilon_{i,t}) = 0$; $i = 1 \ldots 19$ and $t = 2008 \ldots 2019$. The variables of the model are expressed in logarithm.

The vector $Controls_{i,t}$ is made up of independent variables that include GDP in PPP per capita and population, hence the following estimated model:

$$\log Trade^{j}_{i,t} = \beta_0 + \beta_1 IDI_{i,t} + \beta_2 \log(GDP_{i,t}) + \beta_3 \log\left(Pop_{i,t}\right) + \beta_4 IDF_{i,t} + \alpha_i + \varepsilon_{i,t} \quad (2)$$

The specification of this model was based on some of the conclusions drawn from the empirical literature in previous work. The model adopted helps to estimate the effects of ICTs represented by the IDI variable of interest, and of a vector consisting of certain independent variables including population, GDP per capita, and the financial development on international trade in the MENA region. These variables are among the most important determinants of services trade flows. In this study, the variables GDP per capita and population are introduced in order to control the "wealth/income effects" and the "size

effects" of the market, respectively (Biswas and Kennedy 2016; Freund and Weinhold 2002). These variables are often included in aggregate and bilateral trade regressions. For example, Frankel and Romer (1999) include both variables in a gravity model of trade, arguing that theory does not clearly suggest the better measure; Rose (2004) includes area directly and population indirectly because he includes logs of both per capita GDP and GDP in a gravity model. The financial development variable is also included as a proxy for an overall comparative advantage in services in a country. Greater financial development is expected to increase service trade (Choi 2010).

In our model, the presence of potential endogenous variables in the right-hand side of the equation to be estimated does not allow us to use standard econometric techniques (OLS, fixed-effect, and quasi-generalized least squares), since they do not enable us to obtain efficient and convergent estimates. One reason for this endogeneity fundamentally stems from the simultaneity bias between variables. Here, the endogeneity source resides in the bias of simultaneity (reverse causality) and the enunciation of the existence of this problem emanates from the lessons learned from economic theory. It has been demonstrated that there is a reverse causality between international trade and the development of ICTs, the Internet in particular (Gnangnon 2020). Indeed, some economists suggest that countries with greater contact with the outside world via trade (or tourism or because of geographical location) are more likely to be developed with respect to digital technology than other countries (Clarke and Wallsten 2006). However, it is also possible that Internet access might also influence trade behavior (Choi 2010; Bhujabal and Sethi 2019). However, within this study, the Internet is an indicator of the composite index IDI, which constitutes the theoretical justification for using the GMM-S technique as an estimation method. This problem can be solved by the GMM-S panel estimator, which controls for individual specific effects μ_i and resolves biases arising from simultaneity. This estimator also has the advantage of taking into account correlation between the endogenous variable and the error term. The GMM estimator thus takes account of the endogenous nature of the independent variable Internet, whose values are partly explained by the dependent variable trade in services. Panel data econometrics offer two variants of generalized moments: Arellano and Bond (1991) generalized first-difference moments and Blundell and Bond (1998) system GMM estimators. The first estimator is based on the first difference in the variables and thus eliminates country-specific effects, resolving the problem of the presence of associated estimation biases. Although this first-difference GMM technique is widely used, it faces the problem of weak instruments. To remedy this type of problem, Blundell and Bond (1998) proposed the system GMM method, which provides relatively more robust estimates than generalized first-difference moments. The latter, by using a series of instrumental variables generated with their lagged differences and lagged levels, makes it possible to control for the problem of endogeneity at the level of the lagged variable and the other independent variables. Estimates are made using the XTABOND2 command on the Stata software developed by (Roodman 2006). The econometric quality of the model estimated by the system GMM method is assessed by means of two tests: the Sargan (1958) and/or Hansen (1982) instrument validity test, and the absence of second-order autocorrelation in the error term[9]. This method is applied to data from 19 MENA countries over the 2008–2019 period. The aim is to examine the effects of ICTs on exports, imports, and total trade (exports + imports) for five different services considered in this study. These are divided into ICT-based services, including IT services, financial services, and telecommunications services, while the others are potentially non-ICT-based services, including transport and travel services.

The literature on ICTs and trade focuses primarily on the positive average (or aggregate) impact of ICT on services trade and ignores the potential heterogeneity in its impacts across various service items. Through outsourcing and offshoring, services can be provided by more cost-effective suppliers. In these cases, ICT is also the vehicle of service delivery and the growth of this technology may have positive impacts on trade flows. Furthermore, ICT proliferation itself may lead to the development of ICT-enabled service industries (e.g.,

computer services, including technical support for computer and mobile phone hardware and software) within a country. These industries may eventually engage in international trade. But, how this will affect the direction of trade (exports and imports) in those services is not intuitively clear (Nath and Liu 2017).

The data on international transactions in services used in this study are extracted from the WTO's Balance of Payments statistics, and are available online on its website (https://stats.wto.org/, accessed on 1 July 2023). Table 1 presents a summary (definition and sources) of the most relevant variables introduced into the estimation. Finally, with regard to the choice of the 2008–2019 period, we feel that it is indeed relevant insofar as the evolution of e-commerce activities worldwide during this period has seen considerable growth. For example, it is estimated that the value of e-commerce transactions worldwide reached USD 2500 billion in 2015, compared with USD 1600 billion in 2013 (UNCTAD 2017). At the same time, and for statistical purposes, this choice is based on the availability of data on our main independent variable of interest IDI, which are only available between 2008 and 2019 and come from the International Telecommunications Union reports.

Table 1. Definitions and data sources for study variables.

Variable Symbol	Definition	Data Source
IDI	The ICT Development Index is most often used to measure ICT resources, and is defined as a composite index that combines 11 indicators (classified into three sub-indices: access, use, and skills), ranging from 0 (the country with the lowest percentage of ICT technologies use) to 10 (the country with the highest percentage of ICT technologies use).	International Telecommunication Union (https://www.itu.int/en/ITU-D/Statistics/Pages/IDI/default.aspx, accessed on 1 July 2023).
GDP/capita	GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the country plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2017 international dollars.	World Bank (https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD, accessed on 1 July 2023).
IDF	Relative ranking of countries on the depth, access, and efficiency of their financial institutions and financial markets. It is an aggregate of the Financial Institutions Index and the Financial Markets Index. The index ranges from 0 to 10, with 10 being the highest level of financial development.	International Monetary Fund (IMF): (https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B&sId=1481126573525, accessed on 1 July 2023).
Population	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.	World Bank (https://data.worldbank.org/indicator/SP.POP.TOTL, accessed on 1 July 2023)

3.2. Estimation Results and Discussion

The empirical results of our various estimates are reported in Tables 2–10. In Tables 2–4, we present the results of the estimates obtained from a specification of the basic model in which IDI is the main independent variable. These estimates separately relate first to exports, then to imports, and finally to total trade in the five services expressed in natural logarithms. The results show that the coefficient of the IDI variable is statistically significant and positive for only one item (out of five) in the case of both imports and total trade. However, although the effect of IDI on exports is also statistically significant at the 5% level, the associated parameter is nevertheless negative (Table 3). The three items to which these results relate are IT services for exports and financial services for both imports and total trade. These are therefore ICT-based services. This empirical finding seems likely to be explained by the fact that ICTs are essential to the production and delivery of these different trade services. It is also likely that trade in ICT-based services accounts for a growing share of total trade in services. In this regard, the globalization of ICT-based services is progressing faster than that of many other services (OECD 2004). Another possible interpretation of this result is that financial services were among the first to adopt ICTs, and the development of this technology has facilitated global financial integration (Nath and Liu 2017). It should be noted here that the econometric results show that a 1% increase in IDI leads to a 9.2% increase in imports and a 6% increase in total trade in financial services, while it leads to a 42% drop in exports of IT services. Although this last result may seem unexpected at first glance and in total disagreement with previous research (Clarke and Wallsten 2006), it seems likely to be explained by the fact that an increase in access to ICTs leads to a rise in domestic demand for these services, which in turn leads to a downward trend in their exports. In the case of ICT-based services (financial and IT services), therefore, the trade-enhancing effects largely stem from the primary role played by ICTs in the production and provision of these types of services. The estimation results also show that the effect of the main independent variable of interest IDI is rather negative on imports of telecom, transport, and travel services, and on exports and total trade in telecom services. On the other hand, we note that the effects of IDI on imports of IT services, exports of financial services, transport services, and travel, and on total trade in IT services, transport services, and travel are rather positive and statistically insignificant. It should be stressed, however, that these globally homogeneous results—positive/negative effects, but not significant—suggest that only a relatively small proportion of these services were delivered via ICTs. However, from a theoretical perspective (Borga and Koncz-Bruner 2012), to limit themselves to the pioneers, we point out that it is almost impossible to know the share of exports that were actually delivered via ICTs.

Despite the possibility that ICT might impact international trade since some services (financial service, IT services) can be delivered directly over the Internet, there is little evidence that this is the case in the MENA region. A related concern is that the trade behavior might be related to overall economic development (see, for example, Clarke and Wallsten 2006). In other words, these results are rather a reflection of structural fragilities of these economies given that international trade depends on a global policy environment and potential interdependencies between key macroeconomic variables. So, these results highlight the need for MENA economies to move toward an economic model that reconciles the development of ICT and efforts that include improvement in their trading environment, productivity, domestic market competition, price mechanisms, and managerial skills, which can promote their international trade. Theoretically speaking, the contribution of ICTs to the growth of technology-based services is obvious (Wang and Choi 2018; Clarke and Wallsten 2006). However, our estimation indicates that ICTs adoption would be negatively correlated with IT services export. A possible explanation for this result is that an increase in ICT having access contributes to the increase in domestic demand for these services and, as such, exports and total trade decrease (Sinha Roy et al. 2022).

Table 2. ICT and services imports: IV-GMM estimates.

Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
IDI	0.010 (0.032)	0.092 * (0.058)	−0.014 (0.035)	−0.004 (0.012)	−0.008 (0.021)
ln (GDP/capita)	0.112 ** (0.055)	0.058 (0.092)	0.073 (0.063)	0.057 ** (0.027)	0.062 (0.047)
lnpopulation	0.056 ** (0.025)	0.002 (0.002)	−0.001 (0.001)	0.03 *** (0.012)	0.004 (0.022)
IDF	0.311 (0.338)	0.312 (0.676)	0.742 ** (0.414)	0.045 (0.131)	0.182 (0.233)
Constant	−1.749 *** (0.698)	0.508 (1.367)	−0.28 (0.691)	1.023 *** (0.35)	−0.185 (0.283)
No. of countries	19	17	19	19	19
No. of observations	201	183	207	209	208
AR(1) *p*-value	0.000	0.000	0.000	0.000 ***	0.000
AR(2) *p*-value	0.004	0.361	0.461	0.399	0.764
Hansen J *p*-value	0.657	0.507	0.804	0.347	0.000

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. ***, **, and * denote the statistical significance level of 1%, 5%, and 10%, respectively.

Table 3. ICT and services exports.

Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
IDI	−0.042 ** (0.02)	0.053 (0.047)	−0.019 (0.035)	0.002 (0.027)	0.002 (0.021)
ln (GDP/capita)	0.952 *** (0.037)	−0.047 (0.094)	0.12 (0.096)	0.012 (0.046)	0.029 (0.043)
lnpopulation	0.237 *** (0.021)	−0.002 (0.029)	−0.019 (0.035)	−0.063 *** (0.023)	−0.011 (0.023)
IDF	0.211 *** (0.270)	0.548 (0.527)	0.503 (0.616)	0.438 * (0.309)	0.898 *** (0.294)
Constant	−8.457 *** (0.461)	−0.481 (1.023)	−0.257 (1.072)	0.889 (0.496)	−0.208 (0.491)
No. of countries	19	15	19	19	19
No. of observations	208	150	201	207	209
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.000
AR(2) *p*-value	0.226	0.211	0.057	0.196	0.184
Hansen J *p*-value	0.000	0.101	0.655	0.407	0.001

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01.

Table 4. ICT and services trade.

Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
IDI	0.008 (0.028)	0.062 *** (0.038)	−0.010 (0.032)	0.004 (0.025)	0.014 (0.017)
n (GDP/capita)	−0.022 (0.049)	0.063 (0.062)	0.049 (0.058)	0.065 (0.050)	0.021 (0.030)
lnpopulation	0.030 * (0.018)	0.015 (0.024)	−0.012 (0.019)	0.062 *** (0.026)	0.011 (0.014)
IDF	0.754 *** (0.311)	−0.063 (0.387)	0.788 *** (0.365)	0.381 (0.282)	0.274 (0.193)
Constant	−0.204 (0.520)	−0.641 (0.721)	0.207 (0.584)	−0.903 (0.568)	−0.161 (0.323)
No. of countries	19	18	19	19	19
No. of observations	209	186	209	209	209
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.000
AR(2) *p*-value	0.000	0.926	0.603	0.007	0.041
Hansen J *p*-value (Sargan test)	0.814	0.857	0.787	0.963	0.147

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. * *p*-value < 0.1; *** *p*-value < 0.01.

Table 5. ICT access, use, skills, and services imports.

ICT Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
ICT access	−0.006 (0.022)	0.057 (0.069)	0.020 (0.04)	−0.011 (0.016)	−0.024 (0.025)
ICT use	−0.037 (0.036)	0.094 (0.061)	0.02 (0.04)	0.022 (0.015)	0.049 ** (0.023)
ICT skills	0.013 (0.028)	−0.019 (0.048)	−0.01 (0.03)	0.000 (0.012)	0.020 (0.018)
Constant	−0.083 (0.124)	0.604 ** (0.269)	0.09 (0.15)	0.167 ** (0.088)	0.039 (0.102)
No. of countries	17	17	19	19	19
No. of observations	149	149	169	171	171
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.001
AR(2) *p*-value	0.244	0.75	0.187	0.736	0.277
Hansen J *p*-value (Sargan test)	0.366	0.584	0.994	0.105	0.001

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. ** denote the statistical significance level of 5%.

Table 6. ICT access, use, skills, and services exports.

Variables TIC	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
ICT access	0.049 (0.041)	0.070 (0.058)	−0.009 (0.063)	−0.019 (0.036)	−0.025 (0.026)
ICT use	0.072 ** (0.036)	−0.019 (0.053)	0.057 (0.054)	0.036 (0.032)	0.059 *** (0.024)
ICT skills	−0.022 (0.027)	0.005 (0.040)	0.019 (0.043)	0.001 (0.026)	0.007 (0.019)
Constant	−0.022 * (0.027)	−0.032 (0.214)	0.271 (0.221)	0.283 *** (0.119)	0.266 *** (0.106)
No. of countries	19	15	19	19	19
No. of observations	171	120	166	171	171
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.000
AR(2) *p*-value	0.787	0.251	0.057	0.267	0.287
Hansen J *p*-value (Sargan test)	0.282	0.946	0.993	0.340	0.591

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01.

Table 7. ICT access, use, skills, and services trade.

Variables TIC	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
ICT access	0.216 *** (0.026)	0.020 (0.047)	−0.019 (0.045)	−0.062 *** (0.023)	−0.0261 (−0.213)
ICT use	0.088 *** (0.024)	0.054 (0.042)	0.055 (0.040)	0.066 *** (0.021)	0.049 (0.023)
ICT skills	−0.060 *** (−0.019)	−0.012 (−0.034)	−0.003 (0.032)	−0.028 *** (0.017)	0.095 ** (0.048)
Constant	−4.325 *** (0.13)	−0.083 (0.124)	0.310 *** (0.177)	0.177 (0.115)	0.039 ** (0.102)
No. of countries	19	19	19	19	19
No. of observations	171	149	171	171	171
AR(1) *p*-value	0.202	0.000	0.000	0.004	0.001
AR(2) *p*-value	0.013	0.561	0.269	0.897	0.117
Hansen J *p*-value (Sargan test)	0.000	0.880	0.999	0.010	0.304

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. ** *p*-value < 0.05; *** *p*-value < 0.01.

Table 8. IV-GMM estimates with interaction terms: case of service imports.

ICT Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
ICT access	0.095 (0.064)	−0.034 (0.162)	0.124 * (0.070)	0.046 (0.027)	0.279 *** (0.119)
ICT skills	0.084 (0.070)	−0.143 (0.171)	0.159 ** (0.083)	0.040 (0.03)	0.071 ** (0.046)
ICT access × ICT skills	−0.012 (0.011)	0.020 (0.020)	−0.026 ** (0.013)	−0.007 (0.004)	−0.008 (0.007)
Constant	−0.284 (0.306)	0.942 (0.841)	−0.61 (0.734)	−0.029 * (0.115)	0.119 (0.508)
No. of countries	17	17	19	19	19
No. of observations	149	149	169	171	152
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.001
AR(2) *p*-value	0.245	0.741	0.223	0.701	0.225
Hansen J *p*-value (Sargan test)	0.601	0.946	0.998	0.174	0.0424

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01.

Table 9. IV-GMM estimates with interaction terms: case of service exports.

ICT Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
Access	0.074 (0.073)	0.233 * (0.125)	0.134 (0.116)	0.175 *** (0.073)	0.051 (0.008)
Skills	0.067 (0.077)	0.158 (0.132)	0.173 (0.115)	0.094 (0.071)	0.052 (0.05)
ICT access × ICT skills	−0.015 (0.012)	−0.028 (0.02)	−0.027 (0.018)	−0.022 ** (0.011)	−0.011 (0.008)
Constant	−0.054 (0.656)	−0.988 (1.206)	−0.306 (0.969)	−0.166 (0.69)	−0.091 (0.422)
No. of countries	19	19	19	19	19
No. of observations	171	120	166	171	171
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.001
AR(2) *p*-value	0.783	0.213	0.054	0.292	0.246
Hansen J *p*-value (Sargan test)	0.863	0.925	1	0.711	0.237

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. ***, **, and * denote the statistical significance level of 1%, 5%, and 10%, respectively.

Table 10. IV-GMM estimates with interaction terms: case of service trade.

ICT Variables	IT Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
ICT access	0.083 (0.053)	0.140 (0.093)	0.115 (0.082)	0.019 (0.041)	0.060 ** (0.037)
ICT skills	0.071 (0.056)	0.063 (0.095)	0.091 (0.083)	−0.004 (0.046)	−0.004 (0.046)
ICT access × ICT skills	−0.013 (0.009)	−0.014 (0.015)	−0.015 (0.013)	−0.004 (0.007)	−0.004 (0.007)
Constant	−0.284 (0.306)	−0.363 (0.402)	−0.121 (0.321)	−0.057 (0.007)	−0.071 (0.153)
No. of countries	19	19	19	19	19
No. of observations	171	171	171	171	171
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.005
AR(2) *p*-value	0.029	0.632	0.255	0.701	0.943
Hansen J *p*-value (Sargan test)	0.763	0.859	0.995	0.174	0.014

Notes: The S-GMM two-step estimation results were obtained with the "xtabond2" command developed by Roodman (2006). Robust standard deviations are reported in parentheses. ** *p*-value < 0.05.

For the control variables, we found that the estimated coefficients of GDP/capita (in PPP) are positive and statistically significant at conventional levels in the case of two items (out of five) for imports and one item (out of five) for exports. These items are IT services and transport on the one hand, and IT services on the other. The effect of GDP/capita on total trade is statistically insignificant. This result is unexpected for us because it is incompatible with most previous results, which assume that this effect is rather positive and statistically significant (Rodríguez-Crespo and Martínez-Zarzoso 2019). As for the population variable, it has a positive and statistically significant impact on imports of IT services and transport services. It also has a statistically significant positive impact on exports of IT services, but a negative impact on transport services. Finally, the IDF variable has a positive and significant impact on the import of telecommunications services and the export of three types of services (out of four), namely IT services, transport, and travel. In addition, this variable has a positive and significant effect on total trade in IT and telecom services, and a significant but negative effect on financial services.

Finally, the estimation results provided in the different tables show that the goodness of fit is acceptable, since the Hansen and second-order autocorrelation tests confirm the validity of the instruments and thus validate the use of the dynamic specification.

To summarize, the above empirical results indicate that ICT (as measured by the proxy variable IDI) particularly affects international trade in two of the five types of services considered in this study. Indeed, ICT adoption reduces exports of IT services and increases imports and total trade in financial services. It should be noted that these two types of services are considered as ICT-based services. On the other hand, the effect of ICTs (IDI) on the other three types of services—travel, transport, and telecommunications—is not statistically significant. For the first two services—which are non-ICT-based services—we can explain them in that the global development of ICTs may not have been accompanied by a much greater international provision of these services via ICTs. Cultural, linguistic, and regulatory factors, as well as protectionist strategies, remain relevant in explaining this hit back for the digital age. For example, when trading partners have observable linguistic differences, they are likely to trade little with each other (Isphording and Otten 2013). For the third case, however, the extent of telecoms use by a wide variety of industries in these countries was so great that it had no significant impact on their overall trade.

Finally, to deepen our analysis, we will examine the effect of different pillars of ICTs development, namely ICT access, ICT use, and ICT skills. To this end, and with the aim of accounting for this relative effect, we propose below different regression equations that include these three sub-indices at the same time. This work will be the subject of Section 3.3.

3.3. Effects of ICT Access, Use, and Skills on Trade and Discussion

In this section, we try to determine the specific origin of the effect of ICTs on the five types of trade mentioned above by taking into account the distinct effects of the three sub-indices making up the IDI. By assuming that they do not strictly have the same degree of importance to trade in different services, the main results of our estimates are summarized in Tables 5–7. These results (without control variables) show that the access sub-index has no statistically significant effect on either imports or exports of trade services. On the other hand, it does have a positive and statistically significant effect on total trade in IT services, and a statistically significant but rather negative effect on total trade in transport. For the ICTs use sub-index, its effect on travel service imports is positive and statistically significant, while it has a positive and statistically significant effect on exports of both travel and IT services. The estimation results also reveal that the effect of this variable is positive and statistically significant on total trade in travel and IT services. With regard to the last skill sub-index, the results show that it has no significant effect on either imports or exports. It does, however, generate significant and positive effects on total trade for three (out of five) types of services: IT services, travel, and transport, at the 1%, 5%, and 1% thresholds, respectively. It should be noted, however, that the coefficient of the transport variable has a negative sign.

In addition, and insofar as we have noted that the results obtained using the previous models sometimes appear to be at odds with our expectations, and since some coefficients of the independent variables show negative signs, we saw it fit that these results deserve further scrutiny. However, it is worth pointing out in this regard that although each of the three sub-indices making up the IDI measures distinct aspects of ICT development, they are not completely independent of each other. Similarly, their effects are not equal for trade in different services. Therefore, and in order to better understand these results, we hypothesized that the effect of each of the three categories designed to measure ICT access, ICT use, and ICT skills on the independent variable varies, particularly according to the values taken by the other sub-indices introduced into the model. In other words, we are testing the hypothesis of a possible interaction effect that may exist between the independent variables represented by the three aforementioned sub-indices. Therefore, and in order to deepen the analysis of the results through this hypothesis, we favor a modification of our basic model (Equation (2)) by including an additional sub-index representing a new variable of interest, namely access to ICT and its interactions. Then, we estimate two models: one with ICT access, ICT use, and their interaction; and the other with ICT access and ICT skills and their interaction. In Tables 8–10, we report the obtained results. However, it follows from these results that, broadly speaking, the previous findings seem to be confirmed (Tables 2–4). In other words, the model does not reveal an interaction relationship between the three sub-indices. Indeed, with ICT access and ICT use, the interaction coefficients for access and use are overall either negative and statistically significant, or positive but statistically insignificant. Thus, this specification provides little justification for the negative effects of ICT access.

4. Robustness Tests

In order to ensure the robustness of the previous results, we estimated the model presented in Equation (2) using other estimation techniques, namely the fixed-effects model[10]. The estimates are reported in Tables 11–13. In essence, the different estimates provided by the fixed-effects model confirm the previous results on the impact of the different independent variables on trade in services. In particular, these results show that the variable of interest IDI has a positive and statistically significant effect on imports of

financial services, transport services (4), and travel (5). This variable also has a positive and statistically significant effect on exports of IT services (1), transport (4), and travel (5). Finally, IDI has a statistically significant effect on total trade in all services.

Table 11. Fixed-effects regression model: case of service imports.

Variables TIC	Computer Services (1)	Financial Services (2)	Telecommunication Services (3)	Transportation (4)	Travel (5)
GDP/capita	6.510 ** (3.150)	−28.810 (139.13)	0.080 (0.171)	0.010 (0.060)	0.040 (0.150)
Population	21.81 *** (18.66)	−3.650 (53.51)	0.210 (0.130)	0.070 (0.040)	0.060 (0.150)
IDI	27.320 (5.850)	8.100 * (5.140)	0.310 *** (0.080)	0.090 ** (0.030)	0.220 *** (0.060)
IDF	4.700 (15.010)	−11.230 (7.560)	−1.060 ** (1.720)	−0.030 (0.530)	−3.31 * (1.94)
No. of countries	19	19	19	19	19
No. of observations	228	228	227	228	227
R^2	0.250	0.020	0.490	0.140	0.030

Notes: Robust standard deviations are reported in parentheses. * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01.

Table 12. Fixed-effects regression model: case of service exports.

Variables TIC	Computer Services (1)	Financial Services (2)	Telecommunication Services (3)	Transport (4)	Travel (5)
GDP/capita	0.260 * (0.190)	0.060 (0.090)	0.110 (0.120)	0.090 (0.230)	0.090 (0.230)
Population	0.160 * (0.140)	0.150 (0.100)	0.140 (0.110)	0.090 ** (0.160)	0.090 (0.160)
IDI	0.230 ** (0.100)	0.100 (0.100)	0.090 (0.06)	0.280 *** (0.090)	0.280 *** (0.090)
IDF	−2.760 * (2.660)	−1.280 (1.460)	−4.300 ** (1.700)	−2.190 (1.310)	−2.190 (1.310)
No. of countries	15	19	19	19	19
No. of observations	165	228	221	226	226
R^2	0.020	0.120	0.230	0.260	0.260

Notes: Robust standard deviations are reported in parentheses. * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01.

Table 13. Fixed-effects regression model: case of service trade.

Variables TIC	Computer Services (1)	Financial Services (2)	Telecommunication Services (3)	Transport (4)	Travel (5)
GDP/capita	0.250 (0.240)	0.090 (0.140)	0.220 (0.190)	0.050 (0.100)	−0.080 (0.230)
Population	0.130 (0.130)	0.090 (0.160)	0.150 (0.100)	0.080 (0.040)	0.090 (0.160)
IDI	0.280 *** (0.090)	0.170 * (0.090)	0.180 ** (0.080)	1.140 *** (3.200)	0.220 *** (0.090)
IDF	−2.340 * (2.570)	−0.630 ** (1.580)	−2.480 (1.780)	−1.660 (0.770)	−2.19 * (1.310)
No. of countries	19	19	19	19	19
No. of observations	228	206	228	225	228
R^2	0.360	0.450	0.110	0.10	0.010

Notes: Robust standard deviations are reported in parentheses. * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01.

5. Conclusions

This paper investigates the impact of ICT on exports, imports, and total trade in services for 19 MENA countries. Using IDI, a composite index of ICT, the paper finds that ICT negatively impacts exports of IT services and positively impacts the imports and total trade of financial services. The sub-indices of ICT have differing impacts on IT, travel, and total trade in services. In summary, our findings indicate that introducing ICTs in MENA countries has had a marginal and low impact on the growth of international trade in services with the rest of the world. It is important to note that, unlike many previous studies that often report positive effects of ICTs on trade, our study reveals modest positive effects on MENA countries. In fact, there is scant evidence, particularly during the 2005–2019 period, to suggest that ICT adoption alone is the decisive factor for increasing international trade in services. In other words, our results suggest that expansion of international trade does not solely stream from the adoption of ICTs. This is particularly true given the multifaceted challenges, both economic and political, that this region faces, hindering its integration into the global economy, as we mentioned in the introduction. Additionally, it is worth noting that the MENA region is recognized as one of the most restrictive when it comes to trade in services, as highlighted by the (OECD 2017).

From a practical point of view, and to harness the potential benefits offered by ICTs, it is strongly recommended that these countries initiate comprehensive structural reforms, implemented concurrently with an accelerated adoption of these technologies. This adoption should cover various fronts, including enhancing Internet accessibility, mobile and broadband infrastructure, promoting e-commerce practices, and fostering digital payment methods. These channels serve as crucial conduits through which the tangible economic impacts of ICTs are likely to manifest themselves in the MENA region's economies. The requisite reforms should primarily center on redirecting trade policies to dismantle numerous lingering quantitative barriers. These barriers impede international trade for MENA countries and constrain their integration into global markets. Additionally, there is a need for institutional reforms that facilitate trade, such as initiatives aimed at improving business productivity (Esfahani 1991; Feenstra and Hanson 1997), fostering increased competition in the local market (including price competition), and enhancing corporate governance capabilities. These reforms must extend beyond conventional practices to ensure the survival and thriving of businesses in this evolving landscape.

Like most research works, the current review is not without its limitations that should be considered in the future. For instance, one limitation is that we used data for 19 MENA countries, and therefore we can find it difficult to generalize the results to all other MENA countries. However, this is due to the lack of data related to the variables of importance to the MENA countries that were not considered within the study sample. Second, in this research, we study the relationship between ICT and international trade for a group of MENA countries only, which makes the results one-sided. We recommend that researchers in the future conduct a comparative study between MENA countries and groups of high-income countries, middle-income countries, and low-income countries. It is also possible that future studies will focus on the role of ICT development in inclusive trade.

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Notes

1 For example, between 2000 and 2010, Internet use increased more than tenfold, exceeding 100 million, cell phone penetration exceeded 100% and the number of broadband (fixed) Internet subscribers rose by 200% from 25 million in 2010 to 73 million in 2020. However, an inter- and intra-regional comparison shows strong disparities in the spread and use of these technologies (Abeliansky et al. 2021; OECD 2017).

2 According to the US International Trade Commission (USITC) (2017), global e-commerce, for example, grew from US$19.3 trillion in 2012 to US$27.7 trillion in 2016. The United Nations Conference on Trade and Development (UNCTAD 2019) estimates the global value of e-commerce at US$29 trillion in 2017 (https://www.iisd.org/system/files/publications/commerce-electronique-organisation-mondiale.pdf, accessed on 1 July 2023).

3 Studying the effects of ICT availability and use on trade in EU countries, they conclude that there is no significant impact of ICT on trade in this zone. Nevertheless, they show that trade growth is conditional on significant adoption of ICT by trading partner countries.

4 See UNCTAD (2015), "International trade in ict services and ict-enabled services" (https://unctad.org/system/files/official-document/tn_unctad_ict4d03_en.pdf, accessed on 1 July 2023). And also. So, in our case potentially ICT-enabled services are financial services, IT services and telecommunications services, while non-potentially ICT-enabled services include travel and transport.

5 Although data shows that price dispersion persists on the web, partly because companies are more successful at price differentiation, offering different rates to different consumers based on their search history, geographical location or other information gathered about them (World Bank Group 2016, Digital Dividends).

6 Also known as non-ICT services, including mainly travel and transport, but also including certain trade services such as construction, maintenance and repair services (https://www150.statcan.gc.ca/n1/pub/13-605-x/2018001/article/54965-fra.htm, accessed on 1 July 2023).

7 IDI is a composite index made up of three sub-indices: ICT access, use and skills (by weighting the first two by 40 percent and the third by 20 percent). These three sub-indices are in turn composed of 11 indicators as follows: CT access is measured by five indicators: mobile-cellular subscriptions per 100 inhabitants, fixed-telephone subscriptions per 100 inhabitants, international internet bandwidth per internet user, percentage of households with a computer and percentage of households with Internet access. ICT use is measured by three indicators: percentage of individuals using the internet, fixed-broadband internet subscriptions per 100 inhabitants and active mobile-broadband subscriptions per 100 inhabitants. ICT skills are approximated by three indicators: secondary gross enrolment ratio, adult literacy rate and tertiary gross enrolment ratio.

8 See The ICT Development Index (IDI): conceptual framework and methodology: (https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2015/methodology.aspx, accessed on 1 July 2023).

9 The dynamic fixed effects panel data model also has some shortcomings. Nickell (1981) showed that within-groups estimates of a dynamic panel data model can be badly biased for small T, even as N goes to infinity. This bias is commonly called Nickell bias. This is essentially an endogeneity bias, originating from the correlation between the lagged dependent variable and the error term. The use of a sufficiently large T allows the reduction of this bias (it will eventually tend towards zero when $T \to \infty$) and thus, the convergence of the estimators (Eberhardt and Teal 2011).

10 The fixed-effect methods provide a solution to the problem of the omission of some important variables, which leads to a biased estimate of the other variables' effect. The important role of the fixed effect lies in their ability to attract and control, in modeling, all the not observed and stable in time characteristics without having to measure them. This eliminates a significant amount of the estimate bias (Allison 2005). The fixed-effect method is an intra-individual (within-subject) estimation method. The latter does not provide an estimate for the coefficients of variables with no intrasubject variation (i.e., the variables that do not change with time). All these variables are controlled by the fixed-effect regression even if they are not measured (Allison 2005).

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