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Proposal of a New National Innovation Capacity Index: Cross-Country Comparison of MENA Countries and Comparative Insights with Europe

A B S T R A C T

As national innovative capacity is one of the key factors for economic, social and environmental development, researchers and policy makers are trying to understand its concept as well as the drivers of differences between countries. The aim of this paper is to reflect on, and evaluate factors influencing national innovation capacity (NIC). This study develops a methodology for measuring NIC based on the entropy method with a view to provide the evidence for policy-making concerning national innovation capacity-building within Middle East and North Africa (MENA) countries, conducts a cross-country comparison for the period 2006-2020, and offers a comparative perspective with European innovation systems to contextualize MENA's innovation landscape.

The findings show that MENA countries wishing to boost their level of national innovative capacity should concentrate mainly on scientific excellence and international economic activities. The comparison with Europe further underscores the importance of robust institutional frameworks, sustained R&D investment, and developed human capital for achieving higher innovation performance.

Keywords

National innovative capacity, cross-country comparison, MENA countries, European comparison, entropy method

1. Introduction

In the context of intensifying global competition, countries are increasingly prioritizing innovation to stimulate economic growth and long-term development (Porter, 1990; Porter and Stern, 1999). Innovation, particularly in science and technology, plays a critical role in enhancing productivity, firm performance, and national prosperity (Tellis et al., 2008; Temiz and Gökmen 2014 and Araújo and Salerno, 2015). “Innovation is critically important in contemporary economies. A key driver of the improvement in consumers’ living standards is the growth and success of firms, and the wealth of nations. Investment in research and development (R&D) is essential for firms and nations to produce innovations and compete for the future” (Tellis et al. 2008). Therefore, both developed and developing nations policies and

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objectives increasingly place acquiring the ability to innovate at their basis (Morrar 2018). Since competitiveness and economic growth are supported by innovation, developing economies are catching up and expanding in the global economy (Terzić 2017; Naude et al. 2011).

While much of the literature has focused on innovation in advanced economies, this study turns its attention to the Middle East and North Africa (MENA) region—a region marked by distinct characteristics such as high youth unemployment, uneven institutional development, resource dependency, and substantial disparities in innovation performance. These features, coupled with increasing pressures from globalization, stricter intellectual property regimes, and the imperative of economic diversification, make MENA a compelling and underexplored context for innovation studies.

This research has four primary objectives: first, to develop a novel entropy-weighted National Innovation Capacity (NIC) index tailored to the economic, social, and institutional dynamics of MENA countries; second, to provide the first comprehensive longitudinal analysis of NIC across 18 MENA countries from 2006 to 2020; and third, to derive actionable, context-sensitive policy recommendations for fostering innovation capacity in diverse national settings within MENA; and fourth, to provide a comparative analysis against European innovation systems to better contextualize MENA's challenges and opportunities. To accomplish this, the study adopts an empirical approach based on a broad cross-country comparison among 18 MENA nations, and a more detailed analysis of five selected countries—Egypt, Morocco, Tunisia, Jordan, and Saudi Arabia—chosen for their documented and recent national innovation strategies is included in Appendix 1. While Israel stands out as a global innovation leader and is included in the broader comparison, its distinct institutional structure justifies its exclusion from the focused subgroup. Countries without available data or without formalized strategies, such as Djibouti, and Malta, are not included in the main analysis.

Though patent applications are commonly used to measure innovation, this study acknowledges their limitations—including quality disparities and filing biases—and thus relocates related data and discussion (formerly Figure 1) to the Appendix 2. Consistent with innovation system literature, the study focuses not narrowly on macroeconomic indicators (e.g., GDP growth, inflation), but on a broader set of economic, social, and institutional factors that influence NIC.

Grounded in the National Innovation Systems (NIS) framework and building on the NIC model of Furman et al. (2002), this study contributes to the empirical literature by

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constructing a multidimensional indicator system using the entropy method and by offering cross-regional comparative insights. The paper proceeds by detailing the NIC framework and methodology, presenting the empirical results from the cross-country and in-depth analyses for MENA, discussing these findings in light of European innovation performance, and concluding with key insights and limitations relevant to innovation policymaking in the MENA context.

2. An overview of various National Innovation Capacity measurements

The purpose of this section is to give an overview of previous findings regarding classic structural models that explain national innovative capacity. These findings provide the basis on which we will build our own model specification, while also acknowledging established frameworks used in other major economic regions like Europe.

In 1987, Freeman introduced the notion of National Innovation Systems (NIS), defined as a network of public and private sector entities whose activities and interactions generate, import, modify, and diffuse new technologies (OECD, 1997). Since then, numerous studies have expanded the NIS framework. Lundvall (2016) emphasized the role of learning and knowledge exchange, seeing innovation systems as composed of interacting elements engaged in the creation, dissemination, and application of economically valuable knowledge. Edquist (1997) argued that innovation is shaped by the interplay of institutional and organizational factors that collectively define the innovation system. These perspectives underscore NIS as a holistic, institutional framework for understanding innovation ecosystems, emphasizing actors and their systemic interactions.

While the NIS approach remains foundational, scholars have sought more operationalizable and comparative models, leading to the development of the National Innovative Capacity (NIC) concept. According to Furman et al. (2002), NIC is defined as “the ability of a country to produce and commercialize a flow of innovative technology over the long term.” The NIC framework builds upon three theoretical pillars: endogenous growth theory (Romer, 1990; Solow, 1957), Porter's theory of national competitiveness (Porter, 1990), and the NIS approach (Freeman, 1987; Lundvall, 2016). It represents a shift from a descriptive, institutional approach to a more quantitative, performance-oriented framework, allowing for cross-national benchmarking of innovation potential and outcomes.

Balzat and Hanusch (2004) have been instrumental in linking NIS to NIC, arguing that measurable indicators must be derived from theoretical constructs within NIS. Their work bridges the gap between the qualitative institutional analysis of NIS and the quantitative

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assessment of NIC, stressing the importance of conceptual clarity when translating system-level insights into measurable components.

While the Furman et al. (2002) framework attempts to list NIS elements contributing to NIC, it has limitations in assessing internal linkages and dynamic feedback among innovation determinants. Mu et al. (2010) addressed this gap by redefining NIC in terms of the innovation process and value creation, highlighting four key components: innovation input, innovation condition, innovation output, and innovation outcome. In a broad sense, NIC refers to a country's ability to combine innovation resources and turn them into fortune, demonstrating an integrative capacity to boost economic and social development. Mu and Fan (2011) introduced the EAA (Elements, Actors, Activities) framework to conceptualize NIC as the ability to transform innovation resources into economic and social value.

The measurement of NIC has become a focus of policy and management research on innovation development; therefore, it has evolved from a single indicator technique to a multi-dimensional indicator system approach since the 1990s. The shift toward multi-dimensional measurement systems has enabled deeper policy insights. While early NIC measurement (e.g., Suarez-Villa, 1990) relied on single indicators such as patents, more recent approaches favor composite indices integrating multiple variables. Although using a single indicator has the advantages of a large amount of international data and simple data analysis tools, it has a number of flaws, such as skewed conclusions that are useless for policymaking. As a result, the use of a single indicator is being phased out. The multi-dimensional indicator system has recently emerged as the preferred method for NIC measurement. With their unique interpretations of NIC, several scholars and institutes have established numerous indicator systems for varied evaluation aims (Mu et al., 2019). In fact, significant differences between the scientific and practice-oriented models behind the studies and their underlying data sets lie in the choice of the determinants supposed to influence innovative capacity, the measured value reflecting the innovative capacity, and the statistical method used to examine the interdependencies between them (Proksch et al., 2017).

A literature survey reveals that there are numerous research on measuring NIC in a broad sense, with the majority of them focusing on two categories of innovation measurements.

The first category of researches tries to use a comprehensive set of indicators related to innovation to measure the NIC, including the widely recognized European Innovation Scoreboard (EIS), Global Innovation Scoreboard (GII) and The National Innovation Index proposed by Chinese Academy of Science and Technology for Development (NII-CASTED). The European Innovation Scoreboard (EIS) compares the performance of EU Member States

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in terms of research and innovation, as well as the relative strengths and weaknesses of their research and innovation systems (European commission, 2019). The EIS indicator system is composed by four different types of indicators and ten different innovation dimensions, totaling 27 indicators. It includes a lot of indicators related to enterprise innovation, and indicators related to social impacts of innovation. The Global Innovation Index (GII) (2019) provides detailed innovation measures for 129 economies, covering 91.8 percent of the global population and 96.8% of global GDP. The Innovation Input Sub-Index and the Innovation Output Sub-Index make up the GII. The Innovation Input Sub-Index captures elements of the national economy that enable innovative activities. The Innovation Output Sub-Index provides information about outputs that are the result of innovative activities within economies (Cornell University et al., 2014). The NII elaborated by Chinese Academy of Science and Technology for Development, measures national innovation index based on an indicator matrix comprising five pillars, including the innovation resources, the knowledge creation, the enterprise innovation, the innovation performance, and the innovation environment. However, this index did not make a clear distinction between innovation capacity and innovation performance, which made it difficult to reveal the difference in innovation capacity between countries.

The second category of researches tries to develop a multi-dimensional indicator system specific to innovation capacity. The Global Competitiveness Report takes NIC as a part of the Global Competitiveness Index, and measures it from three aspects: the interaction and diversity, the research and development, and the commercialization (Word Economy Forum., 2017). However, the measurement by World Economic Forum mainly focuses on the innovation environment and R&D, which is relatively simple and cannot fully reflect the connotation and extension of NIC. Porter and Stern (1999) proposed the National Innovation Index (NII) based on their understanding of NIS and the Furman et al. framework to measure the NIC, which highlights the resource commitments and policy choices that affect innovative output in the long run. The NII contains three aspects such as the quality of the common innovation infrastructure, the cluster-specific innovation environment, and the quality of linkages, and aims to monitor the innovation capacity of different countries and regions from multiple perspectives. However, the NII does not distinguish the difference between the contribution of scale indicators and the contribution of efficiency indicators to NIC, which is very helpful for identifying and analyzing the policy issues related to innovation capacity-building.

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Mu et al. (2010) proposed a National Innovation Capacity Index (NICI) with two sub-indexes concerning the innovation strength and the innovation effectiveness in order to provide evidence for the formulation of innovation capacity-building policies. However, it is necessary to improve the NICI indicator system continually to reflect the changes in scientific, technological, economic and social development and the transformation from innovation policy to innovation development policy.

Within this macro-level framework of national innovative capacity, empirical research has increasingly focused on identifying the concrete institutional, legal, and economic mechanisms that enable or hinder technological innovation across different national contexts. Beginning with the initial economic conditions and extending to national social, cultural, and political dimensions—such as prevailing mindsets, bureaucratic inefficiencies, corruption, suboptimal investment decisions, limited political will, and insufficient managerial capacity—these factors collectively shape a country's ability to realize its full innovation potential. A number of scholars (e.g., Azagra-Caro and Consoli 2016; Malik 2020; Proksch et al. 2017; Santana et al. 2015; Andrijauskiene et al. 2021; Wu et al. 2017) emphasize that, among the various frameworks available for analyzing this broader innovation environment at the macro level, the concept of national innovative capacity remains the most suitable and widely applied.

Boldrin and Levine (2002) claim that Innovation progress relies on the presence of rules, institutions, and laws that balance the attribution of monopoly power to patent holders, the economic and financial recognition of inventors, and the application of technological innovations to create new products and services. More recently, Samoilikova (2020) analyzes the determinants of the Innovation Index in Ukraine, highlighting that R&D expenditure as a percentage of GDP, the availability of public and private funding, and an efficient regulatory system are positively linked to national innovation growth. Additionally, Sener and Delican (2019) compile a composite dataset of 31 developed and 26 developing countries to investigate the relationship between innovation, competitiveness, and exports. Their findings reveal a one-way causality: from exports to innovation and from innovation to competitiveness in developing countries. Moreover, Angelo et al. (2022), analyze the determinants of the innovation index in Europe for the period between 2010 and 2019 for 36 countries. The results show that the Innovation Index is negatively connected to some variables (GDP per capita, R&D expenditure public sector, Venture capital, Tertiary education), and positively connected to some others (Government procurement of advanced

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technology products, Average annual population growth, Finance and support, Human resources, Marketing or organisational innovators, Linkages).

This paper contributes to the literature by offering a novel entropy-based NIC index, which enhances prior models by introducing a systematic weighting scheme based on information theory. Unlike traditional NIC frameworks, summarized in Appendix 3 (which include European-centric models like the EIS), that either adopt arbitrary weights or rely on principal component analysis, the entropy method considers the degree of variation and informational value of each indicator, ensuring a more objective and statistically robust assessment. Moreover, our model retains the multi-dimensional logic of NIS while allowing for cross-national comparison, particularly suited for regions like MENA where innovation system heterogeneity is high and context-specific constraints (e.g., political, cultural, institutional) play a critical role. The eventual comparison with European innovation systems aims to further situate these findings within a global context.

Thus, this study aims to redevelop the original NIC framework by Furman et al. (2002) to better fit the policy and performance realities of MENA countries. Despite the proliferation of innovation measurement models, studies that handle endogeneity, while also offering region-specific insights—particularly in the MENA context—remain scarce. Our objective is to identify the macroeconomic determinants shaping national innovation performance across MENA countries from 2006–2020, with the ultimate aim of informing context-sensitive innovation policies, and to understand these dynamics in comparison to established innovation regions.

3. Methodology

In this section, we first define the concept of national innovative capacity (NIC) and present the framework for selecting indicators. We then elaborate on the construction of the NIC Index (NICI) using the entropy weight method. This NICI will primarily be used to assess MENA countries, with findings later contextualized through a comparative lens with European innovation systems.

3.1. Measurement indicator system

The selection of indicators is grounded in a robust theoretical framework based on the literature on National Innovation Systems (Nelson 1993; Furman et al. 2002; Mu et al. 2019). Innovation is understood as a multi-dimensional, dynamic process that spans across scientific, technological, economic, institutional, and social spheres. Accordingly, a comprehensive assessment of National Innovation Capacity (NIC) must encompass both input and output factors, institutional and governance conditions, as well as broader socio-economic enablers.

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To ensure the comprehensiveness and relevance of the NIC Index (NICI), 25 indicators were selected across multiple dimensions, guided by three key principles. Firstly, theoretical alignment was prioritized, ensuring that the chosen indicators reflected established dimensions of national innovation capacity—such as economic structure, scientific infrastructure, innovation outputs, institutional quality, and human capital—as identified in the literature and featured in leading composite indices like the Global Innovation Index, Global Competitiveness Report, and European Innovation Scoreboard. Secondly, data availability and reliability were considered, with indicators included only if they were available for a majority of MENA countries and based on consistently defined metrics across time and geographic contexts. Lastly, comparability and operability were emphasized, requiring that indicators be comparable across countries and over time, and quantitatively measurable to enable meaningful statistical analysis. These principles collectively ensure that the NICI provides a robust and context-sensitive assessment of national innovation capacity within the MENA region.

Primary data sources include the World Bank, the Worldwide Governance Indicators, the Human Development Report, the United States Patent and Trademark Office (USPTO), and the Polity IV database. For missing values, two-year averaging was used for intermediate gaps, while trend extrapolation was applied for data missing at the beginning or end of the time series.

This study constructs a NICI with 25 indicators, as presented in Table 1, based on the NIC analytical framework.

Insert Table 1

3.2. Critical Reflection on Indicator Selection

Although many of the selected indicators are widely recognized in the innovation literature, a more systematic justification of their inclusion is necessary. Some indicators may exhibit overlap or collinearity—for example, R&D expenditure and researcher density—which raises concerns about multicollinearity potentially distorting weight allocation or introducing noise into the composite index. While the entropy weighting method helps address this issue by assigning lower weights to less informative or redundant indicators, further analytical rigor is advisable. In future extensions of this work, a Variance Inflation Factor (VIF) analysis could be employed to detect and quantify multicollinearity, thereby refining the selection of indicators. Additionally, variations in indicator quality and potential measurement bias across countries—particularly for governance or corruption metrics—should be acknowledged.

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Although these indicators are retained for consistency with established practices in the literature, their interpretation should be approached with caution, as they may reflect differences in reporting standards rather than true institutional performance.

3.3. Why the Entropy Method?

The entropy weight method is a quantitative approach based on information theory (Shannon 1948), traditionally used in multi-criteria decision analysis. In this study, it serves a new but well-justified purpose: objectively assigning weights to indicators in a composite innovation index based on the degree of variation (information content) each indicator contributes.

Unlike subjective weighting schemes (e.g., expert judgment), entropy weighting is data-driven and sensitive to country-level differences. Indicators with greater variability are presumed to carry more information, and thus receive proportionally higher weights.

Despite its origin in decision science, the entropy method is increasingly used in composite index construction across economics and policy evaluation. It is particularly relevant in the MENA context, where heterogeneity across countries makes subjective or equal-weighting approaches less defensible.

We acknowledge that entropy weighting may result in relatively small deviations between country scores—particularly when indicators show limited variation. However, we view this as a realistic representation of the NIC landscape, which often evolves gradually. The goal here is not to exaggerate differences but to reveal underlying trends and dynamics.

3.4. Steps of NIC Index construction

We detail the steps necessary to implement the algorithm of the entropy weight method below.

3.4.1. Data Standardization

Suppose that we have n evaluation indicators for m periods that are grouped in the original data matrix, noted $X = x_{(ji)}$ of dimension (m, n). Since there are many differences among the indices in dimension, magnitude and expected impact on NIC, it is necessary to standardize this original data matrix. In particular, as we have shown before, some indicators have an expected negative impact on the final results while others have an expected positive impact. Hence, the method should be based on the values of R_{ji}, which are elements of normalized vector R defined as follows:

If the indicator plays a positive role: $R_{ji} = (X_{ji} - \min X_{ij})/(\max X_{ji} - minX_{ij})$

If the indicator plays a negative role: $R_{ji} = (\max X_{ji} - X_{ij})\ /(\max X_{ji} - minX_{ji})$

where: i=1,…,m periods and j=1,…,n indicators.

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3.4.2. Entropy calculation

For the n indicators and m periods, the definition of the entropy of the j indicator is defined as following, for j=1,.., n:

$$H_j = -k \sum_{i=1}^{m} f_{ji} \times Inf_{ji}$$

Where $k = \frac{1}{ln\, n}$ and $f_{ij} = \frac{R_{ij}}{\sum_{i=1}^{m} R_{ij}}$

Note that when $f_{ji} = 0$ or $f_{ji} = 1$ then $f_{ji} \times ln\, f_{ji} = 0$. This can be corrected using the following transformation:

$$f_{ji} = \frac{1 + R_{ji}}{\sum_{j=1}^{n}(1 + R_{ji})}$$

3.4.3. Weight determination

Let's define the utility of the j indicator as: $d_j = (1 - H_j)$. This notion is necessary for the definition of the entropy weight of the j indicator:

$$w_j = (1 - H_j)/(n - \sum_{j=1}^{n} H_j) = d_j / \sum_{j=1}^{n} d_j$$

Where $0 \leq w_j \leq 1$ and $\sum_{j=1}^{n} w_j = 1$

3.4.4. Composite NIC calculation

After computing the entropy weight for each indicator, we can determine the index of each subsystem:

$$s_i = \sum_{j=1}^{n} w_j \times R_{ij}$$

Finally, to obtain a comprehensive overview of the overall level of innovation, we can compute an overall NICI level:

The National Innovation Capacity index (NICI):

$$0 \leq NICI_i \leq 1$$

This overall indicator allows defining a five grade evaluation criteria of the overall NICI level referring to the evaluation criteria of the resources National Innovation Capacity level. This coefficient reflects the situation and trend of National Innovation Capacity of a region or country. These five grades are shown in Table 2.

Insert Table 2

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4. Measurement Result Analysis

In this section, we apply the steps described above. The weights of the indicator of NIC in the level of development for each variables are summarized in Appendix 4.

We analyze country-level data using a functional model of national innovation capacity to examine the development status of NIC across countries and over time. We calculated NIC index scores using national-level annual time-series data from 2006 to 2020. The NIC score consists of individual scores for the 25 variables and represents the results for MENA countries in the sample through 5 stages of overall innovation capacity. This study analyzes the change trend of the overall and variables NIC, as well as the spatial heterogeneity of MENA countries.

This provides simple evidence for measuring NIC at the national level, considering the role of internal and external innovation elements, as modeled in the NIC. These MENA-specific findings will subsequently be contextualized through a comparative discussion involving European innovation performance in Section 5.

4.1. The General Trend of National Innovation Capacity

Overall, the means of the NICs in the MENA countries we studied, revealed a gradually rising trend (Figure 3), and the acceleration of NIC slowed and even decreased from 2011 in the countries which have undergone the Arab spring which is a set of popular protests, of very variable scale and intensity, which occur in many countries of the Arab world from December 2010, namely mainly Tunisia, Egypt , Syria, Yemen, Libya. The means of the NICIs in most MENA countries were less than 0.8, representing a fairly low score across the 15 years. The mean NICs at the country level varied from a low of 0.117 in Libya to a high of nearly 1 in Israel. A notable result is the considerably higher variation created by differing NIC levels among countries in different years. The NIC of Israel rose dramatically during the study period, from 0.424 to 0.989, which was the largest increase in the selected countries. The NIC index of some countries declined instead of rising; among these countries, Libya's NIC showed the worst drop, from 0.277 to 0.158.

Insert Figure 1

From the explicit examination of each dimension of the NIC (Annex 1), we observed that the variables of NIC displayed various trends.

The Number of Patents Granted as Distributed by Year of Patent Grant, scientific and technical journal articles and Charges for the use of intellectual property, payments (BoP,

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current US$) rated higher, showing that most nations in MENA countries place serious priority to acquiring external knowledge and technology. In fact, The Number of Patents Granted as Distributed by Year of Patent Grant is also the indicator that has the highest value of national innovation capacity indicators in MENA countries among all the indicators. This demonstrates that this indicator determines how the NIC value grows, and that it is the key factor in improving the NIC (Lee et al., 2020). Although they show the outcomes of innovation activities, patents do not ensure that a country's capacity for innovation would automatically increase. For instance, a nation may have a large number of patents yet they may not be economically relevant or commercially successful. By promoting investment, facilitating public-private collaboration, and attracting talent, patents may help stimulate innovation ecosystems (Smith, 2006; Malik et al. 2021).

Although communication technology and equipment advancements have made knowledge exchange between countries more convenient (Hilbert and López 2011) , the effect of NICs external knowledge dissemination has not increased because states' protection of proprietary technology at the national level has gotten stronger in order to maintain their technological singularity and competitive edge in a particular field (Lu and Chesbrough 2022; Lu et al., 2022).

The 18 nations included in the study may be categorized into five levels (Figure 4) based on the NIC index score. To display the overall NIC spatial pattern for MENA, we used the years 2014, and 2020 as temporal nodes. While United Arab Emirates has the fastest growth, the NIC of Israel has consistently held the absolute leading position. Israel consistently maintained the highest score of more than 0.500 among all the sampled nations.

In the 2020 map, some MENA countries display a darker blue compared to 2014, indicating an increase in innovation capacity. Countries like Saudi Arabia, UAE, and Egypt seem to have improved their NIC over time. Although, some countries, like Morocco and Algeria, have lighter blue shades in 2020 compared to 2014, suggesting either a slight decrease or stagnation in their innovation capacities. Syria and Yemen, affected by socio-political instability, remain in the lighter blue range, reflecting low NIC scores across both years.

In fact, Saudi Arabia shows one of the most significant improvements, moving from a weak NIC stage in 2014 to a strong NIC Stage in 2020, reflecting increased innovation investments and policy changes. United Arab Emirates, already performing well in 2014, maintains or even slightly improves its position by 2020, continuing its status as a regional leader in innovation.

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Concerning Egypt, this country appears to have made noticeable progress from a weak NIC stage in 2014 to an average NIC Stage in 2020, indicating strengthening NIC.

Morocco and Algeria: Both countries seem to have experienced either a stagnation or slight reduction in innovation capacity, as indicated by the lighter blue that suggested an Average NIC stage in 2020.

The overall increase in the upper bound of the index from 0.642 in 2014 to 0.989 in 2020 suggests that several countries in the MENA region have significantly enhanced their innovation capacity. Despite some progress, countries such as Yemen, Syria, and Sudan remain in the lower tier of the index, which could be attributed to ongoing conflicts and economic challenges that hinder innovation.

Insert Figure 2

4.2. Detailed Comparative Study on National Innovation Capacity

The level and nature of interaction among innovative players, as well as their relationship with the innovation environment, can all influence innovative capacity. Besides regulations, the propensity of a country to interact with others to generate new knowledge may also lead to higher levels of innovative capacity (Gregersen and Johnson, 1997).

The amount of government expenditure is also related to higher levels of innovative capacity: the more investments in R&D, the higher the chances to increase technological development. The potential for innovation varies enormously from one country to another within the MENA region. This variation is strongly linked to the educational, cultural and political systems of the countries (Weerasinghe et al., 2024).

In fact, Saudi Arabia has made strategic investments in R&D and diversified its economy away from oil through initiatives such as Vision 2030. This includes a focus on fostering innovation in sectors like renewable energy, biotechnology, and information technology. The establishment of science parks, research institutions, and investments in higher education and technical skills development likely contributed to its upward trend. The country also improved its global partnerships, technology transfers, and the establishment of innovation hubs to encourage startups and tech innovation. Like Saudi Arabia, United Arab Emirates's investment in innovation and smart cities, including initiatives like Dubai's Smart City and Abu Dhabi's Masdar City, have been central to their continued strength in innovation capacity. The UAE also prioritizes research and development in cutting-edge fields like artificial intelligence, renewable energy, and space technology. The country's openness to

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global talent and business-friendly environment are strong factors in maintaining its NIC score. The Dubai Expo 2020 initiative has further pushed innovation, with a focus on sustainability, mobility, and opportunity.

Israel stands out as the leading country in the MENA region in terms of National Innovation Capacity (NIC). Between 2014 and 2020, Israel consistently maintained extremely high levels of innovation performance, driven by a strong culture of entrepreneurship, advanced research and development infrastructure, and extensive collaboration between universities, the private sector, and the military. The country’s innovation ecosystem benefits from significant venture capital availability, a dynamic startup sector, and cutting-edge advancements in fields such as cybersecurity, biotechnology, and artificial intelligence. Despite regional political tensions, Israel's NIC has remained robust, positioning it not only as the top innovator in MENA but also among the global leaders in innovation.

Egypt has also shown signs of emerging innovation capacity. Recent reforms in higher education, investment in research infrastructure, and the development of new science and technology parks, such as the Knowledge City in the New Administrative Capital, have positively influenced its NIC. Egypt’s startup ecosystem has experienced growth, particularly in fintech, edtech, and healthtech sectors. However, bureaucratic inefficiencies, regulatory constraints, and limited access to finance for SMEs continue to hamper the full realization of Egypt’s innovation potential. If these barriers are systematically addressed, Egypt has significant room for advancement.

Morocco has made notable investments in renewable energy and automotive industries, which have helped in improving its innovation profile. Projects like Noor Solar Complex and industrial zones such as Tangier Automotive City represent efforts to integrate innovation within key sectors. Additionally, government programs promoting entrepreneurship, such as Maroc PME and innovation funds, have supported startups. However, challenges remain, including improving the linkages between universities and industries, as well as enhancing R&D investment across broader sectors of the economy.

Jordan’s innovation capacity has benefited from a highly educated workforce and strong IT sector development. The country’s investment in sectors like biotechnology, pharmaceuticals, and information and communications technology has improved its NIC. Initiatives such as the King Hussein Business Park and the establishment of technology incubators have further strengthened its innovation environment. Nevertheless, limited natural resources and regional instability have constrained Jordan’s overall innovation growth, highlighting the need for greater regional partnerships and internal R&D funding.

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Qatar, like the UAE, has made significant investments to enhance its innovation landscape. The establishment of Qatar Science and Technology Park (QSTP), Education City, and its National Vision 2030 strategy have collectively worked to diversify the economy beyond hydrocarbons. Qatar's emphasis on developing a knowledge-based economy and its focus on smart cities and sports technologies (especially following the 2022 FIFA World Cup) are strategic steps in strengthening its NIC. However, Qatar still faces challenges related to scaling startups beyond the domestic market.

Moreover, innovation is affected by political stability since the latter is essential to allow an innovation policy which must strongly favor the spirit of enterprise, the creation of values, allow a great diversity of cultures and knowledge, attract the best students, young researchers, entrepreneurs, make the transfer of research results effective (Wang et al., 2024). This is shown in both Syria and Yemen, which have been severely impacted by political instability and conflict, which has decimated their educational systems, infrastructure, and ability to invest in innovation. Ongoing wars and humanitarian crises have made it impossible for either country to develop strong innovation ecosystems, and they face severe challenges in the near future to rebuild basic infrastructure, let alone foster innovation. These countries will likely require significant international aid and rebuilding efforts to recover and eventually start improving their NIC scores.

Concerning Tunisia, this country has made some progress, especially in its startup ecosystem, but faces significant challenges in scaling innovation across broader industries. The country has invested in digital infrastructure and technology parks like El Ghazala Technopark, but ongoing economic and political issues have slowed its innovation progress. Tunisia has potential for growth, especially with a relatively well-educated workforce and an increasing focus on sectors like ICT, agri-tech, and biotech.

Lebanon presents a mixed picture regarding innovation. While the country has a vibrant entrepreneurial culture, particularly in Beirut's digital startup ecosystem, the severe political and financial crisis since 2019 has dramatically hampered innovation progress. Brain drain, lack of funding, and weakened infrastructure have undermined Lebanon's ability to maintain a steady NIC. Rebuilding trust in institutions and supporting local entrepreneurship are critical steps for Lebanon's future innovation resurgence.

Our data shows a positive correlation between the weight of PAT and the NICI values: a positive change of one unit in the degree of PAT causes an increase of approximately 0.2 in NICI. Patents may be a cause of NIC as well as one of its consequences. For instance, national patents encourage innovation; they also mitigate threats of misappropriation in

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international business (Malik et al. 2021).The results demonstrate that PAT play important role in determining NIC as suggested by the proponents of the endogenous growth theory. With the development of the patent system for hundreds of years (Machlup and Penrose, 1950), it is widely accepted that a strong patent system is likely to encourage innovation for the benefit of economic growth (Zhang et al., 2024). This implies that economies with higher level of PAT have been able to achieve higher index of NIC which is consistent with the findings of Resta et al. (2024) and others (Porter and stern, 2001; Natário et al., 2011, …etc). Although international patents constitute the best available measure of innovation that is consistent across time and location, Research and Development expenditures and human capital appear to be important determinants to measure NIC with a high coefficient values of the entropy weight.

Another important factor in building innovation capacity is the founding for R&D. Moreover, expenditure on R&D reflects the nation’s absorptive capacity and represents innovation efforts (Adikari et al. 2021). R&D investments generate R&D knowledge regarding new products, which improves market performance by introducing innovate products (Novillo-Villegas et al. 2022). This direct and positive impact of R&D investment on NIC is proven in this study as shown in Appendix 4.

Concerning institutional factors (ID, IPF, SPAV, V&R, CR, RQ and L&O), they can help improve a country’s NIC. Within an economy, laws, policies, and institutional frameworks govern the roles and interactions of various actors. The political, regulatory, and business environments establish the conditions for innovation, with varying capacities to manage the inherent uncertainties of innovation activities (Watkins et al., 2015; Nelson, 2008). Countries with robust institutional support provide comprehensive policies and a stable political climate for enterprises, including intellectual property protection, tax exemptions, and measures to mitigate operational risks, thus fostering innovation among firms and research institutions (Erzurumlu et al., 2022). The regulatory environment reflects government efforts to minimize conflicts among economic actors and to promote stable and cooperative relationships (Furman et al., 2002; Yu et al., 2020). Similarly, the business environment focuses on reducing uncertainty for corporations by supporting entrepreneurship, facilitating bankruptcy resolution, addressing tax issues, and encouraging competitiveness, all of which are critical for fostering innovation (Schot and Steinmueller, 2018).

Specifically, the 18 MENA countries, subject of this study, were divided into 5 categories according to their score in National Innovation Capacity Index using entropy method. From the perspective of country classification, the NICI value of most MENA countries was low

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but it improved during the study period. At the beginning of the study period, there were 13 countries in the no NIC stage, four countries in the weak NIC stage and just one country in the basic NIC stage. According to the different characteristics of the countries distributed in the five stages, we proposed the corresponding optimization direction for these MENA nations.

Countries belonging to very weak NIC stage and weak NIC stage have a low National Innovation Capacity Index which does not exceed 0,45. Most of the 18 countries subject of the study belonged to these two categories in the beginning, because of their insufficient performance in the NIC. At the end of the study, just four countries have a low NICI (Iraq, Libya, Syria and Yemen). These nations still need improvement in all determinants of NIC, while some countries have certain advantages in a certain determinants. Countries in these stages often have low number of patents and deficiency in research scores at the same time and should take action to simultaneously improve determinants of national innovation capacity. In addition, given that institutional factors play a key role in defining a country's national innovation capacity (NIC) which is a gap for these countries, it is essential for them to correct this weakness. In fact, Huang et al. (2024) affirm that strong institutional frameworks provide stability, promote intellectual property protection, and encourage innovation through policies that reduce risks for enterprises and research institutions. While the regulatory environment minimizes conflicts among economic actors, the business environment supports entrepreneurship and competitiveness, creating favorable conditions for innovation.

Thus, these countries are required to create their own advantages in innovation and improve their competitiveness.

Countries belonging to basic NIC stage and average NIC stage are nations whose economies have not yet reached developed innovation status but have outpaced other countries in terms of their innovation growth. In fact, their capabilities to communicate with other innovation systems needs to be improved. Such countries should combine their own advantages in different stages of innovation and development, pay more attention to the improvement of their independent R&D capabilities, maintain their attractiveness to external innovation resources, and improve their localization efficiency of external knowledge and technology, so as to stimulate and drive knowledge creation vitality within the system.

The countries of the strong NIC stage type are NIC leaders. This type provides a benchmark for other MENA countries to improve their NIC. As we expected, the major countries of this type performed well in different determinants of the innovation process. These countries should maintain excellent performance in key innovation determinants such as research and

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development (R&D), human capital, business environment, legal and regulatory framework (L&O, RQ, CR,…),…etc.

5. Comparative Perspective: MENA and Europe's National Innovation Capacity

While this paper focuses on developing a National Innovation Capacity Index (NICI) for MENA countries and analyzing their performance, a brief comparison with a more established innovation region like Europe can provide valuable context and highlight distinct challenges and opportunities.

5.1. Foundational Pillars: R&D, Human Capital, and Institutional Frameworks

Europe, as a whole, generally exhibits a higher and more mature National Innovation Capacity, built upon decades of concerted policy efforts. A key differentiator lies in the foundational pillars supporting innovation. European Union countries, for instance, have long-standing targets for R&D expenditure, driven by both substantial public funding and significant private sector involvement (Eurostat, 2024a; OECD, 2023a). This sustained investment fuels a broad and deep research landscape, enabling "scientific excellence," which this study also identifies as crucial for MENA. In contrast, R&D investment in many MENA countries, while increasing, often starts from a lower base and can be more heavily reliant on public sector funding (UNESCO Institute for Statistics, 2023). Furthermore, Europe possesses a deep and established pool of highly skilled researchers, scientists, and engineers, supported by world-class universities and research institutions with long traditions of excellence and strong university-industry linkages (OECD, 2023b). While MENA nations are making strides in education and human capital development, challenges such as aligning educational outputs with innovation-driven market needs and fostering a critical mass of researchers are often more pronounced (World Bank, 2023b; UNICEF and ILO, 2022). Complementing these aspects, Europe generally benefits from more stable and predictable institutional environments, strong rule of law, robust intellectual property rights (IPR) protection, and established governance systems conducive to innovation (European Commission, 2023b). The MENA region, as discussed, faces a wider spectrum of institutional quality, impacting the enabling environment. The European Innovation Scoreboard (EIS) (European Commission, 2023a), reflects these stronger institutional underpinnings in its overall higher scores compared to the average NICI observed for MENA in this study.

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5.2. Innovation Ecosystem Dynamics: Outputs, Commercialization, and Policy Integration

Beyond foundational inputs, the dynamics of the innovation ecosystem also present contrasts between the two regions. Reflecting its mature R&D and institutional strengths, Europe typically demonstrates higher innovation outputs, including more extensive patenting activity, high-tech exports, and the successful commercialization of research (Eurostat, 2024b). European startup ecosystems are also generally more developed, with greater access to venture capital and support networks that facilitate the journey from idea to market (Invest Europe, 2023). While MENA has emerging vibrant startup scenes (Magnitt, 2023), particularly in countries like the UAE, Egypt, and Saudi Arabia, the overall scale of commercialization and the depth of venture capital markets often lag. In terms of policy, European innovation policy is characterized by comprehensive, long-term strategic frameworks, such as Horizon Europe, and a significant degree of regional coordination and integration (European Commission, 2021). This fosters cross-border collaboration and knowledge sharing. In the MENA region, while national innovation strategies are increasingly adopted (Appendix 1), a cohesive, region-wide innovation policy framework is less developed, though the need for "international economic activities" highlighted for MENA in this paper points towards the potential benefits of such integration.

5.3. Contextualizing Performance and Pathways Forward

While Israel stands out as a global innovation leader within MENA, and some Gulf states are making rapid advancements, the MENA region overall is characterized by greater heterogeneity in its innovation journey compared to the more established, albeit still diverse, European landscape (UN ESCWA, 2022). Many MENA countries are still in earlier stages of building their National Innovation Capacity. The European experience, while not a direct blueprint, underscores that long-term, sustained commitment to strengthening R&D, human capital, and institutional quality is paramount for enhancing national innovation capacity. For MENA, continued focus on these areas, coupled with fostering greater international and regional collaboration where feasible, will be crucial in closing observed gaps and realizing its full innovation potential. Learning from both internal successes and external benchmarks, while adapting strategies to local realities, will be key for MENA countries to effectively respond to global technological changes and foster long-term socioeconomic resilience.

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6. Major Conclusions and Policy Implications

Using data from the United States Patent and Trademark Office, the World Bank and the Human Development Report, this study examines the present state of innovation in the MENA area. It also examines the specific efforts of a set of MENA countries, as well as the major obstacles to innovation’s role in socioeconomic growth. Furthermore, by drawing comparisons with European innovation systems, this study provides a broader context for understanding MENA's innovation landscape. This study aimed to analyze how different variables of National Innovation Capacity evolves over time, providing an empirical measurement through a case study. The literature review revealed an extensive work on national innovation capacity determinants. However, it also highlighted the fragmented nature of these studies, with few addressing all relevant factors in a comprehensive manner (Khedhaouria and Thurik 2017; Menna et al. 2019). Additionally, there is a notable lack in modeling the contextual relationships between these determinants to outline a clear pathway for developing innovation capacity. This research, therefore, offers both theoretical insights and practical contributions to address these gaps, enhanced by a cross-regional comparative lens.

Previous studies have attempted to assess national innovation activities or capacity by creating multi-dimensional indicator systems that encompass a wide range of innovation-related metrics. However, these efforts often encounter challenges in quantifying and explaining the influence of the scale and effectiveness of a country’s innovation activities on its national innovation capacity (NIC). This study introduces a novel methodology for measuring NIC, offering redefined concepts of innovation and innovation development, and examining new perspectives for understanding NIC. The key findings of the study are as follows.

First, this study develops a National Innovation Capacity Index (NICI) based on the innovation capacity-building process, the structure of innovation capacity, and refined definitions of terms such as “innovation” and “national innovation system”. The NICI and its sub-indices can be used to track the evolution of national and global innovation capacities, offering valuable insights for analyzing innovation-driven development strategies and policies related to resource allocation and the development of science and technology infrastructure within MENA, and for benchmarking against other regions like Europe.

Second, although the literature highlights the significance and importance of national innovation capacity, empirical studies at different research scales remain scarce. Most research has focused on the firm or sector level, with limited quantitative studies at the

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national level specifically MENA countries. This study addresses that gap by exploring NIC at the national scale for MENA, enriching our understanding of how NIC interact both internally and externally within the global innovation system. The comparison with Europe further contextualizes these interactions, highlighting common challenges and distinct regional trajectories.

Third, despite extensive theorizing on national NIC, there has been little process-oriented empirical research, especially regarding NIC assessment in MENA countries. This study contributes by offering a framework based on NIC determinants, illustrating how these interactions build up a nation's innovation capacity. Through the entropy approach, the study examines different stages of innovation in MENA, offering insights into how innovation policies can be tailored to different types of NICs. The European experience, while not directly transferable, offers valuable lessons on long-term institutional development and R&D commitment.

Furthermore, this study offers practical benefits for national innovation capacity and policymakers. First, as an early attempt to develop innovation capacity at the national level, the proposed framework can help policymakers, decision-makers, and government agencies design NIC strategies. The findings suggest that innovation elements inside and outside the system should be considered to improve the innovation capacity across 18 dimensions of the NIC framework in MENA. The comparative analysis suggests that while MENA countries must forge their own paths, principles of sustained investment in human capital, research, and robust governance are universally critical.

While, this study depicts the evolution trend of the MENA innovation landscape, improves the transparency and replicability of innovation paths for different economies, and provides robust data support for adjusting innovation strategies for each economy, its main shortcoming remains, although, on average, MENA is classified as high-income region, countries are not homogenous; seven countries[1] are grouped as high, four upper-middle[2], six lower-middle[3] and two low-income[4] countries according to WB 2023 economies' classification[5]. Grouping countries according to their level of economic development and investment in innovation would allow for a more homogeneous and relevant assessment. This

[1]Bahrain, Israel, Kuwait, Oman, Qatar, Saudi Arabia and UAE.
[2]Algeria, Iran, Iraq and Libya.
[3]Egypt, Jordan, Lebanon, Morocco, Palestine and Tunisia.
[4]Syria and Yemen.
[5]Economies are divided among income groups according to 2023 gross national income (GNI) per capita, calculated using the World Bank Atlas method, for operational and analytical purposes. The groups are: low income, $1,145 or less; lower middle income, between $1,146 and $4,515; upper middle income, between $4,516 and $14,005; and high income, more than $14,005.

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can be done for a larger sample because of the existing of some limitations due to incomplete datasets, despite efforts to collect data from MENA countries. Similarly, the comparison with Europe is broad; future research could delve into specific European sub-regions or country clusters for more nuanced insights.

Although some studies shorten research periods to increase national data coverage, this study focuses on long-term trends, recognizing their importance in NIC research. Future studies can build on this work by verifying the NIC framework across more countries and refining the model to address linear simplifications. Further comparative work could also explore specific policy interventions and their transferability between regions.

Additionally, this study highlights the need for further exploration of the relationship between the different elements within the NIC framework, particularly between explorative and exploitative components. Thereby, Future research could further expand the analytical perspective by incorporating other possible key elements.

Policy Implications

This study underscores the necessity for differentiated and context-specific innovation policies to strengthen National Innovation Capacity (NIC) across the highly heterogeneous MENA region. Given the region's diversity in economic structures, political stability, and innovation readiness, policy responses must be strategically tailored. Countries were classified into distinct clusters—hydrocarbon-dependent economies, diversified economies with emerging innovation capacity, and conflict-affected or fragile states—each requiring a distinct set of interventions to optimize their innovation ecosystems. The comparison with European nations, which also exhibit diversity but operate within a more integrated innovation policy framework, highlights potential long-term benefits of greater regional cooperation and harmonization within MENA, where appropriate.

For hydrocarbon-dependent economies such as Saudi Arabia, Algeria, Libya, and Iraq, fostering NIC requires an urgent pivot away from reliance on resource-based models towards knowledge-driven economic structures. In these countries, policy efforts must prioritize diversification through increased investments in research and development, particularly targeting non-oil sectors such as renewable energy, biotechnology, and advanced manufacturing. Strengthening linkages between universities and industry is critical to ensure the effective transfer and commercialization of knowledge. Furthermore, these economies must enhance their intellectual property frameworks to provide stronger protections and incentives for domestic innovation while attracting international investment and collaboration. Saudi Arabia's Vision 2030 serves as a notable example, demonstrating how a comprehensive

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national strategy can embed innovation objectives into a broader diversification agenda, stimulating systemic changes necessary for long-term economic resilience.

Diversified economies such as the United Arab Emirates, Tunisia, Morocco, and Jordan, which exhibit emerging capacities for innovation, should concentrate on consolidating and scaling their existing innovation ecosystems. Policies in these contexts must focus on expanding access to venture capital and nurturing startup ecosystems through accelerators and innovation hubs. Moreover, enhancing technical and higher education programs with an emphasis on future-oriented fields like information and communication technology, artificial intelligence, and sustainable technologies will be crucial for maintaining momentum. These economies should also prioritize building strong global research partnerships to ensure integration into international innovation networks and value chains. The United Arab Emirates, through initiatives such as Smart Dubai and Masdar City, illustrates the benefits of proactive investment in creating specialized innovation zones, offering valuable lessons for other diversified economies aiming to enhance their global innovation standing.

Conflict-affected and fragile states, notably Syria, Yemen, and Libya, face fundamentally different challenges. In these countries, the devastation of educational institutions, research infrastructure, and basic governance structures necessitates a phased approach to rebuilding NIC. The immediate policy priority should focus on reconstructing education and research infrastructures, as these form the bedrock of any innovation ecosystem. International aid and development cooperation must be directed not only toward humanitarian relief but also towards rebuilding human capital and innovation-supporting institutions. Transitional innovation hubs, designed to operate even under conditions of political volatility, can serve as catalysts for early-stage knowledge creation and skill development. For these nations, innovation policy must be intricately linked with broader post-conflict recovery strategies, recognizing that long-term NIC rebuilding will depend heavily on parallel progress in political stabilization, institutional development, and economic reconstruction.

Cross-cutting policy recommendations applicable to all MENA countries also emerge from this analysis. Across the region, strengthening governance and improving the quality of institutions remain foundational for nurturing an environment conducive to innovation. Transparent regulatory frameworks, predictable political climates, and efficient legal systems are prerequisites for both domestic and foreign innovation investments. Lessons from Europe emphasize the long-term benefits of stable, high-quality institutions in fostering sustained innovation. Moreover, inclusive innovation policies that encourage the participation of women, youth, and marginalized populations are essential for unlocking the full potential of

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national innovation ecosystems. Regional cooperation offers additional opportunities: developing joint research and development programs, harmonizing intellectual property systems, and establishing shared technology transfer platforms could significantly enhance collective innovation capacity within MENA, potentially emulating some of the collaborative successes observed within the European Research Area.

In summary, aligning national innovation strategies with each country's economic structure, stage of political stability, and specific innovation challenges will be critical for transforming innovation potential into sustainable and inclusive economic growth. By learning from both internal successes and external benchmarks like those in Europe, while adapting strategies to local realities, MENA countries can position themselves to better respond to global technological changes while fostering long-term socioeconomic resilience.

7. References

1. Adikari, A. P., Liu, H., & Marasinghe, M. M. S. A. (2021). Inward foreign direct investment-induced technological innovation in Sri Lanka? Empirical evidence using ARDL approach. *Sustainability*, *13*(13), 7334.
2. Andrijauskiene, M., Dumciuviene, D., & Vasauskaite, J. (2021). Redeveloping the national innovative capacity framework: European Union perspective. *Economies*, *9*(4), 201.
3. Angelo, L., Laureti, L., & Alberto, C. (2022). The Innovation Index in Europe. Available at SSRN 4091597.
4. Araújo, B. C., & Salerno, M. S. (2015). Technological strategies and learning-by-exporting: The case of Brazilian manufacturing firms, 2006–2008. *International Business Review*, *24*(5), 725-738.
5. Azagra-Caro, J. M., & Consoli, D. (2016). Knowledge flows, the influence of national R&D structure and the moderating role of public–private cooperation. *The Journal of Technology Transfer*, *41*(1), 152-172.
6. Balzat, M., & Hanusch, H. (2004). Recent trends in the research on national innovation systems. Journal of evolutionary economics, 14(2), 197-210.
7. Boldrin, M., & Levine, D. (2002). The case against intellectual property. *American Economic Review*, 92(2), 209-212.
8. Chaabouni, R. (2008). Progress towards the implementation of the National Innovation System in Tunisia. *Communications of the IBIMA*, *2*, 188-191.
9. Chaabouni, R., & Bouzaiane, L. (2020). Tunisian National Innovation System futures: an actors’ analysis focus. *foresight*, *22*(3), 273-286.

ISSN: 2961-6611

10. Cornell University, INSEAD, WIPO. (2014). The Global Innovation Index 2014. Geneva: The Human Factor in Innovation.
11. Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (Eds.). (2018). *The global innovation index 2018: Energizing the world with innovation*. WIPO.
12. Economic and Social Commission for Western Asia (ESCWA). "The Innovation Landscape in Arab Countries: A Critical Analysis," E/ESCWA/TDD/2017/Technical Paper 1, 2017.
13. Edquist, C. (Ed.). (1997). *Systems of innovation: technologies, institutions, and organizations*. Psychology Press.
14. Erzurumlu, S. S., Erzurumlu, Y. O., & Yoon, Y. (2022). National innovation systems and dynamic impact of institutional structures on national innovation capability: A configurational approach with the OKID method. *Technovation*, *114*, 102552.
15. European Commission. (2019). European Innovation Scoreboard 2019 - Methodology Report. Maastricht Economic and Social Research Institute on Innovation and Technology – MERIT
16. European Commission. (2021). Horizon Europe: Strategic plan 2021–2024. Publications Office of the European Union.
17. European Commission. (2023a). European Innovation Scoreboard 2023. Publications Office of the European Union.
18. European Commission. (2023b). Single Market Scoreboard 2023. Publications Office of the European Union.
19. Eurostat. (2024a). Gross domestic expenditure on R&D [Data set]. Retrieved April 20, 2024, from https://ec.europa.eu/eurostat/databrowser/view/rd_e_gerdtot__custom_3417336/default/table?lang=en
20. Eurostat. (2024b). Innovation statistics [Data set]. Community Innovation Survey. Retrieved April 20, 2024, from https://ec.europa.eu/eurostat/web/science-technology-innovation/data/database
21. Feng, W., Reich, R. W., & Sheng, S. Y. (2018). Factors of Global Innovation Index.
22. Flamand, M., Frigant, V., & Miollan, S. (2025). Knowledge production in technological innovation system: A comprehensive evaluation using a multi-criteria framework based on patent data—a case study on hydrogen storage. *World Patent Information*, *80*, 102337.

ISSN: 2961-6611

23. Freeman, C. (1987). Technology policy and economic performance/C. *London: London Printer*.
24. Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. *Research policy*, *31*(6), 899-933.
25. Gregersen, B., & Johnson, B. (1997). Learning economies, innovation systems and European integration. *Regional studies*, *31*(5), 479-490.
26. Hilbert, M., & López, P. (2011). The world’s technological capacity to store, communicate, and compute information. *science*, *332*(6025), 60-65.

https://www.globalinnovationindex.org/gii-2020-report

27. Hu, M. C., & Mathews, J. A. (2005). National innovative capacity in East Asia. *Research policy*, *34*(9), 1322-1349.
28. Hu, M. C., & Mathews, J. A. (2008). China's national innovative capacity. *Research policy*, *37*(9), 1465-1479.
29. Huang, Y., Li, S., Xiang, X., & Huang, L. (2024). Analyzing the configuration of the National Innovation System for Innovation Capability: evidence from Global Innovation Index reports. *Humanities and Social Sciences Communications*, *11*(1), 1-13.
30. INSEAD (2020). Global Innovation Index 2020. INSEAD.
31. Invest Europe. (2023). Investing in Europe: Private equity activity 2022. Invest Europe.
32. Khedhaouria, A., & Thurik, R. (2017). Configurational conditions of national innovation capability: A fuzzy set analysis approach. *Technological Forecasting and Social Change*, *120*, 48-58.
33. Lee, K., Lee, J., & Lee, J. (2021). Variety of national innovation systems (NIS) and alternative pathways to growth beyond the middle-income stage: Balanced, imbalanced, catching-up, and trapped NIS. *World Development*, *144*, 105472.
34. Lee, S., Lee, H., & Lee, C. (2020). Open innovation at the national level: Towards a global innovation system. *Technological Forecasting and Social Change*, *151*, 119842.
35. Lu, H., Du, D., & Qin, X. (2022). Assessing the dual innovation capability of national innovation system: Empirical evidence from 65 countries. *Systems*, *10*(2), 23.
36. Lu, Q., & Chesbrough, H. (2022). Measuring open innovation practices through topic modelling: Revisiting their impact on firm financial performance. *Technovation*, *114*, 102434.
37. Lundvall, B. Å. (2016). 31. Innovation systems and development: history, theory and challenges.

ISSN: 2961-6611

38. Ma, X., Yao, X., & Xi, Y. (2009). How do interorganizational and interpersonal networks affect a firm's strategic adaptive capability in a transition economy?. *Journal of Business Research*, *62*(11), 1087-1095.
39. Machlup, F., & Penrose, E. (1950). The patent controversy in the nineteenth century. *The Journal of Economic History*, *10*(1), 1-29.
40. Magnitt. (2023). MENA Venture Investment Report: H1 2023. Magnitt.
41. Malik, S. (2020). Macroeconomic determinants of innovation: Evidence from Asian countries. *Global Business Review*, 0972150919885494.
42. Malik, T. H., Xiang, T., & Huo, C. (2021). The transformation of national patents for high-technology exports: Moderating effects of national cultures. *International Business Review*, 30(1), 101771.
43. Menna, A., Walsh, P. R., & Ekhtari, H. (2019). Identifying enablers of innovation in developed economies: A National Innovation Systems approach. *Journal of Innovation Management*, *7*(1), 108-128.
44. Metcalfe, S., & Ramlogan, R. (2008). Innovation systems and the competitive process in developing economies. *The Quarterly review of economics and finance*, *48*(2), 433-446.
45. Morrar, R. (2018). Innovation in the MENA Region. *Strategic Sectors| Economy & Territory*.
46. Morrar, R., Abdeljawad, I., Jabr, S., Kisa, A., & Younis, M. Z. (2019). The role of information and communications technology (ICT) in enhancing service sector productivity in Palestine: An international perspective. *Journal of Global Information Management (JGIM)*, *27*(1), 47-65.
47. Mu, R., & Fan, Y. (2011). Framework for building national innovation capacity in China. *Journal of Chinese Economic and Business Studies*, *9*(4), 317-327.
48. Mu, R., Chi, K., & Chen, K. (2019). National innovation capacity index: A cross-country comparative analysis. *Innovation and Development Policy*, *1*(2), 132-158.
49. Mu, R., Ren, Z., Song, H., & Chen, F. (2010). Innovative development and innovation capacity-building in China. *International Journal of Technology Management*, *51*(2-4), 427-452.
50. Natário, M. M., Couto, J. P., Tiago, M. T., & Braga, A. (2011). Evaluating the determinants of national innovative capacity among European countries. *Global Journal of Management and Business Research*, 11(11), 67-78.

ISSN: 2961-6611

51. Naude, W., Szirmai, A., & Goedhuys, M. (2011). *Innovation and entrepreneurship in developing countries*. UNU.
52. Nelson, R. R. (1993). *National innovation systems: A comparative analysis*. Oxford University Press.
53. Nelson, R. R. (2008). Economic development from the perspective of evolutionary economic theory. *Oxford development studies*, *36*(1), 9-21.
54. Novillo-Villegas, S., Ayala-Andrade, R., Lopez-Cox, J. P., Salazar-Oyaneder, J., & Acosta-Vargas, P. (2022). A roadmap for innovation capacity in developing countries. *Sustainability*, 14(11), 6686.
55. OECD. (1997). National Innovation Systems. Paris : OECD.
56. OECD. (2023a). OECD science, technology and innovation outlook 2023. OECD Publishing. https://doi.org/10.1787/sti_outlook-2023-en
57. OECD. (2023b). Education at a glance 2023: OECD indicators. OECD Publishing. https://doi.org/10.1787/eag-2023-en
58. Porter, M and Stern, S (1999). The New Challenge to America's Prosperity: Finding from the Innovation Index. Council on Competitiveness, Washington, D.C., March
59. Porter, M. E., & Stern, S. (2001). National innovative capacity. *The global competitiveness report*, *2002*, 102-118.
60. Proksch, D., Haberstroh, M. M., & Pinkwart, A. (2017). Increasing the national innovative capacity: Identifying the pathways to success using a comparative method. *Technological Forecasting and Social Change*, *116*, 256-270.
61. Resta, E., Laureti, L., Costantiello, A., Anobile, F., & Leogrande, A. (2024). The Impact of Patent Applications on Technological Innovation in European Countries. *International Journal of Entrepreneurship*, *28*(3,), 1-15.
62. Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), S71-S102.
63. Samoilikova, A. (2020). Financial policy of innovation development providing: The impact formalization. *Financial Markets, Institutions and Risks*, 4(2), 5-15.
64. Santana, N. B., Mariano, E. B., Camioto, F. D. C., & Rebelatto, D. A. D. N. (2015). National innovative capacity as determinant in sustainable development: a comparison between the BRICS and G7 countries. *International Journal of Innovation and Sustainable Development*, *9*(3-4), 384-405.
65. Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research policy*, *47*(9), 1554-1567.

ISSN: 2961-6611

66. Sener, S., & Delican, D. (2019). The causal relationship between innovation, competitiveness and foreign trade in developed and developing countries. *Procedia Computer Science*, 158, 533-540.
67. Shannon, C. E. (1948). A mathematical theory of communication. *The Bell system technical journal*, *27*(3), 379-423.
68. Smith, K. (2006). Measuring innovation.
69. Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics*, *39*(3), 312-320.
70. Suarez-Villa, L. (1990). Invention, inventive learning, and innovative capacity. *Behavioral Science*, *35*(4), 290-310.
71. Tellis, G. J., Eisingerich, A. B., Chandy, R. K., & Prabhu, J. C. (2008). Competing for the future: Patterns in the global location of R&D centers by the world's largest firms. *ISBM Report*, *6*.
72. Temiz, D., & Gökmen, A. (2014). FDI inflow as an international business operation by MNCs and economic growth: An empirical study on Turkey. *International Business Review*, *23*(1), 145-154.
73. Terzić, L. (2017). The role of innovation in fostering competitiveness and economic growth: Evidence from developing economies. Comparative Economic Research. Central and Eastern Europe, 20(4), 65-81.
74. UN ESCWA. (2022). Arab Horizon 2045: Pathways to a resilient and sustainable future. United Nations Economic and Social Commission for Western Asia.
75. UNESCO Institute for Statistics. (2023). R&D expenditure database [Data set]. Retrieved April 20, 2024, from http://data.uis.unesco.org/
76. UNICEF & ILO. (2022). More than a billion reasons: The urgent need to build universal social protection for children. UNICEF and International Labour Organization.
77. Varsakelis, N. C. (2006). Education, political institutions and innovative activity: A cross-country empirical investigation. *Research policy*, *35*(7), 1083-1090.
78. Voutsinas, I., Tsamadias, C., Carayannis, E., & Staikouras, C. (2018). Does research and development expenditure impact innovation? Theory, policy and practice insights from the Greek experience. *The Journal of Technology Transfer*, 43, 159-171.
79. Walter, C. E., Ferreira Polónia, D., Au-Yong-Oliveira, M., Miranda Veloso, C., Santos Leite, R. Â., & Aragão, I. (2021). Drivers of innovation capacity and consequences for

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open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, 7(2), 140.

80. Wang, J. Z., Feng, G. F., & Chang, C. P. (2024). How does political instability affect renewable energy innovation?. *Renewable Energy*, 120800.
81. Watkins, A., Papaioannou, T., Mugwagwa, J., & Kale, D. (2015). National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: A critical review of the literature. *Research policy*, *44*(8), 1407-1418.
82. Weerasinghe, R. N., Jayawardane, A. K. W., & Huang, Q. (2024). Critical inquiry on National Innovation System: Does NIS fit with developing countries?. *Sustainable Technology and Entrepreneurship, 3*(1), 100052.
83. World Bank. (2023a). Worldwide governance indicators 2023 update. The World Bank. https://info.worldbank.org/governance/wgi/
84. World Bank. (2023b). Digital RIQ: A regional initiative for digital transformation in the Middle East and North Africa. The World Bank.
85. Wu, J., Ma, Z., & Zhuo, S. (2017). Enhancing national innovative capacity: The impact of high-tech international trade and inward foreign direct investment. *International Business Review*, *26*(3), 502-514.
86. Yu, X., Paudel, K. P., Li, D., Xiong, X., & Gong, Y. (2020). Sustainable collaborative innovation between research institutions and seed enterprises in China. *Sustainability*, *12*(2), 624.
87. Zhang, M., Zhu, X., & Liu, R. (2024). Patent length and innovation: Novel evidence from China. *Technological Forecasting and Social Change*, *198*, 123010.

8. Appendix

<u>Appendix 1</u>

National innovation strategies are detailed for five countries (Egypt, Morocco, Tunisia, Jordan, Saudi Arabia) because they have documented and recent innovation policies. Countries without available data or without formalized strategies, such as Djibouti, and Malta, are not included in the main analysis.

In order to create a supportive environment for scientific research, innovation, and technology, Egypt’s Ministry of Higher Education and Scientific Research inaugurate the National Strategy for Science, Technology, and Innovation 2015–2030 in 2015. The main objective was to build an innovation system that links the economic, educational, and research

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sectors in order to translate research discoveries into fresh inventions and enhance NIC in Egypt.

Following regional (MENA region) and international trends, Morocco started working on its National Innovative Capacity (NIC) in the late 1990s. The main objective was to promote economic growth through innovation and scientific research. Additionally, the Morocco Innovation Initiative was launched in 2009 by the Moroccan Ministry of Trade, Industry, and New Technologies with the goals of fostering an innovative and entrepreneurial culture, increasing the competitiveness of the Moroccan economy, and enhancing R&D in Moroccan universities (ESCWA 2017).

Early on, Tunisian policymakers recognized the value of innovation, research, and technology. A comprehensive framework has been established over the past four decades to support innovation, create specialized programs that integrate science, R&D, and economic growth, and advance a new entrepreneurial culture (Chaabouni and Bouzaiane 2020). The Secretary of State for Scientific Research and Technology (SERST), the Higher Council for Scientific Research and Technology (HCSRT), the Grant for Investments in R&D (PIRD), the National Program for Technology Parks, and the National Research and Innovation Program were just a few of the organizations Tunisia established to support the nation’s innovation and scientific research policies (Chaabouni 2008).

The National Innovation Strategy 2013-2017 was produced by Jordan’s Higher Council for Science and Technology in 2013 as part of the nation’s efforts to develop an innovation-based economy, with assistance from the World Bank and the Korean Development Institute. The main objectives are to promote an innovation and R&D culture, enhance specialized human resources, and foster an entrepreneurial environment.

The National Policy for Science, Technology, and Innovation was launched by the Saudi Council of Ministries in 2002 with the audacious goal of transforming Saudi Arabia into a knowledge-based economy. In 2016, with "Vision 2030", Saudi Arabia set out to create a competitive and dynamic non-oil economy. Innovation, entrepreneurship, and advanced technology are prioritized in Vision 2030.

Israel’s science and technology sector is one of the most developed in the world. In 2021, Israel spent 5.557 percent of its GDP on civil research and development, the highest percentage in the world[6].

<u>Appendix 2</u>

[6] "Research and development (R&D) - Gross domestic spending on R&D - OECD Data". *data.oecd.org*. Retrieved 2022-02-10.

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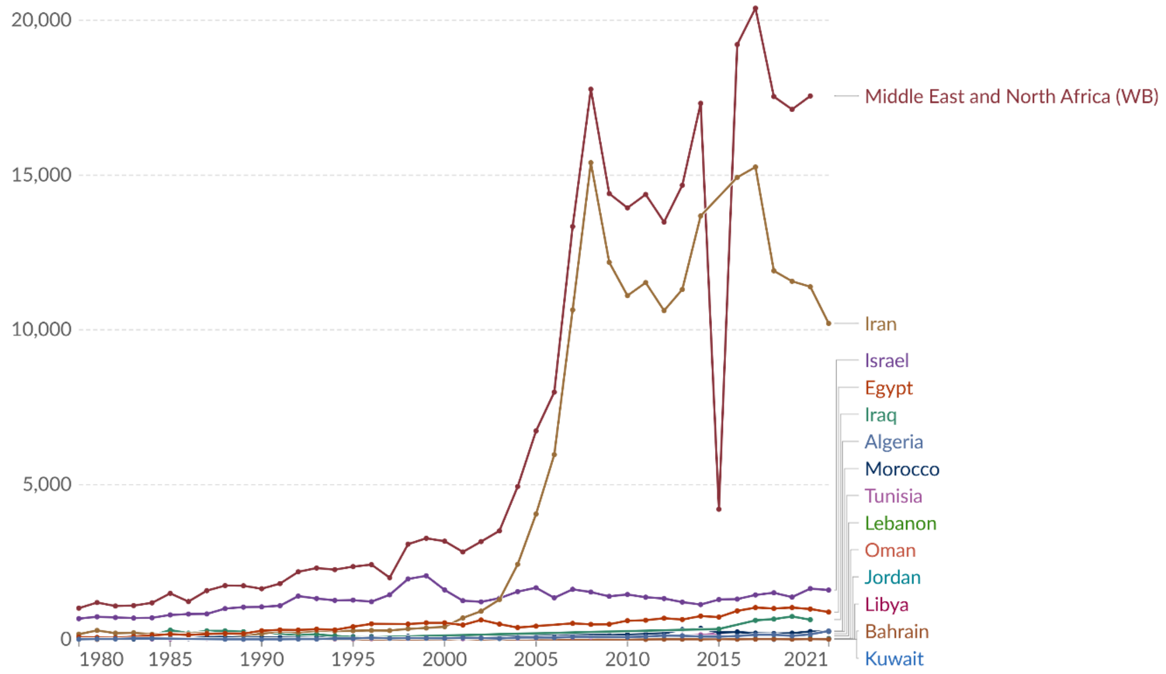
For measuring innovation capacity, patents are a commonly used indicator, since the ability to patent an invention is a clear sign of successful innovation activity (Lee et al. 2021; Ma et al. 2009; Varsakelis 2006). However, the number of patent applications is inherently biased for several reasons. Not all patent filings hold the same value—some lead to granted rights, while others are never examined (Walter et al. 2021;Voutsinas et al. 2018). Additionally, innovative actors differ in their capacity to file patents; some allocate substantial resources to amass large portfolios of marginal or non-essential patents. Consequently, relying solely on the number of patent filings may distort the true extent of investment in knowledge production, potentially leading to an over estimation of inventive efforts (Flamand et al.2025).

According to the statistics of the World Bank, the number of patent applications in recent years has witnessed noticeable fluctuations. Figure 1 shows that there has been an increase in the number of patent applications in 2020 by 428 patent compared to 2019, while in 2018, the number was 17,542. This inconstancy is the result of political instability in the countries forming the MENA region as well as the COVID-19 pandemic.

Figure 1. Annual patent applications



Note: *Each country's data includes patent applications for which the first-named applicant is a country resident.*
Source: *Done by the author, data from World Bank (2024).*

Patent applications show innovation output disparities between countries (Figure 1). While Iran has the lion's share in the number of applications (65%), other countries have a mediocre share (Israel, Egypt and Iraq) or even a negligible one (Oman, Bahrain…etc.).

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In order to close the innovation gap by creating effective policies, it is necessary to identify the factors that drive innovation. This is due to differences in the innovative output of different nations and areas. In consideration of these circumstances, the purpose of this research is to look into the important macroeconomic factors that influence innovation in countries, MENA countries in particular.

Appendix 3

Table 1: Overview of National Innovative Capacity (NIC) Indicator Systems and Models

Indicator/Model	Focus/Description	Key Components	Key References
National Innovation Systems (NIS)	A framework for understanding how public and private entities interact to drive innovation within a country.	Actors, Institutions, Networks, Knowledge Exchange, and Innovation Process	Freeman (1987), Lundvall (2016), Edquist (1997)
National Innovative Capacity (NIC)	Measures the ability of a country to produce and commercialize innovative technology over the long term, focusing on the performance and potential of innovation systems.	Innovation Input, Innovation Output, Innovation Effectiveness, and Innovation Outcome	Furman et al. (2002), Balzat and Hanusch (2004)
National Innovation Capacity Index (NICI)	A framework for assessing NIC with two sub-indexes: innovation strength and innovation effectiveness.	Innovation Strength, Innovation Effectiveness	Mu et al. (2010)
European Innovation Scoreboard (EIS)	A benchmarking tool for EU Member States that compares innovation performance across countries, focusing on research, innovation, and enterprise.	27 Indicators across 10 innovation dimensions (e.g., enterprise innovation, social impacts)	European Commission (2019)
Global Innovation Index (GII)	Provides detailed innovation measures for 129 economies, focusing on input and output factors that enable and result from innovative activities.	Innovation Input Sub-Index (e.g., R&D expenditure) and Innovation Output Sub-Index (e.g., patent applications)	Cornell University et al. (2014)
National Innovation Index (NII-CASTED)	Measures national innovation capacity in China based on five pillars, including innovation resources and knowledge	Innovation Resources, Knowledge Creation, Enterprise Innovation, Innovation Performance, Innovation Environment	Chinese Academy of Science and Technology for Development

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Indicator/Model	Focus/Description	Key Components	Key References
	creation.		
Global Competitiveness Index (GCI)	A comprehensive assessment of national competitiveness, where NIC is measured as part of the overall competitiveness framework.	Interaction and Diversity, R&D, Commercialization	World Economic Forum (2017)
National Innovation Index (Porter & Stern)	An index focusing on the infrastructure, clusters, and linkages that drive national innovation output.	Quality of Innovation Infrastructure, Cluster-Specific Environment, Quality of Linkages	Porter and Stern (1999)
Entropy-Based NIC Index	A novel entropy-based NIC index that uses information theory to determine weights for each indicator, offering a statistically robust assessment of innovation capacity.	Uses entropy method to assign weights based on the degree of variation and informational value of each indicator	(Proposed in the current study)
Various Macro-Level Innovation Factors	Broader factors influencing national innovation growth, such as R&D expenditure, regulatory efficiency, political environment, and managerial capacity.	R&D Expenditure, Public and Private Funding, Regulatory System, Governance, Managerial Capacity	Boldrin and Levine (2002), Samoilikova (2020), Sener and Delican (2019), Angelo et al. (2022)

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Appendix 4

Table 2. Weights of indicators in each of National Innovation Capacity variables

Country	Algeria	Bahrain	Egypt	UAE	Iraq	Iran	Israel	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Qatar	Saudi	Syria	Tunisia	Yemen
EXP(gdp)	0,0326	0,0398	0,0473	0,0496	0,1899	0,0195	0,0614	0,0308	0,0651	0,0216	0,0225	0,0233	0,0350	0,0428	0,0445	0,0910	0,0214	0,0409
EXP(gov)	0,0337	0,0301	0,0861	0,0355	0,0118	0,0294	0,1135	0,0679	0,0324	0,0237	0,0193	0,1041	0,0308	0,0304	0,0465	0,0460	0,0303	0,0419
R&D	0,0392	0,0671	0,0521	0,0415	0,0239	0,0368	0,0680	0,0531	0,2312	0,1244	0,0247	0,0786	0,0448	0,0308	0,0461	0,0428	0,0641	0,0289
R&D(exp)	0,0175	0,0395	0,1111	0,0969	0,0935	0,0325	0,0590	0,1073	0,0547	0,0757	0,1123	0,0958	0,0516	0,0341	0,0482	0,1947	0,0296	0,1314
PAT	0,3068	0,2419	0,1645	0,1418	0,2677	0,2064	0,1450	0,1869	0,1273	0,0902	0,3587	0,0923	0,2390	0,2252	0,1999	0,1989	0,2026	0,4198
PAT (res)	0,0633	0,0791	0,0395	0,0512	0,0979	0,0569	0,0366	0,0858	0,0556	0,0449	0,0849	0,0602	0,0641	0,0462	0,0364	0,0653	0,0586	0,0440
PAT(n.res)	0,0568	0,1839	0,0336	0,0936	0,0894	0,1448	0,0324	0,0384	0,0711	0,0526	0,1010	0,0463	0,0575	0,1303	0,0958	0,0522	0,0652	0,0585
POP	0,0298	0,0705	0,0540	0,0771	0,0450	0,0257	0,0776	0,0615	0,0623	0,0817	0,0237	0,0489	0,0432	0,0777	0,0395	0,0479	0,0342	0,0369
TR	0,0216	0,0509	0,0575	0,0760	0,0463	0,0200	0,0820	0,0234	0,0291	0,0393	0,0280	0,1062	0,0508	0,0209	0,0364	0,0279	0,0337	0,0442
H-TECH	0,0638	0,0972	0,0662	0,1364	0,0089	0,1189	0,0539	0,1067	0,1537	0,0811	0,1471	0,0781	0,0640	0,1895	0,0370	0,0364	0,2268	0,0505
JOR	0,1336	0,0829	0,1537	0,1059	0,0899	0,1743	0,0949	0,1502	0,0408	0,0874	0,0589	0,1518	0,0938	0,1244	0,1487	0,0998	0,1610	0,1069
IPP	0,2297	0,1925	0,0318	0,1797	0,1043	0,1227	0,1412	0,1214	0,1457	0,2855	0,0314	0,1057	0,2445	0,1570	0,1996	0,0994	0,1298	0,0080
IPR	0,1753	0,1381	0,0226	0,1253	0,0499	0,0683	0,0868	0,0670	0,0913	0,2311	0,0230	0,0513	0,1901	0,1026	0,1452	0,0450	0,0754	0,0064
UNEMP	0,0426	0,0223	0,0887	0,0218	0,0120	0,0843	0,0572	0,0237	0,0144	0,0462	0,1486	0,0684	0,0421	0,0108	0,0787	0,0622	0,0185	0,0140
CONS	0,0492	0,0652	0,0869	0,0379	0,1067	0,1295	0,0463	0,0670	0,0434	0,0432	0,0250	0,0468	0,0604	0,0564	0,0749	0,0530	0,0479	0,0767
ABINT	0,1622	0,1462	0,1588	0,1296	0,1890	0,1495	0,1561	0,1645	0,1735	0,1466	0,1672	0,1591	0,1802	0,1581	0,1330	0,1860	0,1759	0,1825
ABTEL	0,1779	0,1127	0,1848	0,1102	0,1678	0,1654	0,1172	0,1655	0,1445	0,1033	0,1874	0,1374	0,1559	0,1283	0,1275	0,1855	0,1771	0,1612
IHD	0,0405	0,0707	0,0468	0,0363	0,0504	0,0399	0,0398	0,0653	0,0393	0,0576	0,0446	0,0608	0,0423	0,0813	0,0243	0,0451	0,0671	0,1335
ID	0,1405	0,0853	0,1274	0,2004	0,2017	0,1074	0,1768	0,0988	0,1076	0,1782	0,0986	0,0927	0,0695	0,0695	0,2354	0,1199	0,1163	0,0938

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IPF	0,0465	0,0767	0,0528	0,0423	0,0564	0,0459	0,0458	0,0713	0,0453	0,0636	0,0506	0,0668	0,0483	0,0873	0,0303	0,0511	0,0731	0,1395
SPAV	0,0457	0,0759	0,0520	0,0415	0,0556	0,0451	0,0450	0,0705	0,0445	0,0628	0,0498	0,0660	0,0475	0,0865	0,0295	0,0503	0,0723	0,1387
V&R	0,0079	0,0381	0,0142	0,0037	0,0178	0,0073	0,0072	0,0327	0,0067	0,0250	0,0120	0,0282	0,0097	0,0487	0,0083	0,0125	0,0345	0,1009
CR	0,0814	0,0262	0,0683	0,1413	0,1426	0,0483	0,1177	0,0397	0,0485	0,1191	0,0395	0,0336	0,0104	0,0104	0,1763	0,0608	0,0572	0,0347
RQ	0,0523	0,0029	0,0392	0,1122	0,1135	0,0192	0,0886	0,0106	0,0194	0,0900	0,0104	0,0045	0,0187	0,0166	0,1472	0,0317	0,0281	0,0056
L&O	0,0268	0,0570	0,0331	0,0226	0,0367	0,0262	0,0261	0,0516	0,0256	0,0439	0,0309	0,0471	0,0286	0,0676	0,0106	0,0314	0,0534	0,1198

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