THE SCIENTIFIC WEALTH OF NATIONS WITH SPECIAL REFERENCE TO ALGERIA: A CROSS-COUNTRY PRODUCTIVITY ANALYSIS OF ACADEMIC RESEARCH

Mohamed **TOUATI TLIBA**[*]

Received: 25/03/2022/ **Accepted**: 14/06/2022 / **Published**: 06/07/2022
Corresponding authors: touatitm@hotmail.com

ABSTRACT

This article aims at evaluating and explaining cross-country academic research activities through two-stage DEA methodology. A sample of 161 countries including 19 from MENA region is analyzed. In the first stage, DEA is applied to construct *Scientometric Indicator Scores* (SIS) for the full sample and *Scientometric Efficiency Scores* (SES) for 116 countries. In the second stage, as postulated by the New Institutional Economics literature, "*Quality of Institutions*" is treated as a "*fundamental*" factor explaining these indicators through "*Human Capital*" channel. Throughout, an IV approach is applied to correct potential biases where both "*Quality of Institutions*" and "*Human Capital*" are treated as endogenous variables.

With a mean of 1.8 Scopus documents (per thousand people) for Algeria during 1996-2019 and 4.5 for MENA region against 13.2 documents worldwide, MENA countries and particularly Algeria seem to be trailing behind. As shown by DEA scores, the mean constant return to scale (CRS) SIS score confirms that MENA countries are significantly less productive. However, the mean CRS SES score indicates no significant difference suggesting that MENA countries are not significantly less efficient. This last result indicates, as expected, that low performance of scientific research for many developing countries including Algeria, could be explained, at least partly, through low levels of both "*Human Capital*" and "*GERD*". For SIS model, OLS estimations confirm the previous result even if the

[*] Ecole Supérieure de Commerce, m_touati@esc-alger.dz, ALGÉRIE

human capital coefficient is small and barely significant while IV estimations show that human capital coefficient is more than double and highly significant suggesting that the size of the bias due to endogeneity is important. However, a sizable productivity advantage for HIOCED countries is documented beyond what can be attributed to human capital and GERD. Moreover, IV estimations confirm the key role played by the factor "*Quality of Institutions*" in explaining SIS (and SES) scores differences. Furthermore, "*Cultural Zone*" and "*Identity of Colonizer*" as well as "Natural Resources Rents" prove to be significant exogenous variables. These findings seem to be quite robust with respect to alternative measures of "*Quality of Institutions*" and "*Human Capital*". [1]

KEY WORDS

Scientometrics; Gross Expenditure on R&D (GERD); Human Capital; Quality of Institutions; Data Envelopment Analysis (DEA); Instrumental Variables (IV); MENA; Algeria.

JEL CLASSIFICATION: C26; I25; O32; O38; O43.

LA RICHESSE SCIENTIFIQUE DES NATIONS AVEC UNE RÉFERENCE PARTICULIÈE A L'ALGÉRIE

RÉSUMÉ

Cet article vise à évaluer et à expliquer les activités de recherche universitaire transnationales à travers la méthodologie DEA en deux étapes. Un échantillon de 161 pays dont 19 de la région MENA est analysé. Dans la première étape, la méthode DEA est appliquée pour construire des Scores d'Indicateurs Scientométriques (SIS) pour l'échantillon complet et des Scores d'Efficience Scientométriques (SES) pour 116 pays. Dans la seconde étape, comme postulé par la littérature de la Nouvelle Economie Institutionnelle, la « *Qualité des*

[1] The author would like to warmly thank Belbachir H., Boukrami S.A. and Laksaci M. for helpful comments and suggestions.

Institutions » est traitée comme un facteur « *fondamental* » expliquant ces indicateurs à travers le canal du « *Capital Humain* ». Tout au long, une approche IV est appliquée pour corriger les biais potentiels où la « *Qualité des Institutions* » et le « *Capital Humain* » sont traités comme des variables endogènes.

Avec une moyenne de 1,8 documents Scopus (pour mille habitants) sur la période 1996-2019 pour l'Algérie et 4,5 pour la région MENA contre 13,2 documents dans le monde, les pays MENA, particulièrement l'Algérie, semblent être à la traîne. Comme le montrent les scores DEA, le score SIS moyen à rendement d'échelle constant (CRS) confirme que les pays MENA sont significativement moins productifs. Cependant, le score CRS SES moyen n'indique aucune différence significative suggérant que les pays MENA ne sont pas significativement moins performants. Ce dernier résultat indique, comme prévu, que la faible performance de la recherche scientifique pour de nombreux pays en développement, y compris l'Algérie, pourrait s'expliquer, au moins en partie, par de faibles niveaux de « *Capital Humain* » et de « *GERD* ». Pour le modèle SIS, les estimations OLS confirment le résultat précédent même si le coefficient de capital humain est faible et à peine significatif tandis que les estimations IV montrent que le coefficient de capital humain est plus que double et hautement significatif suggérant que la taille du biais dû à l'endogénéité est importante. Cependant, un avantage de productivité considérable pour les pays HIOCED est documenté au-delà de ce qui peut être attribué au capital humain et GERD. De plus, les estimations IV confirment le rôle clé joué par le facteur « Qualité des Institutions » dans l'explication des différences de scores SIS (et SES). Par ailleurs, les variables « *Zone culturelle* » et « *Identité du colonisateur* » ainsi que « *Rentes des Ressources Naturelles* » s'avèrent être des variables exogènes significatives. Ces résultats semblent être assez robustes en ce qui concerne les mesures alternatives de la « *Qualité des Institutions* » et du « *Capital Humain* ».

الثروة العلمية للأمم مع إشارة خاصة للجزائر

ملخص

يهدف هذا المقال إلى تقييم وشرح أنشطة البحث الأكاديمي عبر البلدان من خلال منهجية DEA على مرحلتين. نقوم بتحليل عينة من 161 دولة من بينها 19 دولة من منطقة الشرق الأوسط وشمال إفريقيا (MENA)، حيث يتم في المرحلة الأولى تطبيق DEA لإنشاء درجات مؤشرات الإنتاج العلمي القياسي (SIS) للعينة الكاملة ودرجات فعالية الإنتاج العلمي القياسي (SES) لـ 116 دولة. يتم في المرحلة الثانية –كما تفترض أدبيات الاقتصاد المؤسساتي الجديد– التعامل مع "جودة المؤسسات" كعامل "أساسي" يشرح مؤشرات البحث العلمي من خلال قناة "رأس المال البشري". طوال الوقت، يتم تطبيق منهج IV لتصحيح التحيزات المحتملة حيث يتعامل مع "جودة المؤسسات" و"رأس المال البشري" كمتغيرات داخلية.

يبدو أن بلدان MENA وبخاصة الجزائر تتخلف عن الركب، بالنظر إلى متوسط 1.8 وثيقة Scopus (لكل ألف شخص) خلال الفترة 1996-2019 للجزائر و4.5 لمنطقة MENA مقابل 13.2 وثيقة لجميع أنحاء العالم. كما يتضح من نتائج DEA، فإن متوسط عائد الحجم الثابت (CRS) للمؤشرات SIS يؤكد أن بلدان MENA أقل إنتاجية بشكل جوهري. ومع ذلك، فإن متوسط درجة مؤشرات CRS SES لا يشير إلى وجود فرق جوهري مما يؤكد أن بلدان MENA ليست أقل فعالية بشكل جوهري. تشير هذه النتيجة الأخيرة، كما هو متوقع، إلى أن الأداء المنخفض للبحث العلمي للعديد من البلدان النامية بما فيها الجزائر، يمكن تفسيره، جزئيًا على الأقل، من خلال المستويات المنخفضة لكل من "رأس المال البشري" و "GERD". بالنسبة لنموذج SIS، تؤكد تقديرات OLS النتيجة السابقة حتى لو كان معامل رأس المال البشري صغيرًا وبالكاد جوهري بينما تُظهر تقديرات IV أن معامل رأس المال البشري أكبر من الضعف وذي دلالة عالية مما يشير إلى أن حجم التحيز في الحالة الاولى مهم. ومع ذلك، تم توثيق ميزة إنتاجية كبيرة لبلدان OCED ذات الدخل المرتفع بما يتجاوز ما يمكن أن يُعزى إلى رأس المال البشري وGERD. علاوة على ذلك، تؤكد تقديرات IV الدور الرئيسي الذي يلعبه عامل "جودة المؤسسات" في شرح الفروق في درجات SIS (وSES). علاوة على ذلك أثبتت المتغيرات "المنطقة الثقافية" و"هوية المستعمر" وكذلك "إيجار الموارد الطبيعية" أنها

متغيرات خارجية ذات دلالة. تبدو هذه النتائج قوية وغير حساسة لاستعمال مقاييس بديلة لكل من "جودة المؤسسات" و"رأس المال البشري".

INTRODUCTION

MENA region had known glorious periods from 7th to 15th centuries and was the world scientific center.[2] However, after missing the industrial revolution and encountering colonialism, two main fatal historical shocks, MENA region became scientifically poor and economically underdeveloped. Today, MENA countries are searching for a path to economic development. Bennabi (1990) asserts that historical miracles have resulted from creative ideas alone. In his view a society's wealth is not measured by the "things" people possess but by their ideas. The present article aims at analyzing current scientific wealth of nations with special reference to Algeria.

Outputs of Research & Development (R&D) activities are extremely important for economic growth because "*Ideas are extremely important economic goods, far more important than the objects emphasized in most economic models*" (Romer, 1997). It is useful to distinguish between invention and innovation. While the notion of invention is "*interpreted broadly as the production of knowledge*" (Arrow, 1962), the notion of innovation is defined as "*the transformation of knowledge into new products, processes and services*" (Porter & Stern, 1999). As explained by Romer (1986), economic growth is driven by the accumulation of knowledge. Endogenous growth theory holds that investment in human capital, R&D and innovation are the main factors contributing to boost economic growth (Romer, 1990). As to economic Development, "*it is discoveries of big ideas together with the discovery of millions of little ideas that make persistent economic growth possible*" (Romer, 1997). According to Mansfield (1991), about 1/10 of the new products and

[2] Sabra (1996) cites many periods and many places, e.g., Baghdad (9th and 10th), Egypt (11th century), Al-Andalous (12th century), Maragha in Iran (13th century) and Samarkand (15th century). Saliba (2007) documents some of the best work of Islamic astronomy between 13th and 16th centuries.

processes commercialized in the US during 1975-85 could not have been developed without recent academic research where the average time lag between the conclusion of the relevant academic research and the first commercial introduction of the innovations based on it was about 7 years. Mansfield (1991) estimates, tentatively, the social rate of return from academic research at 28%.

Nowadays many developing countries, including Algeria, are seeking a transition to knowledge-based economies. Indeed, Algeria's average annual growth rate of scientific production for the period 1996-2020, estimated at 14% (13.5% for MENA countries), exceeds the world average (10.2%) and is more than double that of high-income OECD (HIOECD) countries (6.5%).[3] According to a recent study based on the Web of Science literature, the collective regional publication output of MENA region has grown from 2% to 8% of global share between 1981 and 2019 (Adams et al., 2021). However, on a per capita basis, the region still has a long way to go. With average publications (per thousand people) of 1.8 for Algeria and 4.51 for MENA against an average of 12.19 worldwide for the period 1996-2019, MENA countries' science production has been largely trailing behind.[4] Furthermore, for the period 1996-2015, these countries invested on average, less than 0.4% of their GDP on R&D (0.2% for Algeria) while OECD countries invested near 1.9% and Israel invested the maximum rate of 3.88%. As pointed out by UNESCO (2015), the 1990 commitment by Arab countries to raise their GERD to 1% had not been met by any of these countries 25 years later. Likewise, on the human capital side, despite some achievements much remains to be realized. The colonial heritage of many MENA education systems is particularly poor. Perhaps the example of Algeria is extreme but is not atypical. On the eve of the war of independence, in 1954, the primary enrollment rate was 15% for indigenous Algerians with only about 350 high school graduates (Bacheliers).[5] After independence, during

[3] Advanced countries seem to have exhausted their growth potential.

[4] The total number of Scopus documents for the period 1996-2019 is divided by 2017 population (in millions).

[5] Pervillé, 2004 ; Kadri, 2006.

1962/63, Algeria counted only 2176 university students.[6] In 1970, the "Average Years of Total Schooling" for adults was only 0.78 for Algeria and the mean for MENA countries did not exceed 1.5 years against 3.81 years worldwide (Barro & Lee, 2013). By 2010, these figures were respectively 5.98 for Algeria and 6.63 for MENA in contrast with 8.09 worldwide (Barro & Lee, 2013).[7] Unfortunately, the recent quantitative achievements of Algeria and many MENA countries are not matched yet by real quality improvements. Results of both the Program for International Student Assessment (PISA) as well as the Trends in International Mathematics and Science Study (TIMSS) have shown that achievements of pupils from MENA countries are well behind those of the rest of the world.[8] Among the 70 countries that participated in PISA 2015, 7 MENA countries ranked above 47 (5 countries ranking above 59 and Algeria ranked 69). Similarly, among 39 countries participating in the 2015 TIMSS eighth-grade assessment, 12 MENA countries ranked above 22 in mathematics and above 20 in science. As to tertiary education, in 2010, the "Average Years of Tertiary Education" for adults was 0.29 for Algeria and 0.36 for MENA countries against 0.85 for advanced economies (Barro & Lee, 2013). Similarly, the average number of researchers (per million people) is estimated for the period 1996-2016 at 169 for Algeria and near 636 researchers in MENA region against an average of 1315 worldwide (3783 for OECD countries). Furthermore, the 2021 Shanghai ranking show that Algeria has no university in the top 1000 and MENA region has none in the top 100 while Israel has 2 universities in the top 100. Moreover, MENA region has an average of one university among the top 1000 per 14 million people against near one university among the top 1000 per one million for Israel. These statistics suggest that Human Capital level remains for MENA region, particularly Algeria, a serious obstacle to R&D and to economic development.

---

[6] MEN, Annuaire statistique, n° 1, 1967.

[7] According to UNESCO figures, by 2015 Algeria reached a net primary enrollment rate of 97.5% and a primary completion rate of 93.6%.

[8] Most developing countries do not participate in these competitions.

The present study aims at evaluating and explaining academic research activities across countries. We, firstly, construct academic research indicators considering both quantity and quality of research output as well as human and financial inputs. These indicators are used to benchmark Algeria and the MENA region. Secondly, we address the issue of measuring efficiency of science production across nations. The efficiency scores are used again to benchmark Algeria and MENA countries. Finally, differences in academic research performance between nations are explained using the "*fundamental*" factor "Quality of Institutions" and the "*proximate*" factor "Human Capital" as endogenous variables as well as "GERD to GDP" and other appropriate historical and cultural exogenous variables. The main research questions addressed in this present article can be summarized as follows:

Are MENA countries significantly less efficient in academic research?

What determines cross-country academic research performance?

What are the roles of institutions and human capital?

Why is Algeria lagging?

To answer these questions, we use a two-stage DEA methodology. In the first stage, DEA is applied to obtain scientometric indicators to benchmark Algeria and MENA region. In the second stage, adopting the New Institutional Economics paradigm and using an IV approach to correct potential biases, we analyze the roles of institutions and human capital in determining cross-country academic research performance.

The rest of the paper is organized as follows. The first section presents a succinct review of the scientific wealth of nations literature including that of developing and MENA countries. In the second section we explore the DEA approach to constructing scientometric indicators. The roles of institutions and of human capital in the production of academic research through the lenses of the New Institutional Economics paradigm are critically assessed in section three. The fourth section documents the data used and comments Algeria's and MENA's main academic research production metrics.

Section five first deals with alternative DEA's scientometric indicators used to benchmark Algeria and MENA countries on an international comparative yardstick before commenting IV estimations of the influence of institutional quality and human capital on research production. Finally, some policy implications for Algeria are discussed succinctly in concluding remarks.

1- ON THE SCIENTIFIC WEALTH OF NATIONS

Most previous studies on cross-country academic research production focused on advanced nations with the largest numbers of publications and citations (May, 1997; King, 2004; Press, 2013). Recently, some papers began to focus on the developing countries (Gonzalez-Brambila, 2016), the Islamic World (Sarwar & Hassan, 2015), the MENA region (Siddiqi et al., 2016), the Middle East (Gul et al., 2015), and the Maghreb (Hammouti, 2010). To study the scientific wealth of nations, May (1997) uses Science Citation Index (SCI) database with 79 countries for the period 1981-1994. The top 15 countries accounted for 81.3% of the world's papers. The USA was dominant with a share of 35% followed by UK and Japan (China ranked 13th with a share less than 1%). The top countries in terms of publications per capita were Switzerland, Israel, and Sweden (USA ranked 9th). The growth rate from 1981 to 1994 was estimated at 3.7% per year worldwide. With growth rates above 10%, the scientifically emerging countries were Hong Kong, China, Singapore, South Korea, and Taiwan. King (2004) uses data from Thomson ISI to measure the quality of science production. Between 1993 and 2010, the 31 major countries analyzed were found producing 97.5% of the world's top 1% most cited publications and the top 8 countries were producing about 84.5%. Bauwens et al. (2011) exploit the same Thomson Scientific data set on the most highly cited researchers (HCR) in 21 disciplines and 41 countries. For each discipline, the 250 most HCRs have been selected from 1981 to 1999. Results reveal the dominance of American universities accounting for 2/3 of the sample, whereas European universities' share is only 22.3%. While advanced nations do not specialize in few domains but rather diversify their research activities

(May, 1997; Cimini et al., 2014), Asian emerging scientific powers have uneven patterns (May, 1997).

Nejati et al. (2010) use cluster analysis on Scopus data to study the quantity (Publication per population) and the quality (Citation per publication) of scientific output of the top 50 countries in four basic sciences over the period 1996-2007. Three clusters have been identified. Cluster A contains exclusively Denmark, Israel, Sweden, and Switzerland. Cluster B includes industrialized countries and Cluster C includes emerging countries. Siddiqi et al. (2016) analyze records from SCI-Expanded between 1981 and 2013 in 17 MENA countries and compare them to selected countries throughout the world. The results show that international collaborators increasingly drove the scientific activity in MENA region. Repeated patterns of stagnation and contraction of scientific activity for many countries of the region are found contributing to a widening productivity gap on an international comparative yardstick. Sarwar & Hassan (2015) study uses Scopus and covers top 11 countries from the Islamic World that have the highest publication count during 2000–2011 where Turkey is leading followed by Iran and Malaysia. The Islamic World shows increase in its annual number of publications by more than 10% across all science & Technology areas and has an average of two authors per paper. Top collaborators of Islamic world are mainly within Islamic countries except for Algeria and Tunisia who have top collaboration with France. Hammouti (2010) uses Scopus database to study the scientific production in the Maghreb during 1996-2009. Results show that the total scientific production of Tunisia is higher than that of both Algeria and Morocco, even though its population is only one third of that of both countries.

2- CONSTRUCTING SCIENTOMETRIC INDICATORS: A DEA APPROACH

In this paper Data Envelopment Analysis (DEA) is applied to measure research productivity for 161 countries, including 19 from MENA region. DEA is a non-parametric method for measuring relative efficiencies of multiple inputs and multiple outputs decision making units (DMUs). Given n DMU, $j \in \{1,2,......,n\}$, with I inputs $X^j \in R^I$and O outputs $Y^j \in R^O$, to measure the efficiency of unit k, the coefficients $v \in R^I$ and $w \in R^O$ are derived in order to maximize a ratio of combination of outputs to combination of inputs of k such that ratios of all DMU with the same coefficients are not more than unity (Charnes, Cooper & Rhodes (CCR), 1978).

$$max\left\{h_k = \frac{w'Y^k}{v'X^k} / \frac{w'Y^j}{v'X^j} \leq 1; \forall j \;\&\; w \geq 0; v \geq 0\right\}$$

Using adequate transformation and duality theory, CCR (1978) show that this problem is equivalent to the linear problem:

$$max\{\theta / X^k - \textstyle\sum_j \lambda_j X^j \geq 0 \;\;\&\;\; \theta Y^k - \sum_j \lambda_j Y^j \leq 0; \lambda \geq 0\} \text{ (CCR)}$$

This CCR Model is said to be output oriented. It assumes constant return to scale (CRS). Adding the convexity constraint $\sum_j \lambda_j = 1$ to CCR model we get the (output oriented) variable return to scale (VRS) BCC model (Banker, Charnes & Cooper, 1984).

$$max\{\varphi /\, X^k - \textstyle\sum_j \lambda_j X^j \geq 0 \;\;\& \varphi Y^k - \sum_j \lambda_j Y^j \leq 0 \;\&\sum_j \lambda_j = 1\& \;\lambda \geq 0\} \text{ (BCC)}$$

The efficiency score of an output oriented CCR (BCC) model is given by $1/\theta$ $(1/\varphi)$. A DMU is said to be efficient whenever its efficiency score equals unity, and all slack variables are zero. Notice that if the optimal solution to the CCR (BCC) problem were given by the feasible solution $\theta^* = 1 (\varphi^* = 1)$, $\lambda_k^* = 1 \;\&\; \lambda_j^* = 0 \;\; \forall j \neq k$, then DMU k must be efficient. Otherwise, the unit k must be dominated by a virtual DMU defined by a linear (convex) combination of efficient DMU's with $\lambda_j^* > 0$ for some $j \neq k$. For a non-efficient DMU k , the set $\{j/\lambda_j^* > 0\}$ define the reference set.

Compared with the number of studies using DEA to measure efficiency of academic research at higher education institutions level for many countries (Johnes & Li, 2008), relatively little work has been done at nations level. The studies by Rousseau & Rousseau (1997, 1998), Wang & Huang (2007) and Kocher et al. (2006) are exceptions but are based exclusively on advanced nations' data. For a sample 18 countries, Rousseau & Rousseau (1997) used active population, GDP and R&D expenditure as inputs and number of publications and number of patents as outputs to conclude that DEA can be used as a tool to construct scientometric indicators. Likewise, using the inputs R&D capital stocks and Manpower and the outputs Academic publications and Patents for 30 countries, Wang & Huang (2007) results show that more than 50% of these countries are inefficient and have more advantage in producing publications than in generating patents. To measure productivity in top-edge economic research, Kocher et al. (2006) used the inputs R&D expenditure, Number of universities and Population and the outputs Publications in 10 leading economic journals for 21 OECD countries. They found that USA are dominant with remarkable distance under CRS while the efficiency frontier is created by USA, Ireland, and New Zealand under VRS.

In this present paper, we extend the previous studies by taking a longer period including recent years and by selecting a larger sample including more developing countries to better benchmark Algeria and MENA countries. In the first stage, DEA is applied to measure research productivity for 161 countries. To benchmark developed countries, King (2004) and Bauwens et al. (2011) use the most HCR which is a good proxy of the quality of research output. However, we use the outputs "Documents" and "Citations" which, we believe, are more appropriate to benchmark developing countries. The inputs "Population" and "GDP" are used to construct Scientometric Indicator Scores (SIS) for the full sample (Rousseau & Rousseau, 1997). However, to obtain Scientometric Efficiency Scores (SES) we need measures of quantity and quality of physical and of human inputs. Because measuring these inputs precisely is very difficult, especially for developing countries, resorting to approximations is necessary (Bauwens et al., 2011). We use the inputs "HC_AYT" and "GERD" for 116 countries (Bauwens et al., 2011; Kocher et al., 2006; Wang & Huang, 2007). Table 1 below shows the inputs and the outputs for alternative DEA models.

Table 1. DEA models outputs and inputs

Model	Output 1	Output 2	Input 1	Input 2
CCR_0 & BCC_0	Docs		Pop	
CCR_1 & BCC_1	Docs	Cits	Pop	GDP
CCR_3 & BCC_3	Docs	Cits	HC_AYT	GERD

Source: Elaborated by the author

3- ROLES OF INSTITUTIONS AND HUMAN CAPITAL IN THE PRODUCTION OF IDEAS: AN INSTRUMENTAL VARIABLES APPROACH

Bauwens et al. (2011) estimate a knowledge Cobb-Douglas production function with output HCR and inputs R&D expenditure and human capital in addition to *GDP per capita.*[9] With these variables, the fit seems somewhat unsatisfactory and calls for the introduction of a country-specific total factor productivity term (Prescott, 1998). In addition to *English proficiency* and *Colonial ties with the UK.*, they include, in this factor term, the key variable *Quality of public governance* (Rule of law). Introducing the factor-augmenting productivity term and taking care of the endogeneity problem seem to improve considerably the quality of the overall fit. The changes in estimates reveal that GDP endogeneity matters for some coefficients and for the significance of human capital.

To explain cross-nation scientific production, we adopt the New Institutional Economics paradigm (North, 1990, 2010; North & Thomas, 1973). As north (1990) puts it "*The economic paradigm—neo-classical theory—was not created to explain the process of economic change*." North (2010) places institutions "*at the center of understanding economies because they are the incentive structure of economies*". According to North (1990), "*Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction.... In consequence they structure incentives in human exchange, whether political, social, or economic.*" Borrowing North & Thomas (1973) view, we consider academic research activities as a mirror rather than a cause for economic and social development. Making a clear distinction

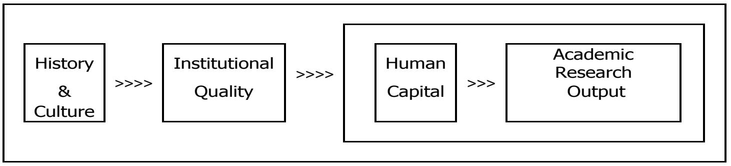
[9] See section 1 above for description of the sample and the output variable.

between "*proximate*" and "*fundamental*" determinants of economic growth, North & Thomas (1973) assert that "*the factors we have listed (innovation, economies of scale, education, capital accumulation etc.) are not causes of growth; they are growth*". Hence, the fundamental explanation of economic growth differences between nations is differences in institutions.

Building on the new institutional economics, Robinson and Acemoglu (2012) ask the vital question, why do some nations become rich, and others remain poor? They argue that the nature of political and economic institutions is the main reason for differences in the economic and social development between nations. Because some societies manage to develop more inclusive political and economic institutions, they end up more developed. In Robinson and Acemoglu's view, compared to the key factor inclusive institutions, the factors geography, climate, genetics, culture, religion are secondary. Likewise, Hall & Jones (1999) show that differences in physical capital and educational attainment can only partially explain the variation in output per worker. They show that the differences in output per worker are driven by differences in institutions and government policies which they treated as endogenous, determined historically by cultural factors captured in part by language. Acemoglu et al. (2014) provide support for the view that institutions are the fundamental cause of long-run development working through human capital. This broad approach to economic development is contrasted with a reverse view maintaining that economic growth causes institutional improvement (Lipset, 1959; Glaeser et al., (2004). This alternative view holds that human capital is a more basic source of growth than are institutions. Using data of 143 countries, Baser & Gokten (2019) examine the roles of institutions and human capital in the development process by applying structural equation modeling with a latent construct. A path between institutional quality and economic development is identified in the non-mediated Model and found significant. When human capital is added as a mediator, the direct relationship between institutional quality and economic development becomes insignificant.

To explain cross-nation scientometric indicators (SIS and SES) obtained in the first stage, we adopt the New Institutional Economics paradigm. Following in the footsteps of Acemoglu et al. (2001, 2012) and Hall & Jones (1999), our empirical strategy considers institutional differences instrumented by their historical and cultural determinants as major causes of current differences in academic research output. Inspired by Acemoglu et al. (2014), we postulate the chain of causality indicated in the following diagram:

Figure 1. Influence of Institutions & Human capital on research output



Source: Elaborated by the author

The link between culture and economic development was inaugurated in the West by Weber (1930) who argued that the origins of European industrialization could be traced to the Protestant reformation. Greif (1994) presents a historical and game-theoretical analysis of the relations between culture and societal organization and argues that different cultures generate different sets of beliefs shaping people's behavior. According to the author, "*economic growth is not a mere function of endowment, technology, and preferences. It is a complex process in which the organization of society plays a significant role. The organization of society itself, however, reflects historical, cultural, social, political, and economic processes*."

On the other hand, there is mounting evidence linking colonial legacy in education to current schooling outcomes. Gallego (2003) presents cross-country evidence concerning the importance of colonial origins in understanding differences in current levels of schooling. Feldmann's (2016) results suggest that the colonial legacy in education had a large negative impact on secondary school enrollment in both Spain's and France's former colonies long after the end of colonization. The partitions of Togoland and Cameroon between France and the UK after World War I provide a natural experiment to test the impact of British and French colonization. Cogneau and Moradi (2014) find that literacy diverged at the border between the parts of Togoland under British and French control as early as in the 1920s and that border effects that began in colonial times persist today. Similarly, using a border discontinuity analysis, Dupraz (2019) find that men born after the partition of Cameroon had, *ceteris paribus*, one more year of schooling if they were born in the former British part. Those born after 1970 are more likely to finish high school, go to university and have a high-skilled occupation if they were born in the British part.

We use in the present paper an instrumental variable approach to correct for potential biases. As argued by Acemoglu et al. (2014), "*empirical models that treat institutions and human capital as exogenous are misspecified, both because of the usual omitted variable bias problems and because of differential measurement error in these variables*". While SIS scores are explained here through 3SLS using the proximate variables "HCIndex" and "GERD%" as two key explanatory variables, SES scores are explained through 2SLS using mainly "Quality of Institutions". Both "Quality of Institutions" and "Human Capital" are treated as endogenous variables determined through appropriate exogenous historical and cultural factors.

Instrumental Variables methods (IV) can be used to solve the problem of endogeneity of one or more explanatory variables in a regression model. Widely used, they were developed to overcome measurement error problems in explanatory variables as well as omitted variables problems in estimates of causal relationship (Angrist and Krueger, 2001). Whenever an explanatory variable in a regression model is correlated with the error term of a regression due to measurement error and/or omitted variables problems, OLS estimation gives biased and inconsistent estimators of all regression coefficients. To use the IV approach with an endogenous variable, we need to find additional observable variable(s) called *instrument(s)* that must be: (i) uncorrelated with the error term; and (ii) correlated with the endogenous variable. Under these assumptions, through 2SLS (3SLS), consistent estimators can be obtained (Wooldridge, 2010).

However, in practice, we might end up with bad instrument(s). While one can test the correlation between the explanatory endogenous variable and its instrument(s), it is impossible to test the correlation between the instrument(s) and the error term.

4- DATA DESCRIPTION & METRICS FOR ACADEMIC RESEARCH PRODUCTION

In this study, data sources are Scopus database for scientific outputs and essentially the World bank database for many variables used. All sources are indicated clearly in table A in the appendix. Scopus is the largest database of scientific information with 27 subject areas. Comparing WoS and Scopus, Archambault et al. (2009) present evidence that indicators of scientific production and citations at the country level are stable and largely independent of the database. These indicators are highly correlated even when countries' papers are broken down by fields. The use of either database for research evaluation may, however, introduce biases in favor of Natural Sciences, Engineering and Biomedical Research to the detriment of Social Sciences and Humanities as well as in favor of English-language journals to the detriment of other languages (Mongeon & Paul-Hus, 2016).

The sample considered in this study consists of 161 countries including 19 from MENA region with full Scopus data representing more than 99.9% of Scopus world publications and citations.[10] Some additional information from other sources suffers from missing data and data quality issues. As shown in Table 2, below, 21 observations are missing for the Barro & Lee (2013) variables (AYTS, AYT and Pop25+). Similarly, the variables GERD and Researchers are missing for 31 and 33 observations respectively.[11] Furthermore, for many developing countries, the series GERD and Researchers are observed

[10] The 19 MENA countries included in the sample are Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, UAE, and Yemen.

[11] MENA countries with missing data are Lebanon, Libya, Oman, Palestine, Syria, and Yemen.

only partially for the indicated periods.[12] Both Population and GDP are 2017 figures. GDP data are the Penn World Table expenditure-side real GDP at chained purchasing power parities in 2017 million US $ (Feenstra et al., 2015). To conduct robustness checks, we consider alternative measures of human capital. In addition to the variable AYTS (Barro & Lee, 2013), we consider two additional indices. The new World Bank Human Capital Index (HCIndex) combines indicators of health and education into one single index measured in units of productivity relative to a benchmark of complete education and full health, and ranges from 0 to 1 (Kraay, 2019). The Harmonized Learning Outcomes (HLO) is a globally comparable learning metric including school enrolment and a direct measure of schooling quality. Available for 164 countries, HLO provides a measure of human capital that is more closely associated with economic growth than current measures (Angrist et al., 2021). As to institutional quality, we rely on the six World Governance Indicators (Kaufmann et al., 2010).[13] From these highly correlated indicators, we construct a composite index *QInst* based on the first principal component. It turns out that *QInst* has the highest correlation coefficient with the *Rule of Law* indicator (98.4%). To capture historical and cultural factors influencing cross-country academic research output, we use dummy variables defining the identity of colonizers from Treisman (2000). We exploit also the 10 culture zones classification developed in Welzel (2013).[14] Table 2 presents main summary statistics for the variables included in this study. The number of missing observations is clearly indicated for each variable.

[12] The indicated averages for these variables are calculated for the available years.

[13] The aggregate World Governance Indicators are: *Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption.*

[14] We use 12 culture zones. We separate ancient soviet central Asian countries from soviet Slavic republics and countries of Indian subcontinent from south Asian countries.

Table 2. Descriptive statistics

Variable	n	Mean	Std. Dev.	Min	Max
DocsR	161	12193.75	19397.37	42	90266
HIndex	161	296.04	332.58	40	2386
CitsR	161	15.18	5.99	4.64	40.96
GrthDocs	161	0.10	0.05	0.02	0.26
GERD%	130	0.73	0.83	0.02	3.88
Researchers	128	1314.91	1769.03	10.56	8255
AYTS70	139	3.73	2.66	.01	10.69
AYT	140	0.46	0.37	0.015	1.71
HC_AYT	140	9.05	28.56	0.01	261.51
HCIndex	138	2.38	0.69	1.10	3.61
HLO	146	419.26	82.10	244.80	578.51
Pop	161	46.40	157.75	.33	1421.02
Pop25+	140	19.74	71.25	0.150	687.64
GDP	161	744.24	2357.88	3.47	19754.75
QInst	161	0	1	-1.69	2.09
NRR	161	8.18	11.13	0	49.15

Source: Elaborated by the author

Table 3 reports, for four groups of countries including MENA, HIOECD and Sub-Saharan Africa, the means of five scientific metrics. Notwithstanding GrthDocs metric, MENA countries are underperforming the world average for all the metrics and Algeria's metrics are below MENA's averages with GERD to GDP even lower than Sub-Saharan Africa's average.[15]

Table 3. Means of Scientific Outputs: Algeria vs 4 groups of countries

Group	n	DocsR	Hindex	CitsR	GrthDocs	GERD%[b]
HIOECD	31	44994.0	784.1	20.9	0.065	1.89
Others	71	6374.9	213.7	13.3	0.110	0.40
MENA	19	4507.4	192.1	10.4	0.136	0.38
SS Africa	40	753.1	113.2	16.3	0.101	0.31
Algeria		1810	178	7.6	0.140	0.20
World	161	12193.8	296.0	15.2	0.102	0.73
Sig[(a)]		**	*	***	***	**

(a) Sig (MENA vs non MENA) : *** (1%), ** (5%) & * (10%)

(b) Based on 31, 61,15 & 23 observations respectively

Source: Elaborated by the author

Table 4 below presents means of selected potential explanatory variables for the four groups of countries. Although neither human

[15] Algeria's average GERD estimation, 0.2%, is based on the available figures of the period 2001-2005.

capital nor per capita GDP for MENA countries seem to be far below world average, the quality of institution variable is well below world average and Algeria is even more extreme. Furthermore, natural resources rents for both Algeria and MENA region seem to be higher than all groups' averages including that of Sub-Saharan Africa.

Table 4. Means of selected variables: Algeria vs four groups of countries

Group	HCIndex[(c)]	AYT[(b)]	Pop25+[(b)]	GDPpc	QInst	NRR
HIOECD	3.19	0.88	17.2	43.1	1.47	1.3
Others	2.47	0.46	31.6	10.0	-0.16	4.8
MENA	2.08	0.37	10.0	13.3	-0.43	19.5
SS Africa	1.66	0.09	4.5	2.2	-0.65	14.1
Algeria	1.92	0.26	13.3	4.1	-0.84	17.9
World	2.38	0.46	19.7	14.8	0	8.2
Sig[(a)]	**	ns	ns	ns	**	***

(a) Sig (MENA vs non MENA) : *** (1%), ** (5%) & * (10%)

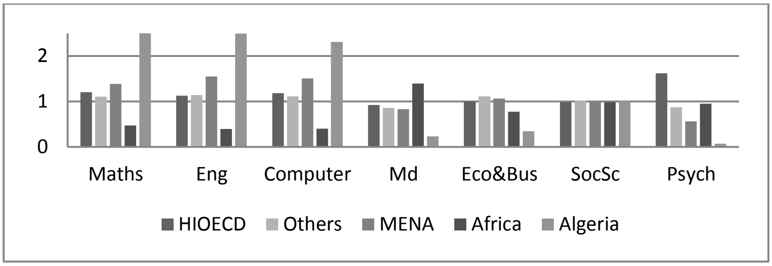
(b, c) Based on (31,31), (61,56), (16,15) & (32,36) observations respectively

Source: Elaborated by the author

For seven subject areas' concentration ratios (documents in a subject area to total documents in all subject areas), figure 2 shows relative concentration ratios of four groups of countries (relative to the world concentration ratios). Compared to the world portfolio, the average MENA academic publications' portfolio appears to be more concentrated in mathematics and hard sciences with relative ratios near 150%. Representing an extreme case compared to all groups, Algeria's relative concentration ratios in mathematics, engineering and computer science are extremely high near 250% and extremely low in psychology, medicine, and Economics & Business, with ratios of 7%, 23% and 35% respectively.[16]

[16] Algeria's case merits further investigation. Knowing that medicine's programs in Algerian universities selected the very top high school graduates for the last 30 years, Algeria's relative low performance in medical scientific research is surprising.

Figure 2. Benchmarking Algeria in seven subject areas' concentration ratios (World average=100%)



Source: Elaborated by the author

5- RESULTS

5.1- Benchmarking Algeria and MENA countries: DEA results

As shown in table 5 below, DEA Scores are given under CRS through the 3 indicators (CCR_0, CCR_1, CCR_3) and under VRS through the 3 indicators (BCC_0, BCC_1, BCC_3) with inputs and outputs as indicated in table 1 above. Numbers of efficient countries are indicated between brackets. While the first two models (under both CRS and VRS) generate SIS for the full sample, the 2 versions of the last model generate SES for only 116 (including 13 MENA) countries due to missing data.

Table 5. Research indicators: Algeria vs four Groups of countries

Group	CCR0	BCC0	CCR1	BCC1	CCR3	BCC3
HIOECD	0.50	0.62	0.70	0.76	0.61	0.81
	(1)	(4)	(4)	(6)	(1)	(8)
Others	0.08	0.10	0.19	0.24	0.23	0.46
	(0)	(0)	(0)	(2)	(2)	(5)
MENA	0.05	0.06	0.17	0.18	0.27	0.56
	(0)	(0)	(0)	(0)	(0)	(1)
SS Africa	0.01	0.01	0.12	0.17	0.28	0.40
	(0)	(0)	(0)	(2)	(1)	(2)
Algeria	0.02	0.03	0.12	0.13	0.17	0.44
World	0.14 (1)	0.17 (4)	0.27 (4)	0.31 (10)	0.35 (4)	0.55 (16)
Sig.	**	**	**	**	ns	Ns

Numbers of Efficient nations between brackets.
Sig (MENA vs non MENA) : *** (1%), ** (5%) & * (10%)

Source: Elaborated by the author

With 90.37 documents (per thousand people), Switzerland has full efficiency score double that of HIOECD average. It is the unique efficient nation under CCR_0 model. The mean CCR_0 score is 2% for Algeria and near 5% for MENA region against 13.8% worldwide. Algeria and MENA region seem to be trailing behind the world average. For CCR_1 scores, estimated under CRS, both quality and quantity of research documents are considered as outputs and both population and GDP are considered as inputs. While adding research quality as output should favor advanced nations, including GDP as input should be more realistic when the sample includes developing poor nations with much smaller GDP per capita. Regarded as SIS, CCR1 scores indicate that in addition to Switzerland three HIOECD countries (Denmark, Finland, and Iceland) form the reference set with best practices. Moreover, estimated at 11.7% for Algeria and 17% for MENA region against 28% for the remaining 142 countries, SIS scores confirm that MENA countries are significantly less productive.[17]

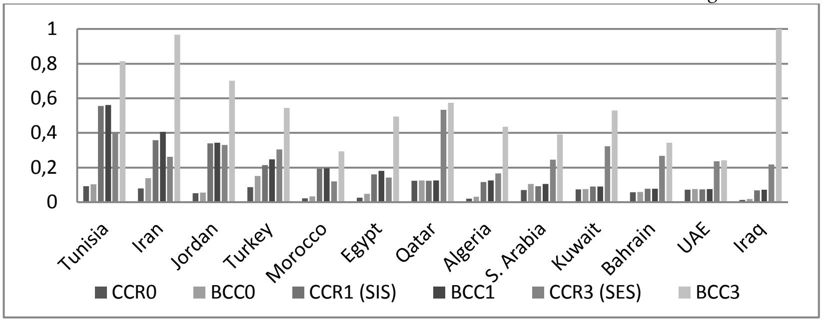
With the same outputs as CCR_1 and the two inputs HC_AYT and GERD, CCR_3 scores are regarded as SES under CRS. These efficiency indicators should be more realistic than SIS scores when countries with different economic development levels are compared. These SES scores indicate that in addition to Switzerland three non HIOECD countries (Brunei Darussalam, Gambia, and Macao) form the reference set with best practices. Moreover, the mean SES, estimated at 16.6% for Algeria and at 27.3% for 13 MENA countries against 34.5% for 103 countries worldwide, indicates no significant difference between the last two means. Compared with SIS (CCR_1) scores, SES scores means difference between HIOECD countries and non HIOECD countries is, as expected, smaller but remains, nonetheless, statistically significant. Under VRS, the models BCC_0 and BCC_1 generate SIS scores and BCC_3 model generate SES scores. VRS results reveal that Switzerland, Iceland, UK, and US are always technically

[17] CCR2 scores (where the output Cits in CCR1 is replaced by H-index) are systematically not lower than CCR_1 scores. Unlike for HIOECD as well as for MENA countries with means difference between CCR_1 and CCR_2 quite small (<1%), the difference for sub-Saharan Africa is significant (7.2%).

efficient. BCC3 results show that the world's average VRS SES score is 55.3% with 16 countries being technically efficient. This indicates that for many countries, much of the CCR SIS inefficiency is due to scale inefficiency (Irak is an extreme example). We note that all but 12 countries operate under decreasing return to scale.

Figure 3. Benchmarking Algeria within 13 MENA countries

(Ranked using CCR1 (SIS))



Source: Elaborated by the author

Figure 3 presents the six academic research indicators to compare performances of 13 MENA countries on an international comparative yardstick., it indicates that Tunisia, Iran, Turkey, and Qatar are the region's performing leaders. However, under CRS, none of the MENA countries reach the 50% level of the world best practices except for Tunisia with SIS score of 55.5% and Qatar with SES score of 53.4. Furthermore, with Irak, Iran and Tunisia realizing a VRS SSE score higher than HIOECD average while Saudi Arabia, Bahrain, Morocco, and UAE realizing a VRS SSE score lower than Sub-Saharan Africa average, the 13 MENA countries in the sample show very heterogenous technical efficiency scores. Finally, we note that Algeria's score is lower than MENA's average score for each indicator. In fact, while Algeria's performance is close to that of Egypt and Morocco, Tunisia dominates significantly.

5.2- Influences of institutional quality and human capital on research production: IV results

Four estimation results are reported in table 6 to explain Scientometric Indicator Scores (SIS) differences. In column (1) we simply report OLS estimations where only dummy variables representing three groups of countries (HIOECD, MENA and Sub-Saharan Africa) are included in the model and the fourth group representing all other countries is taken as a reference group. These ANOVA results indicate that SIS differences between HIOECD and all other groups are large, positive, and highly significant. On the other hand, the difference between Sub-Saharan Africa and the reference group is small, negative, and barely significant while the difference between MENA countries and reference group countries is not significant. In column (2) we report OLS estimations when the two key explanatory variables HCIndex and GERD% are added. Results indicate that the coefficients of the dummy variables MENA and Sub-Saharan Africa are not significant suggesting that SIS differences between non HIOECD groups could be explained solely through human capital and GERD differences. However, HIOECD coefficient remains highly significant even if its value is smaller suggesting again that a sizable part (near 45%) of the SIS difference between HIOECD group and non HIOECD groups could be explained through human capital and GERD differences. While the coefficient of GERD% is highly significant, the coefficient of human capital variable is significant only at 10% level. As argued in section 3, adopting the New Institutional Economics paradigm to explain cross-nation scientometric indicators requires including a quality of institution variable in the model. Moreover, as argued by Acemoglu et al. (2014), endogeneity is a likely issue in the foregoing OLS estimations. The last column in table 9 reports IV estimations through 3SLS where both "Human Capital" and "Quality of Institutions" are treated as endogenous variables. Using OLS, the coefficient of human capital (column 2) was small and barely significant but becomes more than double and highly significant when using IV estimation method (column 4) suggesting that the size of the bias due to endogeneity is important. The Hausman specification test for endogeneity confirm systematic difference in coefficients.[18] Globally, IV estimations confirm the role of "Quality of Institutions" as a "*fundamental*" factor explaining SIS indicators through the "Human Capital" channel. Moreover, Current human capital (HCIndex) is expressed in terms of the endogenous variable Quality of Institutions (QInst) as well as exogenous variables capturing colonial history through colonizer's identity dummies. In line with the mounting evidence linking colonial legacy in education to current schooling outcomes (Gallego, 2003; Feldmann, 2016; Cogneau & Moradi, 2014; Dupraz, 2019), the second stage IV estimation results confirm that western colonial legacy in education had a significant negative impact on current human capital with worst consequences for French colonies.[19] Furthermore, results of first stage IV estimations indicate that Quality of Institutions (QInst) could be reasonably explained through past human capital variable (AYT70) as well as other exogenous historical and cultural factors captured via 12 cultural zone dummy variables in addition to natural resources rent variable (NRRent). It turns out that besides four Western cultural zones only MENA culture zone has a significant positive coefficient in the quality of institution regression suggesting that both low past human capital level and actual high natural resources rents are determining factors for current low-level quality of institutions in MENA countries. We may argue that natural resources dependence creates rent seeking opportunities which in turn weakens institutional quality further. The influence of natural resources dependence is in line with results in economic growth and economic development literature. Using data on rent-seeking legislation from Uruguay, Rama (1993) suggests an association between rent seeking and low growth. Similarly, using stock of natural capital, Arezki & Van der Ploeg (2011) show evidence for "*a direct negative effect of*

[18] Notice that 3SLS and 2SLS coefficients are quasi-identical. We actually use the Hausman test to compare OLS and 2SLS coefficients to get chi2(1)= 0.61 and P-value= 0.009

[19] This result is robust. It is not sensitive to the absence from the sample of neo-Europes countries (the United States, Canada, Australia, and New Zealand).

natural resources on income per capita even after controlling for geography, rule of law and de facto or de jure trade openness". For the sake of robustness, the same IV estimations are reconducted for SIS model. As indicated in the tables B1 and B2 in the appendix, the main findings seem to be quite robust with respect to the use of alternative measures of Quality of Institutions (Rule of law or Control of Corruption instead of the composite index) and Human Capital (HLO or AYTS2010 instead of HCIndex).

Three estimation results are reported in table 7 explaining SES differences. In column (1) we simply report OLS estimations where only dummy variables representing the three groups of countries (HIOECD, MENA and Sub-Saharan Africa) are included in the model. The ANOVA results indicate that SES differences between HIOECD and all other groups are large, positive, and highly significant while differences between the other groups are not significant. However, in the presence of quality of institutions variable, differences between all groups become nonsignificant while the variable QInst is positive and highly significant. This result suggests that HIOECD countries have higher efficiency scores because they have better institutions. On the other hand, the last column in table 10 reports IV estimations through 2SLS where the quality of institutions variable is treated as endogenous. IV estimations of the main equation seem to differ little from those of OLS estimations suggesting that endogeneity is not a severe problem here. Indeed, using the Hausman specification test for endogeneity we find no systematic difference in coefficients.[20]

Table 6. Explaining SIS: OLS vs IV estimations

	OLS	OLS	2SLS	3SLS
Variable	**Coef. (St. Err.)**	**Coef. (St. Err.)**	**Coef. (St. Err.)**	**Coef. (St. Err.)**
SIS				
HIOECD	0.509	0.279	0.210	0.197
	(0.036)***	(0.057)***	(0.060)***	(0.056)***
MENA	-0.017	0.026		
	(0.043)ns	(0.052)ns		

[20] chi2(1)= 6.70 and P-value= 0.434.

S.S. Africa	-0.064 (0.033)*	0.011 (0.050)ns		
HCIndex		0.070 (0.038)*	0.163 (0.054)***	0.166 (0.037)***
GERD%		0.120 (0.029)***	0.107 (0.030)***	0.104 (0.028)***
Const	0.187 (0.020)***	-0.034 (0.094)ns	-0.232 (0.120)*	-0.235 (0.084)***
R^2	0.626	0.699	0.670	0.667
HCIndex				
QInst			0.442 (0.039)***	0.552 (0.046)***
BritCol			-0.284 (0.082)***	-0.186 (0.078)**
FrenCol			-0.505 (0.113)***	-0.350 (0.112)***
Spain&PorCol			-0.324 (0.101)***	-0.215 (0.096)***
Const			2.592 (0.057)***	2.521 (0.057)***
R^2			0.610	0.553
QInst				
AYTS70				0.204 (0.0267)***
CultureZ1				1.158 (0.210)***
CultureZ2				0.830 (0.251)***
CultureZ3				0.757 (0.169)***
CultureZ4				0.400 (0.198)**
CultureZ7				0.422 (0.158)***
CultureZ8				0.409 (0.275)ns
CultureZ12				0.186 (0.157)ns
NRR				-0.011 (0.006)**
Const				-0.843 (0.120)***
R^2				0.705

Source: Elaborated by the author

Table 7. Explaining SES: OLS vs IV estimations

	OLS	**OLS**	**2SLS**
Variable	Coef. (St. Err.)	Coef. (St. Err.)	Coef. (St. Err.)
SES			
HIOECD	0.385	0.046	0.013
	(0.050) ***	(0.057) ns	(0.077) ns
MENA	0.045		
	(0.069) ns		
Africa	0.055		
	(0.059) ns		
Qinst		0.194	0.215
		(0.026) ***	(0.041) ***
Constant	0.228	0.282	0.285
	(0.031) ***	(0.020) ***	(0.021) ***
R2	0.357	0.567	0.564
QInst			
AYTS70			0.117
			(0.030) ***
CultureZ1			1.713
			(0.230) ***
CultureZ2			1.296
			(0.277) ***
CultureZ3			1.185
			(0.187) ***
CultureZ4			0.659
			(0.220) ***
CultureZ7			0.394
			(0.178) **
CultureZ8			0.946
			(0.245) ***
CultureZ12			0.200
			(0.177) ns
NRR			-0.012
			(0.006) **
Constant			-0.604
			(0.130) ***
R^2			0.723

Source: Elaborated by the author

CONCLUDING REMARKS

Algeria and MENA countries seem to be trailing behind. This paper contributes to the debate by explaining the roles of institutions and human capital in the development of academic research activities.

As Baser & Gokten (2019) put it for economic development in general, the findings indicate that "*improving institutions in addition to human capital is needed for countries with low level of institutional quality to start the development process*".

We document, in this paper, the existence of a sizable productivity advantage for HIOCED countries beyond what can be attributed to human capital and GERD (near 40% of the total gap). While increasing money spending is certainly helpful to boost scientific research in Algeria and MENA countries, as attested by our estimates of *Scientometric Efficiency Score* levels, "*the way the money is used is probably as critical as the amount of money itself*" (Bauwens et al., 2011). Our results indicate that attaining the level of 1% of GERD to GDP is not enough to reach the world average *Scientometric Indicator Score* level. Indeed, our estimates indicate that Algeria must reach the level of 1.65% and MENA region must reach 1.31%. Moreover, to boost science in Algeria and MENA region, the quality of human capital must improve, and higher education must go through major changes. As advocated by Guessoum & Osama (2015), "*institutes of higher education must give students a broad education and become meritocratic*". Unlike developed countries, MENA countries seem to concentrate their research activities in hard sciences. Yet, especially for these countries, as Bennabi (1954) puts it "*the moral, social and psychological sciences are infinitely more necessary today than the sciences of matter*". Algeria presents an extreme case in this regard with extremely relative low performances in some subject areas such as Psychology, Medicine and Economics & Business that need further investigation. Algeria has failed to reach its full potential because of its natural resource dependency, this situation has got to its term. The country must change course and adopt the new knowledge-based economy paradigm. However, to overcome the forces of resistance at work, Algeria will have to "*establish a new pact between the political and the scientific elites*"(Djeflat, 2012).

References

Acemoglu D. & **Robinson J. A., (2012).** *Why nations fail: The origins of power, prosperity and poverty*. New York: Crown Publishers.

Acemoglu D., Gallego F. A., & **Robinson J. A. (2014).** Institutions, human capital, and development. *Annu. Rev. Econ.*, *6*(1), 875-912.

Acemoglu D., Johnson S., & **Robinson J. A., (2001).** The colonial origins of comparative development: An empirical investigation. *American economic review*, *91*(5), 1369-1401.

Adams J., El Ouahi J., Pendlebury D. & **Szomszor M., (2021).** *Global Research Report*. https://clarivate.com/webofsciencegroup/wp-content/uploads/sites/2/dlm_uploads/2021/04/WS647760757-ISI-GRR-Changing-Research-Landscape-of-MENAT-DIGITAL.pdf

Angrist J. D., & **Krueger A. B., (2001).** Instrumental variables and the search for identification: From supply and demand to natural experiments. *Journal of Economic perspectives*, *15*(4), 69-85.

Angrist N., Djankov S., Goldberg P. K., & **Patrinos H. A., (2021).** Measuring human capital using global learning data. *Nature*, *592*(7854), 403-408.

Archambault É., Campbell D., Gingras Y., & **Larivière V., (2009).** Comparing bibliometric statistics obtained from the Web of Science and Scopus. *Journal of the American society for information science and technology*, *60*(7), 1320-1326.

Arezki R., & **Van der Ploeg F., (2011).** Do natural resources depress income per capita? *Review of Development Economics*, *15*(3), 504-521.

Arrow K., (1962). *Economic welfare and the allocation of resources for invention*. In *The rate and direction of inventive activity: Economic and social factors*. Princeton University Press.

Barro R. J., & **Lee J. W., (2013).** A new data set of educational attainment in the world, 1950–2010. *Journal of development economics*, *104*, 184-198.

Baser F., & **Gokten S., (2019).** Paths of economic development: A global evidence for the mediating role of human capital. *The Journal of International Trade & Economic Development*, *28*(8), 996-1018.

Bauwens L., Mion G., & **Thisse J. F., (2011).** The resistible decline of European science. *Recherches Économiques de Louvain/Louvain Economic Review*, *77*(4), 5-31.

Bennabi M., (1954). *Vocation de l'Islam*. Paris : Éditions du Seuil.

Bennabi M., (1990). *Le problème des idées dans le monde musulman*. El Bay'yinate.

Cimini G., Gabrielli A., & Labini F. S. (2014). The scientific competitiveness of nations. *PloS one*, 9(12), e113470.

Cogneau D., and **Moradi A., (2014).** "Borders that Divide: Education and Religion in Ghana and Togo since Colonial Times." *Journal of Economic History* 74, no. 3 (2014): 694–728.

Djeflat A., (2012). L'Algérie, du transfert de technologie à l'économie du savoir et de l'innovation : trajectoire et perspectives. *les cahiers du CREAD*, *100*, 71-100.

Dupraz Y., (2019). French and british colonial legacies in education: Evidence from the partition of Cameroon. *The Journal of Economic History*, *79*(3), 628-668.

Feenstra R. C., Inklaar R., & **Timmer M. P., (2015).** The next generation of the Penn World Table. *American Economic Review*, *105*(10), 3150-82.

Feldmann H. (2016). The long shadows of Spanish and French colonial education. *Kyklos*, *69*(1), 32-64.

Gallego F. A., (2003). Colonial origins of schooling: cross-country evidence. *Unpublished graduate paper*.

Glaeser E. L., La Porta R., Lopez-de-Silanes F., & **Shleifer A., (2004).** Do institutions cause growth? *Journal of economic Growth*, *9*(3), 271-303.

Gonzalez-Brambila C. N., Reyes-Gonzalez L., Veloso F., & **Perez-Angón M. A., (2016).** The scientific impact of developing nations. *PloS one*, *11*(3), e0151328.

Greif A., (1994). Cultural beliefs and the organization of society: A historical and theoretical reflection on collectivist and individualist societies. *Journal of political economy*, *102*(5), 912-950.

Guessoum N., & **Osama A., (2015).** Institutions: Revive universities of the Muslim world. *Nature*, *526*(7575), 634-636.

Gul S., Nisa N. T., Shah T. A., Gupta S., Jan A., & **Ahmad S., (2015).** Middle East: research productivity and performance across nations. *Scientometrics*, *105*(2), 1157-1166.

Hall R. E., & Jones C. I., (1999). Why do some countries produce so much more output per worker than others? *The quarterly journal of economics*, *114*(1), 83-116.

Hammouti B., (2010). Comparative bibliometric study of the scientific production in Maghreb countries (Algeria, Morocco and Tunisia) in 1996-2009 using Scopus. *Journal of Materials & Environmental Science*, 1(2), 70-77.

Johnes J., & Li, Y. U., (2008). Measuring the research performance of Chinese higher education institutions using data envelopment analysis. *China economic review*, *19*(4), 679-696.

Kadri A., (2007). Histoire du système d'enseignement colonial en Algérie. In La France et l'Algérie : leçons d'histoire : De l'école en situation coloniale à l'enseignement du fait colonial. Lyon: ENS Éditions. http://books.openedition.org/enseditions/1268.

Kaufmann D., Kraay A., & **Mastruzzi M., (2010**). The worldwide governance indicators: Methodology and analytical issues. *World Bank policy research working paper*, (5430).

King D. A., (2004). The scientific impact of nations. *Nature*, *430*(6997), 311.

Knack S., & **Keefer P., (1995).** Institutions and economic performance: cross-country tests using alternative institutional measures. *Economics & Politics*, *7*(3), 207-227.

Kocher M. G., Luptacik M., & **Sutter M., (2006).** Measuring productivity of research in economics: A cross-country study using DEA. *Socio-Economic Planning Sciences*, 40(4), 314-332.

Kraay A., (2019). The World Bank human capital index: a guide. *The World Bank Research Observer*, *34*(1), 1-33.

Lipset S. M., (1959). Some social requisites of democracy: Economic development and political legitimacy1. *American political science review*, *53*(1), 69-105.

Mansfield E., (1991). Academic research and industrial innovation. *Research policy*, *20*(1), 1-12.

May R. M., (1997). The scientific wealth of nations. *Science*, 275(5301), 793-796.

Mongeon P., & **Paul-Hus A., (2016).** The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, *106*(1), 213-228.

Nejati A., & **Jenab S. M. H., (2010).** A two-dimensional approach to evaluate the scientific production of countries (case study: the basic sciences). *Scientometrics*, 84(2), 357-364.

North D. C., (1990). Institutions, Institutional Change and Economic Performance., (Cambridge University Press: Cambridge.).

North D. C., (2010). *Understanding the process of economic change*. Princeton university press.

North D. C., & **Thomas R. P., (1973).** *The rise of the western world: A new economic history*. Cambridge University Press.

Pervillé G., (2004). Les étudiants algériens de l'université française (1880- 1962), Casbah éditions.

Porter M. E., & **Stern S., (1999).** *New challenge to America's prosperity*. Council on competitiveness.

Prescott E. C., (1998). Lawrence R. Klein lecture 1997: Needed: A theory of total factor productivity. *International economic review*, 525-551.

Press W. H., (2013). What's so special about science (and how much should we spend on it?). *Science*, *342*(6160), 817-822.

Rama M., (1993). Rent seeking and economic growth: a theoretical model and some empirical evidence. *Journal of Development Economics*, *42*(1), 35-50.

Romer P. M., (1986). Increasing returns and long-run growth. *Journal of political economy*, *94*(5), 1002-1037.

Romer P. M., (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), S71-S102.

Romer P. M., (1992). Two strategies for economic development: using ideas and producing ideas. *The World Bank Economic Review*, *6*(suppl_1), 63-91.

Rousseau S., & Rousseau R., (1997). Data envelopment analysis as a tool for constructing scientometric indicators. *Scientometrics*, 40(1), 45-56.

Rousseau S., & **Rousseau R., (1998).** The scientific wealth of European nations: Taking effectiveness into account. *Scientometrics*, 42(1), 75-87.

Sabra A. I., (1996). Situating Arabic science: Locality versus essence. *Isis*, *87*(4), 654-670.

Saliba G., (2007). *Islamic science and the making of the European Renaissance*. MIT Press.

Sarwar R., & **Hassan S. U., (2015).** A bibliometric assessment of scientific productivity and international collaboration of the Islamic World in science and technology (S&T) areas. *Scientometrics*, *105*(2), 1059-1077.

Siddiqi A., Stoppani J., Anadon L. D., & **Narayanamurti V., (2016).** Scientific wealth in Middle East and North Africa: Productivity, indigeneity, and specialty in 1981–2013. *PloS one*, *11*(11).

Treisman D., (2000). The causes of corruption: a cross-national study. *Journal of public economics*, *76*(3), 399-457.

UNESCO. (2015). *Science Report 17*: the Arab States. 38 pp. https://en.unesco.org/sites/ default/files/usr15_the_arab_states.pdf

Wang E. C., & Huang W., (2007). Relative efficiency of R&D activities: A cross-country study accounting for environmental factors in the DEA approach. *Research Policy*, 36(2), 260-273.

Weber M., (1930). The Protestant Ethic and the Spirit of Capitalism. Allen and Unwin, London.

Welzel C., (2013). *Freedom rising*. Cambridge University Press

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.

Appendix A

Table A. Nature and sources of variables

Variable	Nature; (Source)
Docs	Number of Documents 1996-2019; (Scopus)
Cits	Number of Citations 1996-2019; (Scopus)
HIndex	Hiersh Index 2019; (Scopus)
DocsR	Docs/Pop
CitsR	Cits/Docs
GrthDocs	Avg. annual growth rate of publications 1996-2020
GERD%	GERD/GDP (avg, 1996-2010); (WB data)
GERD	Gross Expenditure R&D
Researchers	Number of Researchers per million Pop (avg, 1996-2016); (WB data)
AYTS	Avg. years of total schooling (1970; 2010); (Barro & Lee (2013))
AYT	Avg. years of tertiary education (avg. 1995-2010); (Barro & Lee (2013))
HC_AYT	AYT*Pop25+ (avg. 1995-2010); (Barro & Lee (2013))
HCIndex	World Bank Human Capital Index (avg. 1996-2010); (WB data; Kraay (2019))
HLO	Harmonized Learning Outcomes (avg. 2000-2015); (Angrist et al., (2021))
Pop	Population 2017 (Millions); (WB data)
GDP	GDP ppp 2017 (Billion $); (Penn World Table; Feenstra et al. (2015))
GDPpc	GDP per capita 2017
WGI	Six World Governance Indicators (avg. 2002-2016); (WB; Kaufmann et al., (2010)
QInst	First Principal Component of the 6 WGI's
NRR	Natural Resources Rents, % GDP (avg. 1996-2015); (WB data)
Colonizer Identity	(British, French, Spanish & Portuguese, Others); (Treisman (2000))
CultureZone	Culture Zone (10 zones classification)); (www.cambridge.org; welzel (2013))

Source: Elaborated by the author

Appendix B. Robustness checks.

Table B. Quality of Institutions robustness checks (3SLS)

Variable	QInst	Rule of Law	Control of Corruption
SIS			
OECD	0.197	0.206	0.210
	(0.056) ***	(0.057) ***	(0.057) ***
HCIndex	0.166	0.160	0.166
	(0.037) ***	(0.038) ***	(0.037) ***
GERD%	0.104	0.104	0.100
	(0.028) ***	(0.029) ***	(0.029) ***
Const	-0.235	*-0.224*	-0.237
	(0.084) ***	*(0.085)* ***	(0.085) ***
R^2	0.667	0.669	0.666

Source: Elaborated by the author

Table B2. Human Capital robustness checks (3SLS)

Variable	**HCIndex (n=113)**	**HLO (n=109)**	**AYTS2010 (n=116)**
SIS			
OECD	0.197	0.215	0.201
	(0.056) ***	(0.057) ***	(0.055) ***
HC	0.166	0.0013	0.038
	(0.037) ***	(0.0004) ***	(0.008) ***
GERD%	0.104	0.100	0.099
	(0.028) ***	(0.031) ***	(0.028) ***
Const	-0.235	-0.422	-0.139
	(0.084) ***	(0.172) **	(0.059) **
R^2	0.667	0.678	0.671

Source: Elaborated by the author