Technological Capability and Growth: Evidence from selected Arab MENA Countries

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Summary: The aim of this article is to examine the impact of technological capability on growth in 13 selected Arab Mena Countries measured by High-Technology Exports (current US$), Internet users (per 100 people), Patent application for non-residents, Patent application for residents, Research and development expenditure (% of GDP), Researchers in R&D (per million people), and Scientific and technical journal articles.

We apply an unbalanced panel data regression technique with temporal fixed effects for the period 2000-2018. The results show that Research and development expenditure (% of GDP) is a driver of technological capacity and has an impact on economic growth.

Keywords: Technological capacity; Growth; Panel data; Arab MENA countries.

Jel Classification Codes : O10 ; O30 **.**

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I. Introduction :

Over the past two decades, economic growth in the Middle East and North Africa (MENA) countries has been weak, as most countries do not rely on the capacity and technological innovation in economic development; while technology refers to a design and production activity, often industrial but also service, in response to market needs. The Technology combines technical practices and scientific knowledge, serving explicit economic purposes. In this, the technology is intended to be managed even though, by its very nature, it is partly based on tacit know-how. For its part, innovation can be defined as the realization of novelty. While the invention is limited to the new idea without real confrontation with the need that it intends to satisfy, innovation crosses this considerable step which goes from the idea to its concrete realization and to the satisfaction of the need. Innovation is the change achieved, whether limited or radical, whether it concerns the product concept, the manufacturing process or the organization, etc..

The link between innovation and technology is natural: technology improves continuously through so-called incremental innovations which, along the way, trace a technological trajectory exploiting the potential of the vein thus explored, until a break Technology (a revolutionary innovation) will replace a new technology with the old, in a process of creative destruction described by Schumpeter (1935).

Therefore, the objective of this research is to determine whether the Arab MENA countries take into account the index of technological capacity and innovation in the economic growth of the countries; on the other hand, we show the different variables that have an impact on the index of technological capability.

Our research question is: Does Arab MENA countries development is based on technological capacity?

We suppose the hypotheses that the Arab MENA countries are still in classic development model based on resources (oil, gaz, agriculture, tourism…)

It is important to recognize that research carried out to date on the measurement of technological capacity and the analysis in terms of impact in Arab Countries are at an initial stage.

This article is divided into four sections. In addition to an introduction, section two summarizes the theoretical framework of the technological capacity and its main variables and proxy variables. As far as section tree is concerned, it describes the data and methodology used in the empirical estimation. The estimating results and conclusion are presented in final section.

II. Literature review

Technological capability has always been fundamental to economic growth and well-being. One of its main characteristics is that it is far from evenly distributed between countries, for this purpose the determinants of technological capacity have been studied theoretically and empirically seen by many publications.

In the literature of technology, they cited several indicators to measure technological capacity. There are other factors, besides the indices already mentioned, the Technology Achievement Index (UNDP), the World Economic Forum Technology Index (WEF), The Technological Capabilities Index (ArCo), Industrial Development Scoreboard (UNIDO) and Science and Technology Capacity Index (Archibugi & Coco, 2005).

The WEF Technology Index includes three main categories of technology (Furman et al., 2002):

(i) Innovative capacity (measured by a combination of: patents granted and tertiary enrolment ratio);
(ii) ICT diffusion (measured by internet, telephone, PCs, and survey data);
(iii) Technology transfer (measured by non-primary exports and survey data).
The second index considered is the Technology Achievement Index elaborated by Desai et al. (2002), This Indicator contains four dimensions for measuring technology:
(i) The creation of technologies (based on patents registered by residents in their national offices and royalty and license fees);
(ii) Dissemination of the latest technologies (based on internet hosts and medium and high-technology exports);
(iii) Dissemination of the oldest technologies (based on telephone lines and electricity consumption);
(iiii) Human skills (based on years of schooling).
The third index is the technological capabilities of ArCo (Archibugi & Coco, 2004). It takes into account three dimensions of technology:
(i) Innovative activity (based on patents filed with the patent office and scientific publications);
(ii) Technological infrastructure (including old and new, Internet-based, main and mobile telephone lines and electricity consumption);
(iii) Human capital (based on the scientific base of tertiary education, years of schooling and literacy rate).
The fourth study is strongly inspired by the work of Lall and Albaladejo (2001), who consider four categories:
(i) Technological effort (based on patents);
(ii) Competitive industrial performance (exports of manufactured goods and share of medium and high-tech exports);
(iii) Imports of technology;
(iiii) Skills and infrastructure (based on tertiary technical inscriptions).
The last index is that of Wagner et al. (2004), which were divided science and technology capacity index into three categories:
(i) Favorable factors (GDP and enrollment in tertiary science);
(ii) Resources (based on R&D expenditure, number of establishments and number of scientists and engineers);
(iii) Integrated knowledge (based on patents, scientific and technical publications, and scientific articles).
In addition, many indicators are indicated by researchers who are the most important components of technological capacity and who show technological capacity.
For Furman et al., (2002), the use of patent statistics considers as a strong indicator of technological capability. This is also linked to the ease of availability of patent data for all countries (in contrast, the R&D data are available for a limited set of countries).
Also, Archibugi and Coco (2005) consider that patent is a measure of technological capacity generated for commercial purposes. It represents a codified form of knowledge generated by the companies and for-profit organizations.
Another source of technology generation is R&D expenditure, which is considered by Lall and Albaladejo (2001), as a very relevant indicator, which is easily comparable over time and across countries since it is measured in monetary values. Wagner, et al., (2004), take into account the role of academic institutions is to use the number of scientific publications. This is seen as an indicator that is closely associated with the contribution of public R&D spending.

In the view of, (UNDP, 2001; Desai et al., 2002), trade indicators are highly accurate and can easily be disaggregated according to the technological intensity of the various product groups. UNDP includes high and medium technology exports as diffusion of recent innovations. Also, it considers manufactured exports per capita and the share of medium and high technology exports on total exports as a component of the competitive industrial performance index provide the widest use of trade-based information. Table 1 resumes all methods to compute technological capacity index.

In addition, Technology have not flown from the rich to the poor countries as there is still a considerable disparity between technology and technical progress in High income OECD countries and Low-income countries (Aluko, O. O., & Sani, B. S.,2020). Moreover, local economies tend to be more adaptable if they innovate in sectors with the strongest growth opportunities, even though firms' net entry does not appear to contribute significantly towards resilience (Rocchetta, S., & Mina, A., 2019).

For Arab countries, few studies were conducted about technological capacity and growth. Following Nour (2005), there is a very limited scientific cooperation within and between the Gulf and Mediterranean countries and between them and other Arab countries. Djeflat (1996) explain that the central issue in the Maghreb countries relates, not simply to the magnitude of investment in higher education and training but equally importantly in the type of approach adopted and the extent to which university-industry links are promoted.

Madar Research (2005) reported that R&D funding in the Arab states is still the world's weakest streams relative to GDP, where even the developing nations' R&D spending tripled that of the Arab states. Hence, for R&D, alternative restructuring strategies and the reallocation of resources are both urgently needed (Mohamed et al.,2008).

III. Data and Model Construction

We use in our article unbalanced panel data regression. Panel data, also called longitudinal data or cross-sectional time series data, or data where multiple cases (people, firms, countries, etc.) were observed at two or more time periods.

The classical regression model is:

$$y_i = \beta_0 + x_{1i}\beta_1 + x_{2i}\beta_2 + \ldots + x_{ki}\beta_k + u_i \ , \ i=1,2,3,\ldots N$$

We suppose the data are on each cross-section unit over T time periods for the linear Panel Data Model as:

$$\begin{aligned} y_{i,t1} &= \mathbf{x}'_{i,t1}\boldsymbol{\beta}_{t1} + u_{i,t1} \\ y_{i,t2} &= \mathbf{x}'_{i,t2}\boldsymbol{\beta}_{t2} + u_{i,t1} \\ &\vdots \\ y_{i,T} &= \mathbf{x}'_{i,T}\boldsymbol{\beta}_{T} + u_{i,T} \end{aligned} \quad , \qquad t=1,2,\ldots,T$$

We can express this concisely using **y***i* to represent the vector of individual outcomes for person *i* across all time periods:

$$\mathbf{y}_i = \mathbf{X}_i\boldsymbol{\beta} + \mathbf{u}_i, \text{ where } \mathbf{y}'_i = y_{i,t1}, y_{i,t2}, \ldots, y_{iT}$$

Our Model will
be after the dataset control test:

$$LnGDP = \beta_0 + HTE\ \beta_1 + INTERNUSER\ \beta_2 + PANR\ \beta_3 + PAR\ \beta_4 + RDE\ \beta_5 + RRD\ \beta_6 + STJ\ \beta_7 + U_i$$

Where:

$\beta_{0:}$ is the intercept term.

U_i: is the error term in the statistical regression model.

LnGDP per capita (current US$): from World Bank national accounts data, and OECD National Accounts data files.

HTE (High-Technology Exports (current US$)) of the United Nations: from Comtrade database

INTERNUSER (Internet users (per 100 people): Internet users are individuals who have used the Internet (from any location) in the last 12 months. The internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.)). From International Telecommunication Union, World Telecommunication/ICT Development Report and database, and World Bank estimate.

PANR: Patent application, non-residents

PAR: Patent application, residents

RDE: Research and development expenditure (% of GDP)

RRD: Researchers in R&D (per million people)

STJ: Scientific and technical journal articles

The source of the last five variables is from WDI of World Bank 2019. Considering the lack of data in Arab countries, we used finally a sample of 13 Arab Mena countries (Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Yemen).

We test our sample by fixed and Random effect regression for the period 2000-2018.

IV. Empirical Results

In the Table 2, the descriptive statistics for the different variables. The mean of Internet users is 48.66 per 100 people in the 169 observations of 13 countries with 28.20 as a Standard Deviation. For the HTE, we can see the gap between the minimum and the maximum values 27.80 and 0.00 respectively in the Arab countries.

The Hausman test for the correlated Random Effects as mentioned in Table 3 supposing the null hypothesis as the random effects model shows that we reject the null hypothesis (0.0000 < 5%), so the fixed effects model is appropriate.

For that, we estimate:

$$LNGDP = C(1) + C(2)*HTE + C(3)*INTERNUSER + C(4)*PANR + C(5)*PAR + C(6)*RDE + C(7)*RRD + C(8)*STJ + [CX=F]$$

The results show us that only two variables that have an impact on economic growth in the Arab countries included in this study, namely, RDE and HTE for a 5% probability error. That said internet use and research and development expenditure as a percentage of GDP have a positive and significant impact on economic growth. However, the high technology export HTE has a negative impact on economic growth and this confirms the lack of control of technology in the Arab countries in our sample. For the other variables used in our model, no significance was recorded. Also, the probability of Fisher is significant with a DW value of 1.96, which gives robustness to the applied model.

In terms of elasticities, we show an increase of 1% in GDP of which is related to the increase of 1.32 in research and development expenditure as a percentage of GDP and a decrease of 0.04 in THE.

As far as, the Substituted Coefficients becomes:
LNGDP = 7.6210181426 - 0.047938300244*HTE + 0.000881672268741*INTERNUSER + 0.000518537877455*PANR - 0.000649079970791*PAR + 1.3210133121*RDE + 0.000110395033365*RRD + 2.14060265098e-05*STJ + [CX=F]
From the Jarque-Bera value and the probability of 87.31% >5%, we accept the null hypothesis (H0 the residuals are normally distributed) as shows in Figure 1 for the residual diagnostics.

V. **Conclusion :**

In this paper, we have explored some new factors that supposed to affect economic growth in selected Arab Mena countries. Despite that the majority of these states are not ranked in the top of Technological capacity in the world, we test some proxy variables to see if the contribution of technology will affect significantly the economic growth in this region.
Following the literature and taking in consideration the lack of data in the majority of countries, we apply a fixed effects unbalanced panel data regression for the period 2000-2018 for a group of 13 countries.
The analysis demonstrates that investing in science and more precisely R&D will improve the economic growth and will affect positively the GDP in this region.

Appendices:

Table (1): Attempts to measure Technological Capabilities: A synopsis

Institution	European Commission (EUComm)	European Commission (EUComm)	World Economic Forum (WEF)	World Economic Forum (WEF)	World Economic Forum (WEF)
Synthetic indicator	Summary Innovation Index	Global Summary Innovation Index	Technology Index	Technologica l Readiness Index	Technologica l Innovation Index
Creation of new scientific and technological knowledge	- Public R&D expenditures. - Innovation expenditures. - Patents, trademarks and design registrations	-Public R&D Expenditures -Patents per million Population -Scientific articles per million population	-Patents per million Population -R&D expenditure (% GDP survey)	- Foreign direct investments	-Patents

Human capital	-Population with tertiary Education -Youth education attainment level	-Scientific & engineering graduates (% labour force) -Researcher per million Population	-Tertiary enrolment rate		-Scientists and engineers availability
Considered years	2004–2006	2004	2004–2006	2004–2006	2004–2006
Number of countries	34	48	125	125	125
Associated economic indicator	None	None	Growth Competitiveness Index	Global Competitiveness Index	Global Competitiveness Index
Source	European Commission	European Commission	WEF	WEF	WEF

Source: Elaborate by Authors using different sources.

Table (2): Descriptive Statistics

	LNGDP	THE	INTERNUSER	PANR	PAR	RDE	RRD	STJ
Mean	8.965502	2.780122	48.66333	602.6757	172.9866	0.410086	699.7679	1854.430
Median	8.940491	1.413960	47.50000	438.5000	71.00000	0.396725	543.5112	906.9300
Maximum	11.46104	27.80109	99.70000	2350.000	1078.000	1.303160	2383.084	13326.67
Minimum	6.310573	0.000581	0.082500	13.00000	1.000000	0.042300	129.7324	22.83000
Std. Dev.	1.286313	3.611699	28.20346	549.0894	247.4920	0.286544	598.8876	2393.254
Skewness	0.034933	3.522982	0.097416	1.302733	2.059877	0.423152	1.242361	2.293011
Kurtosis	1.905733	22.27043	1.935724	4.130875	6.540219	2.346817	3.623967	8.419664
Jarque-Bera	12.37369	1982.185	8.243280	49.74856	183.1802	4.381037	18.59567	518.7448
Probability	0.002056	0.000000	0.016218	0.000000	0.000000	0.111859	0.000092	0.000000
Sum	2214.479	314.1538	8224.103	89196.00	25775.00	37.72789	47584.22	458044.1
Sum Sq. Dev.	407.0316	1460.969	133633.1	44320376	9065340.	7.471800	24030643	1.41E+09
Observations	247	113	169	148	149	92	68	247

Source: Author's calculation using Eviews 10

Table (3): Correlated Random Effects - Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	126.247146	7	0.0000

** WARNING: estimated cross-section random effects variance is zero.

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
THE	-0.047938	0.032393	0.000263	0.0000
INTERNUSER	0.000882	0.031337	0.000061	0.0001
PANR	0.000519	0.000509	0.000000	0.9829
PAR	-0.000649	-0.000387	0.000000	0.5075
RDE	1.321013	-0.587125	0.108304	0.0000
RRD	0.000110	0.000009	0.000000	0.6727
STJ	0.000021	-0.000037	0.000000	0.2412

Cross-section random effects test equation:
Dependent Variable: LNGDP
Method: Panel Least Squares
Date: 05/12/20 Time: 17:37
Sample (adjusted): 2008 2018
Periods included: 11
Cross-sections included: 8
Total panel (unbalanced) observations: 30

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.621018	0.518977	14.68470	0.0000
THE	-0.047938	0.022196	-2.159773	0.0474
INTERNUSER	0.000882	0.007855	0.112241	0.9121
PANR	0.000519	0.000463	1.119832	0.2804
PAR	-0.000649	0.000574	-1.131239	0.2757
RDE	1.321013	0.370100	3.569338	0.0028
RRD	0.000110	0.000256	0.430990	0.6726
STJ	2.14E-05	6.24E-05	0.343186	0.7362

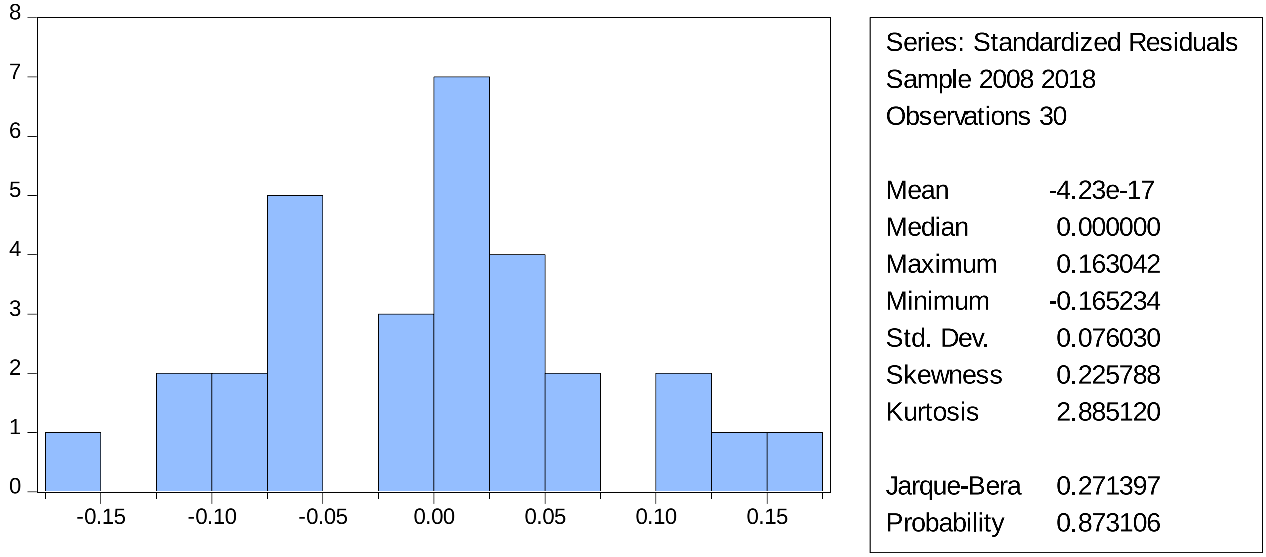
Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.993391	Mean dependent var	8.667281
Adjusted R-squared	0.987223	S.D. dependent var	0.935230
S.E. of regression	0.105715	Akaike info criterion	-1.349287
Sum squared resid	0.167635	Schwarz criterion	-0.648688
Log likelihood	35.23930	Hannan-Quinn criter.	-1.125159
F-statistic	161.0472	Durbin-Watson stat	1.969480
Prob(F-statistic)	0.000000		

Source: Author's calculation using Eviews 10

Figure (1): Normality Test Histogram



Source: Author's calculation using Eviews 10

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