Regional initiatives
Arab States region

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The economic contribution of broadband, digitization and ICT regulation

Econometric modelling for the Arab States region

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Foreword

The transformative power of digital technologies and connectivity is empowering people, creating an environment that nurtures innovation, and is triggering positive change in business processes and in the global economy.

The recent ITU global study on the economic contribution of broadband, digitization and ICT regulation provided a global econometric analysis of robust and reliable data resources to measure the impact of fixed and mobile broadband and digital transformation on the economy as a whole. It also analysed the impact of institutional and regulatory variables to the development of the digital ecosystem.

Based on the data and analysis to measure the impact of digitization as a whole, a further need was identified to conduct studies that delved deeper into these effects, focusing on specific regions of the world. By applying the same methodologies and econometric models used for assessing global effects, this ITU report focuses on the impact of broadband, digital transformation and policy and regulatory frameworks on the growth of markets for digital services in the Arab States region.

In addition to providing evidence of the importance of regulatory and institutional variables in driving digital growth, this report also illustrates that broadband technologies and effective ICT regulation can have positive impacts on the growth of national economies and prosperity, suggesting that an increase of 10 per cent in mobile broadband penetration in the Arab States region would yield an increase in 1.81 per cent in Gross Domestic Product (GDP) per capita, and that an increase of 10 per cent of digitization, in the CAF Digital Ecosystem Development Index results in 2.49 per cent growth in GDP per capita.

I am delighted to present this research for the Arab States region to assist Member States in designing smart and sustainable policies and strategies to reap the benefits of the dynamic and exciting broadband ecosystem.

Doreen Bogdan-Martin
Director, ITU Telecommunication Development Bureau

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1 Introduction

The *Economic contribution of broadband, digitization and ICT regulation: Econometric modelling for the Arab States region* provides a set of econometric analyses that estimate the economic contribution of broadband and digitization, as well as the impact of ICT policy on the development of the digital economy in the Arab States region. It provides substantial evidence regarding the impact of broadband and digital transformation on the economy as well as the impact of institutional and regulatory variables on the growth of the digital ecosystem.

This report follows the findings of the ITU global study, published in 2018, on the economic contribution of broadband, digitization, and ICT regulation[1], which was based on a large set of sample economies, and demonstrated the following impacts and effects:

- Fixed broadband economic impact is guided by a *return-to-scale effect*[2], according to which the economic impact of fixed broadband is greater in high-income country economies than in low-income country economies.
- The economic impact of mobile broadband reflects a *saturation effect*, according to which the mobile broadband contribution is higher in low-income country economies than in mid- and high-income country economies.
- The regulatory and policy framework has a consistent impact on the development of the digital ecosystem, regardless of the level of development or income.

This evidence was considered significant for policy makers and regulators in particular with regards to two key issues:

1. Which technologies should become a policy priority in terms of adoption?
2. How to ensure that, beyond broadband adoption, policies are deployed to stimulate the development of the digital ecosystem?

The conclusions generated by this research has prompted calls to conduct studies that delve deeper into these effects, focusing on specific regions of the world. By applying the same methodologies and models used for assessing global effects, this report focuses on the Arab States region, summarizes the results of the ITU 2018 global study, and presents the results of the analyses for the region.

2 The effects identified on a global scale

This section presents the types of analyses and methodologies and the results presented in the ITU 2018 global study. Section 3 focuses on countries in the Arab States region.

The global ITU study cited above focused on testing three effects:

- the economic contribution of fixed and mobile broadband;
- the economic contribution of digitization (a variable that subsumes broadband technology within a larger set of digital ecosystem components); and

[1] *The economic contribution of broadband, digitization and ICT regulation.* https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/FINAL_1d_18-00513_Broadband-and-Digital-Transformation-E.pdf

[2] Generally, the returns-to-scale effect refers to a reduction in unit cost as the scale of production increases over time, when inputs such as physical capital usage are variable. The ITU report on the impact of broadband on the economy, 2012 states that according to the returns-to-scale theory, the economic impact of broadband increases exponentially with the penetration of the technology (https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf).

- the impact of the policy and regulatory frameworks on the growth of markets for digital services and applications.

The analyses and findings for each of the effects provides the context for the regional models.

2.1 Economic impact of fixed broadband

The structural econometric model, composed of four equations[3], generated evidence of the impact of fixed broadband on the economy between 2010 and 2017. The results, based on a model run for a 139 country sample (general fixed broadband model), showed that an increase of 10 per cent in fixed broadband penetration yielded an increase in 0.8 per cent in gross domestic product (GDP) per capita.

The sample was split into three sets (high-, medium-, and low-income countries) to test whether the fixed broadband contribution to GDP increased or decreased depending on the level of economic development:

1. countries with GDP per capita higher than USD 22 000 (50 countries);
2. countries with GDP per capita between USD 12 000 and USD 22 000 (26 countries);
3. countries with GDP per capita lower than USD 12 000 (63 countries).

The results supported the hypothesis that the economic contribution of fixed broadband increases with economic development:

- high-income countries: a 10 per cent increase in fixed broadband penetration yields 1.4 per cent increase in GDP growth;
- middle-income countries: a 10 per cent increase in fixed broadband penetration yields 0.5 per cent increase in GDP growth;
- low-income countries: while the coefficient of fixed broadband was similar to that of middle-income countries (10 per cent increase in fixed broadband penetration yields 0.5 per cent increase in GDP growth), the impact was not statistically significant[4].

2.2 Economic impact of mobile broadband

The ITU 2018 global study also shows that mobile broadband has a higher impact than fixed broadband on the world economy. Relying on a structural model run for a 139 country sample (general mobile broadband model), it was estimated that on average an increase of 10 per cent in mobile broadband penetration yielded an increase of 1.5 per cent in GDP. However, using the same three data sets (high-, medium-, and low-income countries) to test the economic impact of mobile broadband showed that the level of economic contribution of mobile broadband is higher in low-income countries than in high-income countries, where it had no impact:

- high-income countries: no economic impact was detected;
- middle-income countries: an increase of 10 per cent in mobile broadband penetration yields an increase in 1.8 per cent in GDP;
- low-income countries: an increase of 10 per cent in mobile broadband penetration yields an increase of 2 per cent in GDP.

This difference reflects the high levels of access to fixed broadband in high-income countries, while mobile network access to broadband is the only technology available to the majority of consumers in low-income countries. Consequently, the mobile broadband contribution to high-income economies is only marginal and the impact of mobile broadband in low-income countries is extremely important.

[3] Detailed description of models and methodologies can be found in the ITU global study cited in footnote 1.
[4] The coefficient is not statistically significant due to the lack of proof of causality in that model.

2.3 Economic impact of digitization

The ITU 2018 global study tested the economic impact of digitization using an endogenous growth model that linked GDP to the fixed stock of capital, labour force, and the CAF Digital Ecosystem Development Index (see section 3.5). The approach followed in this case tested the economic contribution for a sample of 73 countries worldwide (the general digitization model) and then split the results into two sets of countries: those within the Organization for Economic Co-operation and Development (OECD)[5] and non-OECD countries. According to the general digitization model, an increase of 10 per cent in the CAF Digital Ecosystem Development Index yielded a 1.3 per cent growth in GDP per capita. When the sample was split between OECD and non-OECD countries, economic impact increased in the OECD countries relative to non-OECD countries:

- OECD countries: An increase of 10 per cent in the CAF Digital Ecosystem Development Index yielded a 1.4 per cent growth in GDP per capita.
- Non-OECD countries: An increase of 10 per cent in the CAF Digital Ecosystem Development Index yielded a 1.0 per cent growth in GDP per capita.

Furthermore, a single variable model with country and period fixed effects indicated that digitization also has an impact on labour and total factor productivity. An increase in the digitization index of 10 per cent yielded an increase in labour productivity of 2.6 per cent and in total factor productivity of 2.3 per cent.

2.4 Impact of policy and regulatory framework on digitization development

In the ITU 2018 global study, the contribution to digitization development was tested through a multivariate regression model with fixed effects based on two independent variables: the ITU ICT Regulatory Tracker[6] and a year lag of the same variable for control purposes. The model provided further evidence of the importance of the regulatory and institutional variable in driving digital ecosystem growth. An increase of 10 per cent in the ITU ICT Regulatory Tracker yielded a positive increase in the CAF Ecosystem Development Index of 0.348 per cent in the subsequent time period.

Having presented the analyses, methodologies and results relied upon for the ITU 2018 global study, section 3 below focuses on validating the results for the Arab States region, starting with a brief review of the research literature on economic contribution of broadband in the region.

3 The economic contribution of broadband and digitization and the impact of policy on digitization in the Arab States region

This section analyses broadband and digitization economic contribution for the Arab States region. The 21 countries included in this analysis are Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen.

[5] Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States of America.

[6] https://www.itu.int/net4/itu-d/irt/#/tracker-by-country/regulatory-tracker/2017

3.1 Review of the research literature

Research on the economic impact of broadband in the Arab States region has generated a number of econometric studies, although in some cases the direction of causality could not be clearly ascertained. For example, Pradan et al. (2017) examined the relationship between broadband penetration, financial development and economic growth for twenty-two Arab League countries between 2001 and 2013. Their results indicated the existence of a long-run equilibrium relationship between the three variables. More specifically, the study concluded identifying a bi-directional causality between economic growth and broadband penetration.

Tsang *et al*. (2011) studied the impact of ICT in the region. Their analysis was correlational in nature studying, in particular, the relationship between fixed Internet and mobile broadband subscriptions and gross national income (GNI) for Bahrain, Kuwait, Oman, Saudi Arabia, and United Arab Emirates. The authors found that the relationship between the variables evolved over time. For example, in Bahrain between 2000 and 2002, fixed Internet subscriptions increased rapidly while GNI increased only modestly. Between 2003 and 2005, the penetration of fixed Internet subscriptions stagnated while GNI continued to grow, though in 2005–2008, fixed Internet subscriptions per 100 inhabitants increased steadily with GNI. Saudi Arabia also went through three phases, although in this case fixed Internet penetration did not stagnate in the second period (2002–2006).

All in all, the analysis for the five countries indicated an initial period of rapid growth for Internet subscriptions, outpacing the economic development rate. The authors concluded that the relationship between ICT penetration and income is driven by an endogenous process with significant reverse effects of income on ICT uptake, and they recommended the development of structural models, such as the one presented in this report, in order to understand the direction of the relationship between ICT and national economic growth.

The growing availability of country data has enabled researchers to fulfil the recommendation of Tsang *et al*. (2011) in terms of developing structural models capable of teasing out the causal links between broadband and economic development for the Arab States region. For example, according to a four-equation model similar to the one implemented in the current study, Katz and Callorda (2015a) estimated that in the case of Jordan a 1 per cent increase in mobile broadband connections yielded a 0.039 per cent growth in GDP. Based on this coefficient, mobile broadband is estimated to have contributed annually an average of USD 396 million to Jordan's economic growth between 2011 and 2014. It was also estimated that a 1 per cent increase in fixed broadband lines yielded a 0.073 per cent growth in GDP. According to this coefficient, between 2006 and 2014, fixed broadband has contributed annually an average of USD 401 million to Jordan's economy.

Based on a similar econometric structural model, Katz and Callorda (2015b) estimated that in Morocco, a 1 per cent increase in mobile broadband connections yielded a 0.054 per cent growth in GDP. Based on this coefficient, mobile broadband is estimated to have contributed annually an average of USD 1 234 million to Morocco's economy between 2011 and 2014. It was also estimated that a 1 per cent increase in fixed broadband lines yielded a 0.084 per cent growth in GDP. According to this coefficient, fixed broadband has contributed annually an average of USD 750 million to Morocco's economy between 2006 and 2014**.**

Finally, a structural model developed by Katz and Callorda (2015c) estimated that 1 per cent increase in fixed broadband lines in Tunisia yielded a 0.101 per cent growth in GDP. According to this coefficient, fixed broadband contributed annually an average of USD 225 million to Tunisia's economy between 2008 and 2014. When it came to mobile broadband, recent technology diffusion prevented measuring a real impact.

Within the same single country study practice, El-Shenawi (2016)[7] conducted a study measuring the economic impact of fixed broadband in Egypt. By relying on data between 2002 and 2010, a multivariate regression model measured the impact on per capita GDP growth rate of broadband penetration, investment rate, literacy rate, and a dummy variable for the 2008 financial crisis. The results showed that in Egypt a 10 percentage point increase in broadband penetration leads to about 1 percentage point increase in the growth rate of GDP per capita. However, the study does not provide an indication of the statistical significance of the model results.

In summary, prior research on the economic impact of broadband in the Arab States region generally shows the significant contribution that technology has on GDP growth, although one study showed that economic development could also be driven as a result of increasing the level of broadband penetration. It is in this context that advanced econometric approaches, such as the one presented in this study, could prove to be more useful.

3.2 Hypotheses

Evidence generated in the ITU 2018 global study reveals the following expected effects for the Arab States region:

- *impact of fixed broadband* should fall between the contribution of low- and high-income countries in the global sample;
- *impact of mobile broadband* should fall between the contribution of low- and high-income countries in the global sample;
- *impact of digitization* a similar prorated effect would be expected in the case of digitization.

3.3 Economic impact of fixed broadband

The estimation of the economic contribution of fixed broadband in the Arab States region relied on the same structural model used in the ITU 2018 global study and in the estimation of effects in the other regions. The model consists of four equations: an aggregate production function modelling the economy and, subsequently, three functions- demand, supply, and output.

Data

To test the hypothesis of fixed broadband economic impact presented above, a database of the countries mentioned above was built, containing time series for all the required variables between 2011 and 2017. The data sources are the International Telecommunication Union, the World Bank, and Ovum (see Annexes A and B for sources of data).

Model results and discussion

Table 1 presents the model results for 14 countries[8] in the Arab States region: Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Yemen.

[7] During the ITU Regional Economic Dialogue for the Arab States region held in Oman, December 2016, a presentation on The economic impact of Broadband in Egypt was delivered by Nagwa El-Shenawi, from the Ministry of Communication and Information Technology of Egypt (https://www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2016/EFF/Pres/S1-Broadband%20impact%20pres%202016.pdf).

[8] Somalia, Sudan and Syria were excluded because of incomplete data sets for the study period. Also excluded were Comoros, Djibouti, Libya, and Mauritania because of low GDP per capita and low fixed broadband penetration. If countries with lower GDP per capita are included in the regression model, the impact of fixed broadband is close to 0 and not statistically significant.

Table 1: Economic Impact of fixed broadband

GDP per capita	
Fixed broadband subscriber penetration	0.07117 ***
Capital	0.19395 ***
Education	-0.01849
Fixed broadband subscriber penetration	
Fixed telephone subscribers	1.08456 ***
Rural population	-0.16317 ***
GDP per capita	0.40632 ***
Fixed broadband price	-0.83279 ***
HHI[9] fixed broadband	0.09156
Revenue fixed broadband	
GDP per capita	0.38789 ***
Fixed broadband price	0.08394
HHI fixed broadband	-0.43083 ***
Fixed broadband adoption growth	
Revenue fixed broadband	-0.39657 ***
Observations	392
Number of countries	14
Country fixed effects	Yes
Year and quarter fixed effects	Yes
Years	2011-2017
R-Squared first model	0.9965

***, **, * significant at 1%, 5%, and 10% critical value respectively.

As expected, according to the fixed broadband general model, this technology has had a significant economic contribution in the Arab States region over the last six years (2011-2017). An increase of 10 per cent in fixed broadband penetration yields an increase in 0.71 per cent in GDP per capita. Capital formation has had a positive impact on GDP growth but education has had no significative impact[10].

Furthermore, the positive economic impact of fixed broadband in the Arab States region are statistically significant, and higher than the impact for low income countries in the global sample (0.71 vs 0.54, although the latter value is not statistically significant)[11] (see Table 2).

9 Herfindahl-Hirschman Index (HHI)

10 The education indicator has no variance in the period under analysis.

11 If we include in the regression model the countries with lower GDP per capita (Djibouti, Libya, and Mauritania) the impact of fixed broadband is close to 0 and not statistically significant.

Table 2: Economic impact of fixed broadband (Arab States region compared to the global model for low income countries)

	ITU global study Low income countries	Arab States region
GDP per capita		
Fixed broadband subscriber penetration	0.05461	0.07117 ***
Capital	0.21024 ***	0.19395 ***
Education	0.15569 ***	-0.01849
Fixed broadband subscriber penetration		
Fixed telephone subscribers	0.49262 ***	1.08456 ***
Rural population	-0.81927 ***	-0.16317 ***
GDP per capita	0.53821 ***	0.40632 ***
Fixed broadband price	-0.30159 ***	-0.83279 ***
HHI fixed broadband	-0.38882 ***	0.09156
Fixed broadband revenue		
GDP per capita	1.24272***	0.38789 ***
Fixed broadband price	0.14314 ***	0.08394
HHI fixed broadband	-0.71760 ***	-0.43083 ***
Fixed broadband adoption growth		
Fixed broadband revenue	-0.74656 ***	-0.39657 ***
Observations	1,724	392
Number of countries	63	14
Country fixed effects	Yes	Yes
Year and quarter fixed effects	Yes	Yes
Years	2010-2017	2011-2017
R-Squared first model	0.9831	0.9965

***, **, * significant at 1%, 5% and 10% critical value respectively.

NOTE: The global model was built starting in 2010 given that by then most countries had exceeded the 5 per cent adoption threshold.

3.4 Economic impact of mobile broadband

The structural model used to test the economic contribution of mobile broadband, comprises four equations: an aggregate production function modelling the economy and three functions- demand, supply, and output.

Data

To test the economic impact of the mobile broadband hypothesis presented above, a database was built for the following countries: Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Yemen. As indicated before, the database contains time series for all the required variables between 2011 and 2017. The data sources are the International Telecommunication Union, the World Bank, and GSMA (see Annexes A and B for sources of data).

Model results and discussion

The model was run with the entire database of 14 countries, and yielded statistically significant results, confirming the effects identified in the global model (see Table 3).

Table 3: Economic impact of mobile broadband

GDP per capita	
Mobile broadband unique subscriber penetration	0.18157 ***
Capital	0.26679 ***
Education	-0.02580
Mobile broadband unique subscriber penetration	
Mobile unique subscriber penetration	1.75700 ***
Rural population	-0.07603 ***
GDP per capita	0.12817 ***
Mobile broadband price	0.11883 ***
HHI mobile broadband	-0.70465 ***
Revenue mobile broadband	
GDP per capita	0.73243 ***
Mobile broadband price	0.19402 *
HHI mobile broadband	-2.16969 ***
Mobile broadband adoption growth	
Revenue mobile broadband	-0.87478
Observations	378
Number of countries	14
Country fixed effects	Yes
Year and quarter fixed effects	Yes
Years	2011-2017
R-Squared first model	0.9968

***, **, * significant at 1%, 5%, and 10% critical value respectively.

According to the mobile broadband model in Table 3, an increase of 10 per cent in mobile broadband penetration yields an increase in 1.81 per cent in GDP per capita, which means that this technology has had a significant economic impact in the Arab States region over the last few years (2011-2017). Furthermore, this coefficient of economic impact of mobile broadband in the Arab States region is lower than the one estimated for low income countries in the global study (see Table 4)[12].

Table 4: Economic impact of mobile broadband (Arab States region compared to the global model)

	ITU global study Low income countries	Arab States region
GDP per capita		
Mobile broadband unique subscriber penetration	0.19752 ***	0.18157 ***
Capital	0.23190 ***	0.26679 ***
Education	0.12406 ***	-0.02580
Mobile broadband unique subscriber penetration		
Mobile unique subscriber penetration	1.63963 ***	1.75700 ***
Rural population	-0.08433 ***	-0.07603 ***
GDP per capita	0.04384 **	0.12817 ***
Mobile broadband price	-0.13139 ***	0.11883 ***
HHI mobile broadband	-0.27510 ***	-0.70465 ***
Revenue mobile broadband		
GDP per capita	0.97739 ***	0.73243 ***
Mobile broadband price	-0.47023 ***	0.19402 *
HHI mobile broadband	-1.65927 ***	-2.16969 ***
Mobile broadband adoption growth		
Revenue mobile broadband	-1.11108 ***	-0.87478
Observations	1,689	378
Number of countries	63	14
Country fixed effects	Yes	Yes
Year and quarter fixed effects	Yes	Yes
Years	2010-2017	2011-2017
R-Squared first model	0.9799	0.9968

***, **, * significant at 1%, 5%, and 10% critical value respectively.

[12] On the other hand, if we included in the regression model the countries with lower GDP (Djibouti, Libya, and Mauritania) the impact of mobile broadband would be higher than in low income countries. That result confirms the dichotomy of the Arab States region.

The fixed and mobile broadband model results indicate that the Arab States region is, as anticipated in the hypotheses, in an intermediate zone between high-income and low-income countries. Consequently, both technologies have a positive contribution to GDP growth.

3.5 Economic impact of digitization

The economic contribution of digitization in the Arab States region was tested using the CAF Digital Eco-system Development Index to measure all countries around the world in terms of the development of their digital economy. The return-to-scale effect to be tested is whether the economic contribution of digitization in the region is higher in the Arab States region than that of less developed economies.

Data

The CAF Digital Ecosystem Development Index was calculated for Algeria, Bahrain, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Yemen. Where country data was unavailable during the period under study, those countries were not included in the study.

It is important to highlight that the model included independent variables for fixed capital formation (source: World Bank), GDP per capita (source: IMF), oil prices, and the education index, as a proxy for labour quality (source: United Nations Development Programme (UNDP)).

Model results and discussion

The model was first run for Algeria, Bahrain, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Yemen for the period 2008-2017, which resulted in 170 observations, and included fixed effects by year (see Table 5).

Table 5: Economic impact of digitization: Arab States region (2008-2017)

Variable	Coefficients
Previous GDP	0.4908 *** (0.0582)
Digitization	0.2486 ** (0.1145)
Capital	-0.0004 (0.0437)
Labour	0.2532 (0.3642)
Oil Price	0.2800 ***
	(0.0437)
Constant	2.6250 *** (0.7379)
Observations	170
Year fixed effects	Yes

***, **, * significant at 1%, 5%, and 10% critical value respectively.

According to the model, an increase of 10 per cent in the CAF Digital Ecosystem Development Index results in a 2.49 per cent growth in GDP per capita. Therefore, an increase in the Digital Ecosystem Development Index from 50 to 51 will yield an increase of GDP per capita of 0.50 per cent (accounting both for direct and indirect effects on output).

The results from the Arab States region model confirms the results of the non-OECD model developed in the ITU 2018 global study (see Table 6).

Table 6: Economic impact of digitization, 2017 (Arab States region compared to non-OECD)

Variable	Arab States region	Non-OECD
Previous GDP	0.4908 *** (0.0582)	0.7279 *** (0.0294)
Digitization	0.2486 ** (0.1145)	0.1044 * (0.0592)
Capital	-0.0004 (0.0437)	0.0471 * (0.0279)
Labour	0.2532 (0.3642)	0.0581 (0.0544)
Oil price	0.2800 ***	-
	(0.0437)	-
Constant	2.6250 *** (0.7379)	1.6827 *** (0.2821)
Observations	170	429
Year fixed effects	Yes	Yes

***, **, * significant at 1%, 5%, and 10% critical value respectively.

However, it should be pointed out that this result is not as robust as that developed for the global sample because of the reduced number of observations.

3.6 Impact of policy and regulatory framework on digitization

The following analysis, similar to that applied in the ITU 2018 global study, tests the impact of the ITU ICT Regulatory Tracker[13] on the CAF Digital Ecosystem Development Index for countries in the Arab States region.

Data

The econometric models used for assessing effects relied on data from the ITU ICT Regulatory Tracker and the CAF Digital Ecosystem Development Index for the period from 2008 to 2017 for Algeria, Bahrain, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Yemen. As indicated in the ITU 2018 global study, the CAF Digital Ecosystem Development Index includes an institutional and regulatory pillar, which had

[13] https://www.itu.int/net4/itu-d/irt/#/tracker-by-country/regulatory-tracker/2018

to be excluded in order to avoid co-linearity[14]. Once this was done and the index was recalculated, it was possible to test the impact of the ITU ICT Regulatory Tracker on digitization.

Model results and discussion

A correlational analysis between both indices was initially run, and the results are presented in Table 7 for the Arab States region.

Table 7: Correlation between the ITU ICT Regulatory Tracker and the CAF Digital Ecosystem Development Index

CAF Digital Ecosystem Development Index (without the regulatory pillar)	Arab States region coefficient (standard deviation)
ITU ICT Regulatory Tracker	0.53715 (0.03914) ***
Constant	5.92852 (2.07653) ***
R-square	0.5270
Fixed effects for year and country	Yes
Countries	17
Observations	187
Years	2007-2017

***, **, * significant at 1%, 5%, and 10% critical value respectively.

In order to test for the causal link, a control of a one-year lag of the ITU ICT Regulatory Tracker was also added (see Table 8).

Table 8: Impact of the lagged ITU ICT Regulatory Tracker on the CAF Digital Ecosystem Development Index

CAF Digital Ecosystem Development Index (without the regulatory sub-index)	Arab States region Coefficient (Standard deviation)
CAF Digital Ecosystem Development Index (without regulation pillar)	0.22128 (0.07648) ***
ITU ICT Regulatory Tracker (t-1)	0.31601 (0.06712) ***
Constant	6.96833 (2.34256) ***
R-squared	0.5238
Fixed effects for year and country	Yes

[14] The CAF Digital Ecosystem Development Index comprises eight pillars, of which one measures the development of institutional and regulatory framework in a given country (see Katz and Callorda, 2018a). If this last pillar were to be included in the measurement of the index, it would be impossible to measure the effect of the ITU ICT Regulatory Tracker on digitization because the high level of correlation between two variables measuring approximately the same phenomenon (a condition known as co-linearity).

CAF Digital Ecosystem Development Index (without the regulatory sub-index)	Arab States region Coefficient (Standard deviation)
Groups	17
Observations	170
Years	2008-2017

***, **, * significant at 1%, 5%, and 10% critical value respectively.

In this model, it was found that an additional point in the ITU ICT Regulatory Tracker yields 0.22128 points higher in the CAF Digital Ecosystem Development Index (without the regulatory sub-index) for the same period, and 0.31601 higher in the subsequent period, which, by adding both effects yields a total coefficient of 0.53729.

Considering that the two previous models tested the correlation between both indices, the variables were concerted to logarithms to assess change. The CAF Digital Ecosystem Development Index was also recalculated without the regulatory and the competition pillars (since, as indicated above, the potential co-linearity with the ITU ICT Regulatory Tracker is high, see Table 9).

Table 9: Impact of the lagged ITU ICT Regulatory Tracker on the CAF Digital Ecosystem Development Index

Log CAF Digital Ecosystem Development Index (without the regulatory and competition pillars)	Arab States region coefficient (Standard deviation)
Log CAF Digital Ecosystem Development Index (without regulation and competition pillars) (t-1)	0.02239 (0.00122) ***
Log ITU ICT Regulatory Tracker (t-1)	0.06373 (0.02578) ***
Constant	2.49135 (0.07860) ***
R-Squared	0.7769
Fixed effects for year and country	Yes
Groups	17
Observations	170
Years	2008-2017

***, **, * significant at 1%, 5% and 10% critical value respectively

In this case, it is possible to prove the hypothesis: an increase of 10 per cent in the ITU ICT Regulatory Tracker yields a positive increase in the CAF Digital Ecosystem Development Index of 0.637 per cent in the subsequent time period.

To test the relationship between the regulatory and the digital ecosystem indices, a set of alternative correlations between pillars of both indices was run (see Table 10).

Table 10: Correlations between ITU ICT Regulatory Tracker and CAF Digital Ecosystem Development Index pillars

Pillars	ITU ICT Regulatory Tracker	ITU ICT Regulatory Tracker (without competition)	Regulatory authority component	Regulatory mandate component	Regulatory regime component	Competition framework component
CAF Digital Ecosystem Development Index	0.3583 (0.0415) ***	0.3332 (0.0443) ***	0.3139 (0.0551) ***	0.4399 (0.0591) ***	0.2710 (0.0408) ***	0.2675 (0.0345) ***
Infrastructure of digital services	0.4261 (0.0600) ***	0.3943 (0.0634) ***	0.3245 (0.0796) ***	0.4735 (0.0861) ***	0.4100 (0.0562) ***	0.3874 (0.0491) ***
Connectivity of digital services	0.5934 (0.0657) ***	0.5438 (0.0708) ***	0.4586 (0.0920) ***	**0.7034 (0.0950)** ***	0.4932 (0.0638) ***	0.4841 (0.0553) ***
Household digitization	**0.6773 (0.0795)** ***	**0.6263 (0.0851)** ***	0.5258 (0.1113) ***	**0.7716 (0.1157)** ***	0.5694 (0.0779) ***	0.5531 (0.0691) ***
Digitization of production	0.1855 (0.0379) ***	0.1826 (0.0392) ***	0.1628 (0.0510) ***	0.2659 (0.0515) ***	0.1680 (0.0368) ***	0.0859 (0.0360) **
Digital competitive intensity	0.3127 (0.0447) ***	0.2866 (0.0473) ***	0.3158 (0.0594) ***	0.4667 (0.0593) ***	0.1556 (0.0416) ***	0.1800 (0.0370) ***
Development of digital industries	0.2100 (0.0452) ***	0.1898 (0.0471) ***	0.2000 (0.0604) ***	0.2311 (0.0632) ***	0.2133 (0.0440) ***	0.2133 (0.0405) ***
Digital factors of production	0.5054 (0.0634) ***	0.4467 (0.0683) ***	0.4090 (0.0866) ***	0.5556 (0.0922) ***	0.3867 (0.0629) ***	0.4797 (0.0500) ***

***, **, * significant at 1%, 5% and 10% critical value respectively.

NOTE: The values in bold have correlations higher than 0.60.

A second set of regressions shows that the regulatory regime component of the ITU ICT Regulatory Tracker appears to be the main path of impact of the CAF Digital Ecosystem Development Index (see Table 11).

Table 11: Arab States region: Impact of the ITU ICT Regulatory Tracker components on the CAF Digital Ecosystem Development Index pillars

	CAF Digital Ecosystem Development Index	Infrastructure of digital services	Connectivity of digital services	Household digitization	Digitization of production	Digital competitive intensity	Development of digital industries	Digital factors of production
Regulatory authority component	0.5427 (0.2154) **	0.6814 (0.3048) **	0.5767 (0.3159) *	1.2959 (0.4345) ***	-0.6464 (0.2359) ***	0.5211 (0.2506) **	1.3093 (0.2766) ***	0.5290 (0.3399)
Regulatory mandate component	0.7191 (0.1745) ***	1.0159 (0.2469) ***	1.2315 (0.2559) ***	1.2491 (0.3520) ***	0.3803 (0.1911) **	0.7210 (0.2030) ***	0.3331 (0.2241)	1.0372 (0.2754) ***
Regulatory regime component	0.2552 (0.0654) ***	0.3788 (0.0926) ***	0.5398 (0.0960) ***	0.5601 (0.1321) ***	0.2454 (0.0717) ***	0.1195 (0.0761)	0.1759 (0.0841) **	0.4544 (0.1033) ***
Constant	-2.9462 (1.1106) ***	-5.6341 (1.5717) ***	-6.2598 (1.6288) ***	-10.1835 (2.2404) ***	3.8570 (1.2163) ***	-1.7999 (1.2920)	-5.1651 (1.4264) ***	-5.6434 (1.7529) ***
R-squared	0.5099	0.5147	0.6192	0.5095	0.2805	0.3106	0.3199	0.5012

***, **, * significant at 1%, 5%, and 10% critical value respectively.

Table 11 indicates that the regulatory regime component and the regulatory mandate component[15] always have a positive and significant impact on each pillar of the CAF Digital Ecosystem Development Index[16]. This indicates that the regulatory regime and the regulatory mandate components have a high impact on digital development[17] in the Arab States region.

4 Conclusion

The purpose of this study was to test the findings of the ITU global study on the economic contribution of broadband and digitization as well as the impact of regulation and policy on the digital economy development to the Arab States region.

An assessment of the research literature on broadband economic contribution in the Arab States region, as indicated in section 3, provided some validation of the findings on the ITU global study. A compilation of prior research on the economic contribution of broadband in the region initially found that broadband and economic growth were linked through two-directional causality.

Research relying on structural models for three countries in the region confirmed the existence of an economic contribution of fixed and mobile broadband, in addition to evidence generated in the

[15] The only exception is the Digital Competitive Intensity for the Regulatory Regime Component; and Development of Digital Industries for the Regulatory Mandate Component.

[16] The regulatory regime component includes indicators such as type of licenses provided to offer telecommunication services, obligations to publish interconnection offers by operators, monitoring of quality of service, infrastructure sharing for mobile operators permitted and/or mandated, unbundled access in local loop, spectrum secondary trading allowed, and number portability.

[17] While the first component of the ICT Regulatory Tracker has sometimes a negative sign, the coefficient of regulatory regime and regulatory mandate is always bigger and positive.

research literature and the ITU 2018 global study, the following effects for the Arab States region can be considered:

- Impact of fixed broadband: The impact of fixed broadband in the Arab States region is expected to fall between the contribution of low income and high-income countries in the global sample.
- Impact of mobile broadband: The impact of mobile broadband in the Arab States region should fall between the contribution of low income and high-income countries in the global sample.
- Impact of digitization: A prorated effect would be expected in the case of digitization in the Arab States region.

The evidence yielded by the econometric analysis confirms the hypotheses, although the lack of statistical significance in the third hypothesis precludes a rigorous validation (see Table 12).

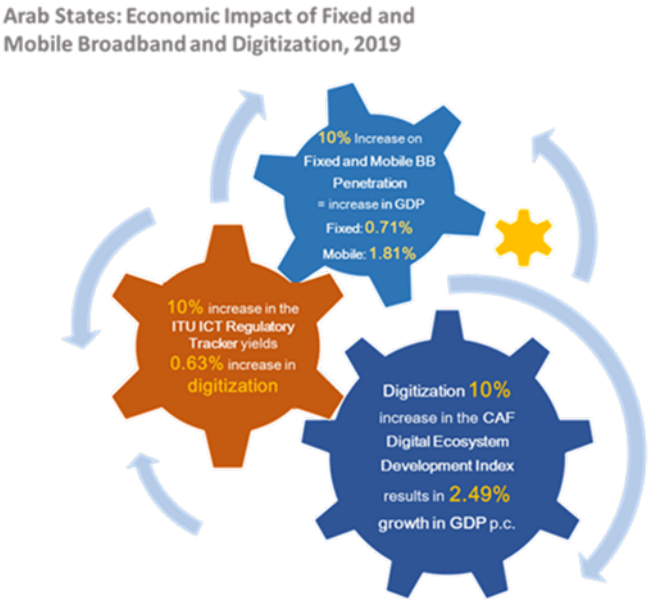
Table 12: Summary of results of econometric models (Arab States region compared to low income countries)

Hypothesis	10% increase impact on GDP per capita growth	
	Arab States region	ITU global study – low income countries
Economic impact of fixed broadband in the Arab States region is twice the impact estimated for low income countries in the global sample (*return-to-scale effect*).	0.7	0.5 (not significant)
Economic Impact of mobile broadband in the Arab States region is half the impact estimated for low income countries in the global sample (*saturation effect*).	1.8	2
Economic Impact of digitization in the Arab States region is higher than that calculated for the global sample (*return-to-scale effect*).	2.4	1 (non-OECD countries)

In summary, the coefficient of economic impact of fixed broadband for the Arab States region (0.7) is somewhat higher than low-income countries (0.5) but lower than high-income countries (1.4). The coefficient of economic impact of mobile broadband for the same geopolitical unit (1.8) is lower than that of low-income countries (2) but positive and statistically significant relative to high-income countries. The impact of digitization is higher for the Arab States region than non-OECD countries due to the weight that High-income countries have on the overall geopolitical unit (although the result in the former model is less robust due to the small number of observations).

The main conclusions of the Arab States region analyses are illustrated in Figure 1.

Figure 1: Main findings for the Arab States region



Source: ITU

The impact of policy and regulatory frameworks on the development of digitization was also tested. In the Arab States region, the results also validated the positive impact of the policy and regulatory variable in the countries in the region. It was noted that an increase of 10 per cent in the ITU ICT Regulatory Tracker yields a positive increase in the CAF Digital Ecosystem Development Index of 0.637 per cent in the Arab States region.

A second set of regressions shows, again, that of all the components of the ITU ICT Regulatory Tracker, the regulatory regime component appears to be the main path of impact of the CAF Ecosystem Development Index. This analysis provided further evidence of the importance of the regulatory and institutional variable in driving the digital ecosystem growth.

Annex A: List of data sources for models testing the economic impact of fixed and mobile broadband

Indicator	Source
GDP per capita	IMF
Fixed broadband subscriber penetration	ITU- OVUM
Capital- Gross capital formation (percentage of GDP)	World Bank
Education- School enrolment, tertiary (per cent gross)	World Bank
Fixed telephone subscribers	ITU
Rural population (per cent of total population)	World Bank
Fixed broadband price	ITU
HHI fixed broadband	OVUM
Fixed broadband revenue	ITU- OVUM
Mobile broadband unique subscriber penetration	GSMA
Mobile unique subscriber penetration	GSMA
Mobile Broadband Price/ARPU (Average revenue per user)	ITU- GSMA
Herfindahl-Hirschman Index (HHI) mobile broadband	GSMA
Mobile broadband revenue	GSMA

Annex B: Indicators included in the CAF Digital Ecosystem Development Index and data sources

Pillar	Sub-pillar	Indicator	Source
Infrastructure	Investment	Telecommunication investment per capita in current prices – five-year average (USD PPP)	World Bank; ITU
Infrastructure	Quality of service	Average fixed broadband download speed (Mbit/s)	Akamai
Infrastructure	Quality of service	Average mobile broadband download speed (Average Mbit/s)	Akamai
Infrastructure	Quality of service	Fixed broadband connections with download speed higher than 4 Mbit/s (percentage)	Akamai
Infrastructure	Quality of service	Fixed broadband connections with download speed higher than 10 Mbit/s (percentage)	Akamai
Infrastructure	Quality of service	Fixed broadband connections with download speed higher than 15 Mbit/s (percentage)	Akamai
Infrastructure	Quality of service	Fibre optical broadband connections as a percentage of total fixed broadband connections	ITU; FTTH; OECD
Infrastructure	Quality of service	International broadband bandwidth per Internet user (bit/s)	ITU
Infrastructure	Coverage	Fixed broadband coverage (% of households)	Eurostat, CAF Ideal; OECD
Infrastructure	Coverage	2G coverage	ITU
Infrastructure	Coverage	3G coverage	ITU
Infrastructure	Coverage	4G coverage	ITU
Infrastructure	Service infrastructure	IXPs per 1 000 000 population	Packet Clearing House; UNCTAD
Infrastructure	Service infrastructure	Number of secure servers (per 1 000 000 population)	World Bank
Infrastructure	Service infrastructure	Number of satellites (per 1 000 000 population)	N2yo.com
Connectivity	Affordability	Monthly fixed broadband subscription as percentage of GDP per capita	ITU
Connectivity	Affordability	Monthly mobile broadband Smartphone subscription (500 Mbit/s cap, prepaid) as percentage of GDP per capita	ITU
Connectivity	Affordability	Monthly mobile broadband PC subscription (1 Gbit/s cap, post-paid) as percentage of GDP per capita	ITU

Pillar	Sub-pillar	Indicator	Source
Connectivity	Affordability	Monthly pay TV subscription as percentage of GDP per capita	Business Bureau; CAF; PwC; TAS
Connectivity	Penetration	Fixed broadband penetration (connections per 100 households)	ITU
Connectivity	Penetration	Mobile broadband penetration (connections per 100 population)	ITU
Connectivity	Penetration	Unique mobile broadband users (per 100 population)	GSMA
Connectivity	Penetration	Pay TV penetration (connections per 100 households)	Business Bureau; CAF; PwC; TAS; ITU; Convergencia
Connectivity	Ownership	Penetration of computers (% of households)	ITU
Connectivity	Ownership	Smartphone users (per 100 population)	GSMA
Connectivity	Ownership	Percentage of population with access to electric energy	World Bank
Household digitization	Internet use	Percentage of population using the Internet	ITU
Household digitization	Internet use	Penetration of dominant social network (users per 100 population)	OWLOO
Household digitization	Internet use	Mobile data ARPU as percentage of total ARPU	GSMA
Household digitization	E-government	E-government index	ONU
Household digitization	E-commerce	Internet commerce as percentage of total retail commerce	Euromonitor
Household digitization	Telemedicine	National health policy (binary variables)	WHO
Household digitization	OTTs	Video on demand penetration (per cent households)	PWC
Digitization of production	Digital infrastructure	Per cent enterprises with Internet access	UNCTADstat; TAS; Eurostats
Digitization of production	Digital supply chain	Per cent enterprises using Internet for electronic banking	UNCTADstat; TAS; Eurostats
Digitization of production	Digital supply chain	Per cent enterprises using Internet for purchasing inputs	UNCTADstat; TAS; Eurostats
Digitization of production	Digital distribution	Per cent enterprises that sell products over the Internet	UNCTADstat; TAS; Eurostats
Digitization of production	Digital processing	Per cent workforce using the Internet	UNCTADstat; TAS; Eurostats

Pillar	Sub-pillar	Indicator	Source
Digitization of production	Digital processing	Per cent workforce using computers	UNCTADstat; TAS; Eurostats
Competitive intensity	Competition level	HHI fixed broadband	Convergencia; Regulators; TAS
Competitive intensity	Competition level	HHI mobile broadband	GSMA; Regulators
Competitive intensity	Competition level	HHI pay TV	Convergencia; Dataxis; Ofcom; TAS; Regulatory entities
Competitive intensity	Competition level	HHI mobile telephony	GSMA; Regulators
Digital industries	Exports	High technology exports (USD per capita in current prices)	World Bank
Digital industries	Exports	ICT services exports (USD per capita in current prices)	World Bank
Digital industries	Weight of digital industries	Digital ecosystem sales as a percentage of GDP	PWC; TAS; ITU
Digital industries	Weight of digital industries	Telecommunication operators revenues per capita (USD in current prices)	ITU
Digital industries	Weight of digital industries	Computer software spending (per cent of GDP)	INSEAD
Digital industries	Internet of Things	M2M connections (per 100 population)	ITU; OECD
Digital industries	Content production	Wikipedia pages edited per month (per million population between 15 and 69 years old)	INSEAD
Factors of digital production	Human capital	Education years expectancy (years)	World Bank; UNESCO
Factors of digital production	Human capital	Tertiary school enrolment (per cent population)	World Bank; UNESCO
Factors of digital production	Schools	Per cent educational establishments with Internet access	UNESCO; ECLAC
Factors of digital production	Schools	Computers per student ratio	UNESCO; ECLAC
Factors of digital production	Innovation	USPTO patents per country (per 1 000 000 population)	USPTO
Factors of digital production	Innovation	Intellectual property revenues (USD per capita PPA in current prices)	World Bank
Factors of digital production	Investment in innovation	R&D spending (per cent of GDP)	World Bank; UNESCO

Pillar	Sub-pillar	Indicator	Source
Factors of digital production	Economic development	GDP per capita (USD current prices)	IMF
Factors of digital production	Economic development	Electric energy consumption (kWh per capita)	World Bank
Institutional and regulatory	Cyber-security and piracy	Per cent of non-licensed installed software	BSA, The software alliance
Institutional and regulatory	Cyber-security and piracy	Commercial value of non-licensed software (as per cent of GDP)	BSA, The software alliance
Institutional and regulatory	Government role	Per cent of regulatory agency attributions based on ITU regulatory tracker	ITU; TAS
Institutional and regulatory	Government role	Per cent of regulatory agency functions based on ITU regulatory tracker	ITU; TAS
-	-	Population	World Bank
-	-	Exchange rate PPP	IMF
-	-	Number of households	ITU
-	-	GDP per capita for first quintile (USD in current prices)	IMF; World Mundial

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