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Innovation and Economic Growth in Jordan

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Abstract

In light of the pressing need to examine Jordan's progress in modernizing its economic structure and advancing along the path of technological development, this study investigates the impact of the Innovation Index on economic growth rates. The research draws upon theoretical literature and growth theories that emphasize the role of technological advancement in stimulating economic performance .Methodologically, the study employs both a descriptive-analytical approach and an econometric framework by constructing a tailored model to achieve its objectives. Several statistical tests were utilized, including the Dickey-Fuller and Phillips-Perron unit root tests for stationarity, the Johansen co-integration test for examining long-term relationships, and the Ordinary Least Squares (OLS) method for parameter estimation. The findings indicate that growth in capital accumulation, labor force expansion, and innovation all exert a positive and statistically significant impact on Jordan's economic growth. Conversely, the results reveal a negative relationship between trade openness growth and economic growth in Jordan. The study recommends that policymakers intensify efforts to foster innovation and increase investment in its key inputs, aiming to bridge the gap between innovation inputs and outputs, given its critical role in enhancing economic growth in Jordan.

Keyword: Innovation, Economic Growth, OLS

Introduction

Innovation has become increasingly critical as individual societies transition toward greater integration within a globalized world that is currently undergoing a pivotal transformation. Amid this shift, the global economy faces significant challenges while gradually adapting to new technological realities. Although the number of mobile phones now exceeds the global population, many economies continue to struggle with the widening technological gap. In this context, innovation and the transformative power of ideas serve as essential drivers of digital advancement, enabling countries to bridge disparities and elevate their economies to more advanced levels.

The global transition toward a knowledge-based and digital economy has marked a fundamental shift from reliance on natural resources, as seen during the Industrial

Revolution, to dependence on knowledge resources. Unlike tangible assets, knowledge cannot be monopolized—its origin lies in human intellect distributed across diverse geographic regions. This shift has led to an increasing global flow of innovation, facilitated by strategic investment in research and development (R&D) hubs in emerging economies. These investments aim to access cost-effective knowledge while creating job opportunities and delivering context-specific benefits. Advanced economies continue to embrace innovation to correct structural imbalances, particularly in light of the lingering effects of recent financial and economic crises. At the same time, emerging economies must invest in innovative infrastructure to build resilience and sustain growth amid external shocks.

The digital economy and the innovation ecosystem have emerged as essential pathways for addressing evolving market needs more efficiently, particularly in an era dominated by advanced technologies (WIPO, 2021). These systems have become powerful engines for driving development and reshaping economic growth models. According to a United Nations World Trade Organization report, the digital economy accounts for approximately 4.5% to 15.4% of global GDP. Notably, China and the United States together contribute around 40% of the world's total digital added value (WIPO, 2021).

Jordan, like many countries in the region, faces a range of domestic and regional challenges that adversely affect its economic performance indicators. In response, successive governments have implemented economic reform programs aligned with royal visions aimed at modernizing the economic structure and enhancing national economic performance. In recent years, Jordan has shown increasing commitment to building an innovation-driven infrastructure to address these obstacles and stimulate sustainable growth. These efforts have contributed to moderating inflation and unemployment, despite fluctuations in growth rates—particularly following Jordan's decline in the 2023 Global Competitiveness Report, where it fell out of the top 50 countries.

Motivation and Contribution of the Study

The motivation behind this study stems from the growing recognition of innovation as a critical driver of economic development, particularly in emerging economies like Jordan. As the country strives to modernize its economic infrastructure and integrate more deeply into the global economy, understanding the relationship between innovation and economic growth becomes paramount. This study addresses a significant gap in the literature by examining the impact of the Global Innovation Index on economic growth in Jordan, a country that is increasingly committed to enhancing its innovation ecosystem.

The contribution of this study lies in its comprehensive analysis of the role of innovation in economic growth in Jordan, using both theoretical frameworks and econometric modeling. By incorporating variables such as capital formation, labor force expansion, trade openness, and innovation inputs and outputs, the study provides a nuanced understanding of how these factors interact to shape economic performance. Furthermore, the study offers valuable insights for policymakers seeking to enhance innovation-driven growth in Jordan, making it a timely and relevant contribution to the field of economic development and innovation studies.

Literature Review

Many empirical studies have investigated the impact of innovation on economic growth in both developed and developing countries. These studies often utilize various innovation indicators, such as research and development expenditures, patents, utility models, and high-technology exports, to measure innovation capacity and output. For instance, Bayarcelik (2012) emphasized that R&D expenditures and the number of R&D employees are key indicators of innovation. Hasan and Tucci (2010) demonstrated that countries with higher growth rates are typically those with a larger number of patents, indicating the importance of intellectual property in driving innovation-led growth. Furthermore, Kim et al. (2012) highlighted the significant role of utility models in enabling developing countries to enhance innovation capacity and competitiveness.

Technological exports and publications in peer-reviewed scientific journals have also been widely used as indicators of innovation activity. Avila-Lopez et al. (2019) employed these measures to assess innovative performance across countries and found them to be effective proxies for innovation output. Meanwhile, Torun and Çiçekci (2007) linked innovation to economic growth by referring back to classical economic thought. They cited Adam Smith's view that technological improvements in capital operations contribute to the creation of added economic value and confer competitive advantage through better resource allocation. The Global Innovation Index (GII) has become an essential tool for assessing innovation capacity and its relationship to economic performance. The GII comprises more than 80 indicators categorized into seven key dimensions: institutions, human capital, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs. Bayarçelik and Tasel (2012) found that while R&D spending had a positive effect on Turkish economic growth, patent activity showed a negative correlation. This suggests that the effect of innovation is context-dependent and may vary across different economies.

Similarly, Saini and Jain (2011) pointed out the substantial contributions of innovation to economic growth in technologically advanced countries. In Japan, Khalili et al. (2016) discovered that patents did not significantly contribute to gross domestic product, although they played a role in enhancing manufacturing processes. This suggests that the benefits of innovation may be externalized or may not directly translate into national output, especially when innovation activities rely heavily on international knowledge spillovers.

Growth theory literature has also emphasized the importance of not only generating innovation but also building the capacity for continued innovative activities. As highlighted by WIPO (2024), empirical studies should consider the stock of knowledge, not just its immediate output, when evaluating the impact of innovation on growth. The capacity to sustain innovation over time is essential for ensuring that its benefits contribute to long-term economic development.

Innovation in Jordan

Jordan is striving to achieve an advanced ranking in innovation indicators. According to the Global Innovation Index 2024, Jordan ranked 73rd globally and 8th in the Arab world. However, it still lags behind Gulf countries such as Saudi Arabia and the UAE, which are ranked 32nd globally. Jordan has achieved this ranking following efforts launched by the Jordanian

government to enhance innovation indicators, driven by the need to transition to a knowledge-based economy and overcome the obstacle of limited resources.

Jordanian Innovation Inputs

When we move on to discuss the inputs of Jordanian innovation according to the Global Innovation Index report, we find that the political environment index. Within the institutions axis, an improvement was noted, reaching 51.9 points in 2024, compared to 45.1 points in the previous year. The government effectiveness indicators, which reflect perceptions of the quality of public services, the quality of the civil service, its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to them, also showed an index of 0.19 in 2022, a decrease of 0.41% from the previous year, equivalent to an index rank of 56. The regulatory quality index, which reflects the government's ability to formulate and implement effective policies and regulations that enable and enhance private sector development, showed an index of 0.16 in 2022, an increase of 16.74% from the previous year, equivalent to an index rank of 65. The rule of law index, which reflects perceptions of the extent of trust and commitment of agents to societal rules, particularly the quality of contract enforcement, property rights, the police and courts, as well as the likelihood of crime and violence, showed an index of 0.22 in 2022, an increase of 0.22. The Ease of Starting a Business Index, which measures the extent to which the government ensures a stable political environment for doing business, was equivalent to a survey score of 4.96 in 2023, an increase of 13.9% over the previous year, equivalent to an index rank of 30 (WIPO,2023).

The human capital and research axis decreased by less than one point during the year 2024, and the education spending index, which indicates the total general government spending (local, regional, and central) on education (current, capital, and transfers), was expressed as a percentage of GDP. Spending financed by international transfers to the government grew at an annual rate of 3.24% of GDP in 2022, an increase of 0.02 percentage points from the previous year, corresponding to an index rank of 98. The government student/secondary finance index as a percentage of GDP per capita, which measures the average total general government spending (current, capital, and transfers) per student at the secondary level, expressed as a percentage of GDP per capita, grew at a rate of 16.63% in 2022, a decrease of 0.51 percentage points from the previous year, corresponding to an index rank of 63. The PISA reading and mathematics scales index, which is constructed using average reading, mathematics, and science scores for each country, is based on the variance in observed results across all test participants in a country. In theory, there is no minimum or maximum score in PISA; Instead, scores are scaled to fit approximately normal distributions, with means of about 500 score points and standard deviations of about 100 score points. China did not participate in the 2022 PISA survey. As a result, China's scores are consistent with the 2018 PISA results and are based only on the provinces/municipalities of Beijing, Shanghai, Jiangsu, and Zhejiang. Azerbaijan's 2022 scores are consistent with only the capital city of Baku, with an average performance score of 359.31 in 2022, a 13.63% decrease from the previous year and equivalent to an index rank of 8, (WIPO.2023).

The student-teacher ratio at the secondary level indicates the number of students enrolled in secondary education divided by the number of secondary education teachers (regardless of their teaching duties). If data for the secondary education level as a whole are not available,

the upper secondary level ratios are included; if they are also unavailable, the lower secondary level ratios are included. A high student-teacher ratio indicates that each teacher is responsible for a large number of students. In other words, the higher the student-teacher ratio, the less access students have to teachers. The student-teacher ratio was 15.13 in 2022, a decrease of 1.56% from the previous year—equivalent to an index rank of 77. (WIPO,2023). The tertiary education enrollment index also indicates the ratio of total enrollment in tertiary education, regardless of age, to the population of the age group officially corresponding to the level of tertiary education. Tertiary education, whether at the advanced research level or not, typically requires successful completion of secondary education as a minimum requirement for admission? School enrollment can exceed 100% due to grade repetition, the inclusion of underage and overage students, and whether they enter early or late. The total growth rate reached 36.009% in 2022, an increase of 2.52 percentage points over the previous year, equivalent to an index rank of 85. The science and engineering graduates index, which indicates the share of all tertiary graduates in natural sciences, mathematics, statistics, information technology, manufacturing, engineering, and construction as a percentage of all tertiary graduates, saw the proportion of new graduates reaching 27.16% of the total graduates in 2022, an increase of 0.3 percentage points over the previous year—equivalent to an index rank of 36. The number of students enrolled in education from abroad index, which indicates the number of students from abroad studying in a given country as a percentage of the total tertiary enrollment in that country, saw a growth rate of 10.76% in 2022, a decrease of 1. This increased by 1.57 percentage points compared to the previous year, equivalent to an index rank of 23. (WIPO,2023).

The researchers per million people indicator, which refers to researchers in the field of research and development (R&D), is a professional working to create or develop new knowledge. They conduct research and improve or develop concepts, theories, models, technologies, hardware, software, and operating methods. The full employment rate reached 577.92 per million people in 2017, an increase of 0.45% compared to the previous year, equivalent to an index rank of 67. The gross expenditure on research and development (GERD) indicator also indicates total domestic spending on research and development over a given period as a percentage of GDP. "Internal R&D expenditure," which is all spending on research and development conducted within a statistical unit or sector of the economy during a given period, regardless of the source of funding, was equivalent to 0.7% of GDP in 2016, equivalent to an index rank of 51. (WIPO,2023).

The investment in research and development indicator, which is calculated by averaging the R&D spending of the three largest global companies, is also calculated. If a country has fewer than three listed global companies, the figure is either the average of the two listed companies or the total of one listed company. A score of zero is assigned to countries with no listed companies. The data includes economies outside the European Union. The average investment income of the top three companies was $0 million in 2023, unchanged from the previous year, corresponding to an index rank of 41.

The University Rankings Index measures the average scores of each country's top three universities. If the number of universities listed in the QS World 1000 rankings is less than three, the total scores of the listed universities are divided by three, meaning that universities not listed are assigned a score of zero. The 2024 ranking corresponds to data published in

June 2023. Note: The 2024 QS edition includes significant methodological improvements, with the addition of three new metrics: sustainability, employability outcomes, and international research network. This equates to an average score of 17.53 for the top three universities in 2023, an increase of 8.88% on the previous year, and equates to an index rank of 52. (WIPO,2023).

As for the infrastructure axis, most of its indicators were included in the report. The information and communications technology access index was included, which refers to a composite that gives weights to three information and communications technology indicators (33% for each): (1) individuals who own a mobile cell phone; (2) households with an internet connection at home; and (3) the percentage of the population covered by mobile phone networks (at least 3G, at least LTE/WiMAX). The ICT Index (3) calculates the proportion of the population covered by mobile networks (at least 3G, at least LTE/WiMAX) by assigning a 40% weight to the population covered by at least 3G networks and a 60% weight to the population covered by at least LTE/WiMAX networks. This equated to an index score of 98.43 in 2022, corresponding to an index rank of 31. (WIPO,2023).

The ICT Use Index, which is a composite index, assigns weights to five ICT indicators (20 percent each): (1) Fixed Broadband Internet Basket (% of GNI per capita); (2) Fixed Broadband Internet Traffic (GB per subscription); (3) High Mobile Data and Voice Consumption Basket (% of GNI per capita); (4) Mobile Broadband Internet Traffic within the country (GB per subscription); and (5) Active Mobile Broadband Subscriptions per 100 people. It was equivalent to an index score of 98.43 in 2022, which is equivalent to an index rank of 31.

The Online Services Index (OSI), a component of the E-Government Development Index, is a composite index that assesses the efficiency of governments' use of technology to deliver public services at the national level. It is based on a survey of national websites and e-government policies, with standard scores ranging from 0 to 1. In the 2022 edition, the E-Services Index is calculated based on five weighted sub-indices: service provision (45%), technology (5%), institutional framework (10%), content provision (5%), and e-participation (35%), with the overall score calculated based on the standard values for each sub-index. This index was equivalent to a score of 0.66 in 2022, corresponding to an index rank of 73. (WIPO,2023).

The E-Participation Index (EPI) measures citizen engagement in public policymaking through e-government programs. It complements the United Nations E-Government Survey, which assesses the extent to which governments use e-services to provide information, interact with stakeholders, and participate in decision-making. Scores range from 0 to 1, with higher scores indicating greater e-participation. The index questions are updated periodically to reflect changes in e-government trends and technologies. In the 2022 survey, the e-participation questions were expanded to reflect current trends and approaches to how governments engage their citizens in public policy making, implementation, and evaluation. This index scored 0.55 in 2022, corresponding to an index rank of 67. (WIPO,2023).

The capital formation index as a percentage of GDP, which expresses gross capital formation as the ratio of gross investment in current local currency to GDP in current local currency, is measured by the total value of gross fixed capital formation and changes in inventories and

holdings, less disposals of valuables for a unit or sector, according to the 1993 System of National Accounts. It reached approximately 16.43% of GDP in 2023, an increase of 0.03 percentage points from the previous year, equivalent to an index rank of 117. Looking at the market forces axis, we find that the value of the axis as a whole decreased for 2024 to 36.4, compared to 37.8 in 2023. One of the most prominent indicators of the market forces axis is the startup financing index, which indicates the average perception scores (five-year average) of experts in the field of financing startups and growing companies (item A1 of the Global Entrepreneurship Monitor's National Expert Survey). Experts in various fields (a purposive sample, with a minimum of 36 experts per year) assess the entrepreneurship conditions in their countries using statements (0 = completely false; 10 = completely true). Countries' participation in the GEM varies, and therefore the number of experts and years of experience on which this item is based varies by country. To be eligible for inclusion in this index, countries must have participated in the GEM survey from 2016 onwards. Participation in surveys conducted before 2016 will result in exclusion from this index. Jordan received a survey score of 4.57 in 2023, corresponding to an index rank of 38. (WIPO,2023).

The Domestic Credit to the Private Sector indicator considers domestic credit to the private sector as financial resources provided by financial companies to the private sector, such as loans, purchases of non-equity securities, trade credit, and other receivables, which create a claim for repayment. In some countries, these claims include credit to public institutions. Financial corporations include monetary authorities and deposit banks, as well as other financial corporations for which data is available (including corporations that do not allow transferable deposits but accept liabilities such as time and savings deposits). Examples of other financial corporations include finance and leasing companies, money lenders, insurance companies, pension funds, and exchange companies. The annual growth rate of this indicator reached 84.43% of GDP in 2022, an increase of 2.46 percentage points over the previous year—equivalent to an index rank of 34. (WIPO,2023).

The microfinance loans index as a percentage of GDP recorded an annual growth rate of 0.93% of GDP in 2022, an increase of 0.09 percentage points over the previous year, equivalent to an index rank of 33. The market capitalization index also refers to the share price multiplied by the number of outstanding shares (including their various categories) for listed local companies. This excludes investment funds, unit trusts, and companies whose commercial objective is limited to owning shares in other listed companies. The data represent the average end-of-year values for the past three years. The market capitalization index was equivalent to 10 venture capital deals invested in 2023, a decrease of 23.08% from the previous year, corresponding to an index rank of 45. (WIPO,2023).

The local industry diversification index, which measures the Herfindahl-Hirschman Domestic Industry Index (HHI), the sum of the squared shares of industries in total industrial output, reached 0.11 in 2021, an increase of 12.05% from the previous year, corresponding to an index rank of 38. The local market size is also measured by the GDP based on the purchasing power parity valuation of a country's GDP in current international dollars (billions of dollars). Real GDP reached US$132.09 billion in 2023, an increase of 6.37% from the previous year, corresponding to an index rank of 85. (WIPO,2023).

The last innovation input axis in Jordan was the Business Sophistication axis, which includes twelve indicators, starting with the Knowledge-Intensive Employment Index, calculated by counting people in categories 1 to 3 as a percentage of the total workforce, according to the International Standard Classification of Occupations (ISCO). The categories included in ISCO 08 are: 1. Managers; 2. Professionals; 3. Technicians and Associate Professionals. Where ISCO 08 data was not available, ISCO 88 data was used. The categories included in ISCO 88 are: 1. Legislators, senior officials, and managers; 2. Professionals; 3. Technicians and Associate Professionals. The index reached 22.1% in 2022, a decrease of 0.86 percentage points from the previous year, equivalent to an index rank of 68. (WIPO,2023).

The Companies Offering Formal Training Index measures the percentage of companies that offer formal training programs to their full-time permanent employees within the sample of companies participating in the World Bank's Enterprise Survey in each country. It reached 16.9% in 2019, an increase of 13.5 percentage points from the previous year, equivalent to an index rank of 87. This is followed by the female workers with advanced degrees index, which indicates the proportion of female employees with higher education degrees out of the total employed population. Employees include all persons of working age who, during a specific short period, were in one of the following categories: (1) paid employment; or (2) self-employment. Data are disaggregated by educational level, which refers to the highest level of completed education, classified according to the International Standard Classification of Education (ISCE). The female labor force constituted 7.99% of the total employed population in 2022, a decrease of 0.42 percentage points from the previous year, equivalent to an index rank of 85. (WIPO,2023).

The Public-Industry Collaboration Index for Scientific Research measures joint research publications between the public and private sectors as a percentage of total research publications. Research publications are limited to the following four main scientific fields: biomedical and health sciences, life and earth sciences, mathematics and computer science, and physical and engineering sciences. The definition of "private sector" includes all for-profit commercial enterprises, including manufacturing and services. This includes research institutes and R&D laboratories of other companies that are fully funded or owned by for-profit commercial enterprises. Institutions in the private education sector and private healthcare institutions (including hospitals and clinics) are not classified within the private sector. The share of scientific publications in 2023 was 0.29% of total publications, a decrease of 0.17 percentage points from the previous year, corresponding to an index rank of 116. (WIPO,2023).

Then follows the Intellectual Property Payments Index, which is calculated by taking into account fees for the use of intellectual property not listed elsewhere, i.e., payments (% of total trade), and the average of the most recent three years or the most recent year. The value is calculated according to the 2010 Extended Balance of Payments Services Classification (EBOPS), code SH: fees for the use of intellectual property not elsewhere classified, as a percentage of total trade. Total trade is defined as the sum of total imports of commercial goods and services (G) and SOX (excluding government goods and services not elsewhere classified) plus total exports of commercial goods and services (G) and SOX (excluding government goods and services not elsewhere classified), divided by 2. According to the sixth edition of the International Monetary Fund's Balance of Payments Manual, the

"goods" item includes general merchandise, net exports of commercial goods, and non-monetary gold. The "commercial services" category is defined as equal to "services" less "government goods and services not elsewhere classified." Receipts between residents and non-residents are for the use of intellectual property rights (such as patents, trademarks, copyrights, industrial processes and designs, including trade secrets and trade franchises), and for licenses to reproduce or distribute (or both) intellectual property embodied in produced assets or prototypes (such as copyrights on books, manuscripts, computer software, cinematographic works, and sound recordings), and related rights (such as live performances and television, cable, or satellite broadcasting). Their share of total trade amounted to 0.14% in 2022, a decrease of 0.01 percentage points from the previous year, corresponding to an Index rank of 97. (WIPO,2023).

Then there is the index of high-technology imports, which include high-R&D-intensive technology products, according to the Eurostat classification, which is based on the Standard International Trade Classification (SITC), Revision 4. Their share of total trade in 2022 amounted to 6.02%, a decrease of 2.25 percentage points from the previous year, equivalent to an index rank of 99. In addition, the index of imports of information and communication technology services as a percentage of total trade according to the OECD's Extended Balance of Payments Services Classification (EBOPS) 2010, coded as SI: telecommunications, computer, and information services, amounted to 0.24% of total trade in 2022, an increase of 0.02 percentage points from the previous year, equivalent to an index rank of 127. (WIPO,2023).

The last of these indicators is the index of net foreign direct investment inflows, which is the average net inflow of investment over the past three years required to acquire a permanent management stake (10% or more of the voting shares) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvested dividends, long-term capital, and short-term capital, as shown in the balance of payments. This data series shows net inflows (new investment inflows less withdrawals) into the reporting economy from foreign investors, divided by GDP. The index grew at 2.34% of GDP in 2022, an increase of 0.99 percentage points over the previous year, equivalent to an index rank of 78. (WIPO,2023).

Figure3.1 : The most prominent incomes of Jordanian innovation
Sources: Global Innovation Index

Jordanian Innovation Outputs

The Global Innovation Report describes the sixth and seventh pillars as innovation outputs. The sixth pillar, Knowledge and Technology Outputs, also saw a decline in 2024, reaching 19.6 points compared to 20.3 in 2023. Indicators for knowledge creation, knowledge impact, quality certifications (9001/billion USD of GDP), advanced technology exports as a share of total trade, and labor productivity growth all rose in 2024. The patents by origin indicator, a resident patent application, refers to an application filed with an IP office in the name of or on behalf of the first applicant's country of residence. For example, an application filed with the Jordanian Patent Office by a resident of Jordan is considered a resident application for Jordan. Measured in billions of GDP (PPP US dollars). The number of patents registered in 2022 was 25, unchanged from the previous year—equivalent to an index rank of 100. A Patent Cooperation Treaty (PCT) patent application is an international patent application filed under WIPO's Patent Cooperation Treaty (PCT). The PCT system makes it possible to seek patent protection for an invention simultaneously in multiple countries through the filing of a single international patent application. The origin of PCT applications is determined by the domicile of the first applicant. Data are available only for PCT contracting countries (156 countries to date). Data are measured by GDP (in billions) in purchasing power parity (PPP) US dollars. The total number of PCT patents registered in 2023 was 19, a decrease of 24% from the previous year, equivalent to an index rank of 54. (WIPO,2023).

The Science and Technology Articles Index includes the number of articles published in the fields of science and technology. This includes 182 different research categories belonging to

research fields including engineering, chemistry, physics, environmental sciences, computer science, mathematics, biochemistry, molecular biology, oncology, agriculture, cell biology, and many others. The number of articles is calculated from a set of journals covered by the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI). Articles are sorted by year of publication and assigned to each economy based on the address of the institution mentioned in the article. Articles are counted on a count basis (rather than a fraction)—that is, for articles in which institutions from multiple economies collaborate, each economy receives credit based on its participating institutions. Data are presented per billion dollars of GDP (Purchasing Power Parity). The total number of articles published in 2023 reached 4,460, an increase of 7.73% over the previous year, corresponding to an index rank of 12. (WIPO,2023).

The labor productivity growth index reached an annual growth rate of 0.62% in 2023, an increase of 2.45 percentage points over the previous year, corresponding to an index rank of 114. The software spending index also includes the total value of purchased or rented bundled software, such as operating systems, databases, programming tools, utilities, and applications. This does not include expenditures on internal software development. Data are estimated based on sales data for the software and services sector. Data are presented as a percentage of GDP. It was equivalent to 0.3% of GDP in 2023, a decrease of 0.01 percentage points from the previous year, and is equivalent to a rank of 34. The High-Tech Manufacturing Index, which measures high- and medium-high-tech output as a percentage of total industrial output, is based on the OECD classification for the definition of technology intensity, which is based on the International Standard Industrial Classification (ISIC) Rev. 4 and Rev. 3. The manufacturing sector's share of GDP reached 20.47% in 2021, an increase of 2.69 percentage points from the previous year, equating to an index rank of 61. This is in addition to the high-tech exports index, which reached US$262.05 million in 2022, an increase of 10.33% from the previous year, equating to an index rank of 75. The ICT services exports index, which accounted for 0.10% of total trade in 2022, a decrease of 0.07 percentage points from the previous year, equating to an index rank of 131.

Creative outputs reached their highest level in 2024, reaching 21.3 points. Among the most prominent indicators that achieved growth was the Additional Indicators by Origin Index, which remained at 0.55 thousand/million industrial designs/industrial designs in 2022, a decrease of 45.62% from the previous year, and equal to the level of 74 indicators for creative information services, in addition to the market and media index, the total output reached 489.37 million US dollars in 2023, 9.51% from the previous year, which is worth an index of 54. The Internet Creativity Index, where the number of global downloads of mobile applications reached 106.01 million in 2023, a decrease of 4.44% from the previous year, which is 26. (WIPO,2023).

Figure 3.2: The most prominent outcomes of Jordanian innovation.
Sources: Global Innovation Index .

On another note, Jordan ranks 69th this year in innovation inputs, a higher ranking than last year. It ranks 74th in innovation outputs, also a higher ranking than last year. Jordan also ranks highest in institutions (52nd), market sophistication (55th), and business sophistication (72nd). Jordan ranks lowest in infrastructure (90th), human capital and research (85th), knowledge and technology outputs, and creative outputs (76th). The chart below illustrates the relationship between innovation inputs and outputs. Economies above the line convert costly innovation investments into higher-quality outputs. (WIPO,2023).

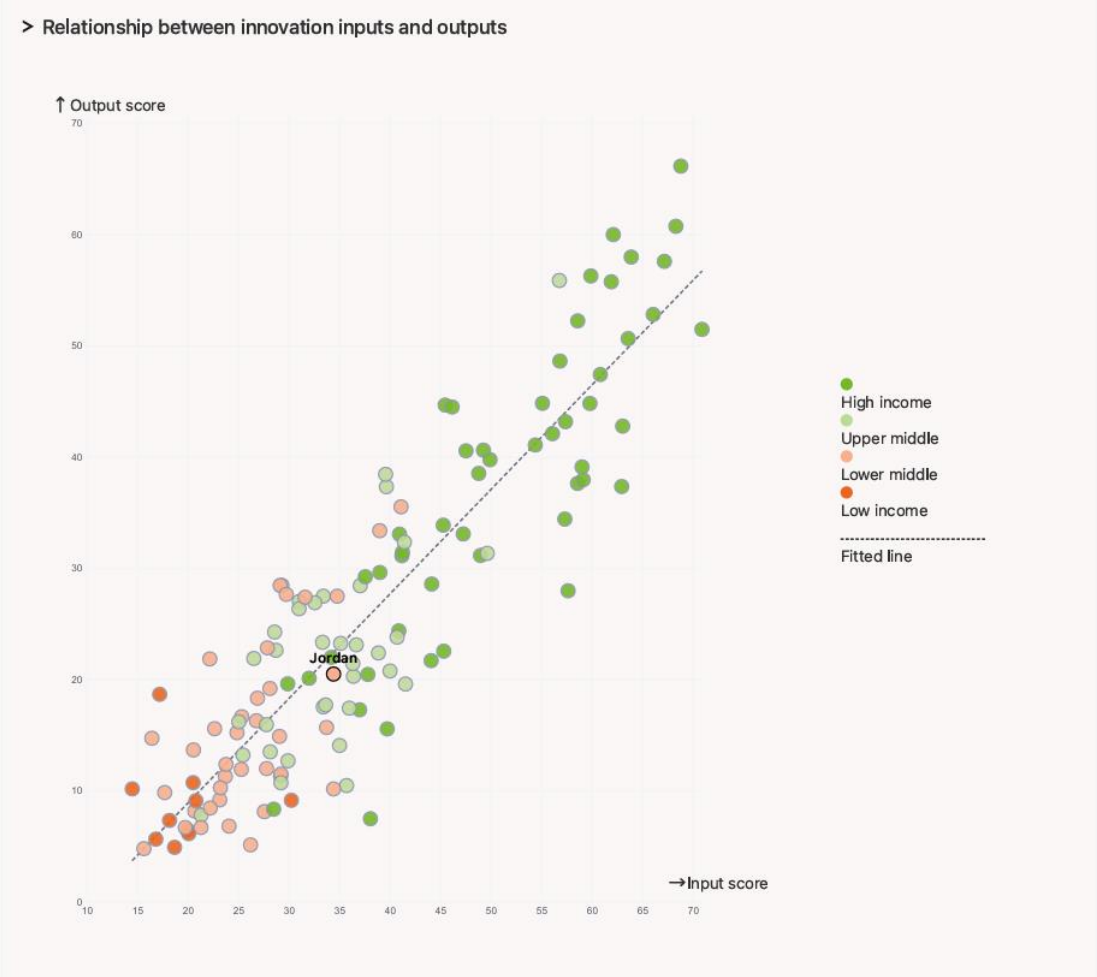

Figure 3.3 : The relationship between the inputs and outputs of Jordanian innovation.
Sources: Global Innovation Index .

When discussing the Jordanian Innovation Index in general, we find that Jordan's ranking among countries worldwide declined in 2024, reaching 73rd place, a two-place drop from 71st place in 2023. Jordan had achieved remarkable progress in its ranking in 2023, moving to 71st place globally after being ranked 78th in 2022. Jordan ranks eighth among 38 economies in the lower-middle-income group and twelfth among 18 economies in North Africa and West Asia. Jordan's performance in innovation outputs is expected to be worse than its inputs in 2024. Table (3.1) and Figure (3.4) below show the value of the Jordanian Innovation Index and the global ranking during the study period. (WIPO, 2023).

Table3.1
Jordanian Innovation Index

Year	Rank	GII
2011	41	38.4
2012	56	37.1
2013	61	37.3
2014	64	36.2
2015	75	33.8
2016	82	30
2017	83	30.5
2018	79	35
2019	86	29.5
2020	81	27.8
2021	81	28.3
2022	78	27.4
2023	71	28.2
2024	73	27.5

Sources: Global Innovation Index .

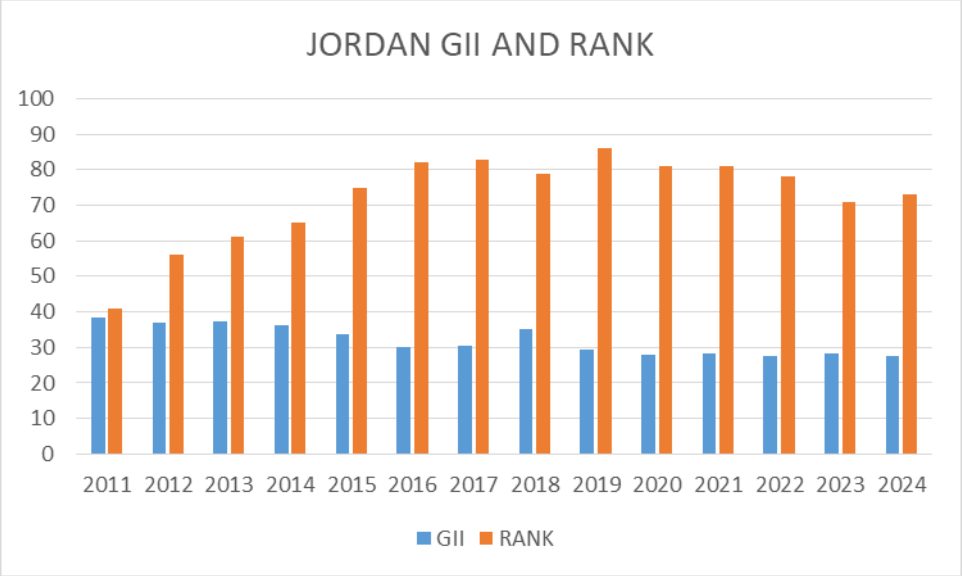

Figure3.4: Trend of Jordanian Innovation Index.
Sources: Global Innovation Index .

Methodology

This study follows the standard descriptive and quantitative approach to demonstrate the impact of innovation on Jordanian economic growth. The study built a standard model based on various previous studies related to the subject of the study (Maradana R. P et al., 2017; Zaroq and Baker, 2020; Khder, 2019), so that the model becomes as follows:

$$(4.1)(RGDPPC_t) = \alpha_0 + \alpha_1 GFCF_t + \alpha_2 EMP_t + \alpha_3 TO_t + \alpha_4 GII_t + \varepsilon_t$$

Table 4.1
Description of model variables

Variable	Discrebtion
$RGDPPC_t$	Economic Growth Rate
$GFCF_t$	Growth in fixed capital formation as an indicator of capital formation
EMP_t	Growth in the number of employed persons as an indicator of the Jordanian labor force
TO_t	Growth in trade openness rates
GII_t	The Global Innovation Index, as a measure of countries' innovation, ranges in value (100-0) from.
α^s	Model parameters
ε_t	Error
t	Time (2011-2024)

Stationarity Test

Before undertaking a quantitative analysis to demonstrate the impact of innovation on economic growth rates in Jordan, it is necessary to ensure the stationarity of the time series. This will enable the study to choose an appropriate analytical methodology to achieve efficient results that can provide the necessary recommendations to decision-makers. The study will rely on the following tests to test the stationarity of the time series used in the study:

First: The Augmented Dickey-Fuller (ADF) test, developed by Dickey and Fuller (1979), is one of the most prominent tests used to determine the stationarity of time series, as it allows for a higher-order autoregressive process. Unit root tests determine whether an individual series (y_t) is stationary using an ordinary least squares (OLS) regression equation. The Augmented Dickey-Fuller (ADF) test then performs a parametric correction for higher-order correlation, assuming it follows an autoregressive process (ρ) and modifying the test methodology, where ρ is the number of lagged changes in (y_t) required to make(ε_t) sequential and uncorrelated. According to the following conditions:
With the intercept:

$$\Delta y_{t-1} = \beta + \delta y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta y_{t-i} + \varepsilon_t \quad (4.2)$$

With Intercept and trend

$$\Delta y_{t-1} = \beta_0 + \beta_{1i} + \delta T y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta y_{i-j} + \varepsilon_t \quad (4.3)$$

Without Intercept

$$\Delta y_{t-1} = \delta y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta y_{t-i} + \varepsilon_t \quad (4.4)$$

Where t is the time trend, Δ is the difference, k is the number of lags y_t is the logarithm of the variable in period t, $\Delta y_t = y_t - y_{t-1}$, and $\beta_0, \beta_1, \alpha, \delta$ is constant parameters, ε_t is the disturbance error term, The optimal number of lags in the equation is determined by the Akaike information criterion (AIC) and Schwarz information criterion (SIC).

Second The Phillips-Perron test is one of the tests that has provided significant significance for the unit root, and it can be said that this test is more reliable than the Dickey-Fuller test, in the presence of a large degree of heteroscedasticity. The Phillips-Perron unit root test (PP), proposed by Phillips and Perron (1988), and has a novel feature: it proposes a non-parametric method for controlling for high-order serial correlation in a series. The procedure for the Phillips-Perron unit root test (PP) is illustrated as follows:

$$y_t = \alpha_0 + \beta y_{t-1} + \mu_t \quad (4.5)$$

$$y_t = \alpha_0 + \alpha_{1i} + \beta y_{t-1} + \mu_t \quad (4.6)$$

Where α_0 is the intercept, β and α_1 the equilibrium parameters, and t is the trend term, and μ_t is white noise error term. In this procedure the first step is to assume that the number of lag terms in the regression functions is equal to zero. The PP unit root test is similar to ADF unit root test from the regression equation in (4.5) and (4.6) with lag *p* = 0.

Table (4.2) shows the results of the time series test for the study model regarding the study model show that the null hypothesis for all study variables is rejected due to the presence of a unit root. This indicates that the time series of the variables are free of a unit root and are stationary at level I (0). Accordingly, the study will use the ordinary least squares (OLS) methodology.

Table 4.1
Results of stationarity (Unit Root) Test

The variables	PP Unit Root Test		ADF Unit Root Test		Status
	At Level	At First Difference	At Level	At First Difference	
$RGDPPC_t$	-2.812*	-7.780***	-2.810*	-4.795***	I (0)
$GFCF_t$	-3.515**	-11.600***	-3.515**	-5.909***	I (0)
EMP_t	-2.727*	-5.749***	-2.245**	-5.899***	I (0)
TO_t	-1.934*	-3.414**	-4.049**	-4.109**	I (0)
GII_t	-3.468***	-6.303***	-2.329**	4.181**	I (0)

Notes: The Lag lengths selection based on SIC, and the critical values from Mackinnon (1996) compared with t-statistics, the signs *, ** and *** denotes significance level at 10%, 5% and 1% respectively.

Cointegration Test

After determining the degree of stability of the study variables and ensuring their stability at the level, the study will move on to conducting the Johansen co-integration test. This test is based on an estimate of the matrix rank Π, attempting to detect the presence of a long-run relationship between the model variables, provided that the number of integration relationships does not exceed the number of variables in the proposed model. One of the most important conditions for using this test is that the variables in the model are stable at the same degree (Panchanan, 2019). Figure () shows the results of the co-integration test for the study model. After determining the degree of stability of the study variables and ensuring their stability at the level, the study will move on to conducting the Johansen co-integration test. This test is based on an estimate of the matrix rank Π, attempting to detect the presence of a long-run relationship between the model variables, provided that the number of integration relationships does not exceed the number of variables in the proposed model. One of the most important conditions for using this test is that the variables in the model are

stable at the same degree (Panchanan, 2019). Table (4.3) shows the results of the co-integration test for the study model.

Table 4.3
The Johansen test for co-integration results

	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None*	0.952	42.92	29.79	0.0009
At most 1	0.307	6.484	15.494	0.638
At most 2	0.159	2.080	3.841	0.149

The table shows the results of the Johansen co-integration test. The results indicate that the model has co-integration. Accordingly, the study will conduct a regression analysis to demonstrate the impact of innovation on economic growth rates in Jordan.

Estimation Results
After completing the stability and co-integration tests, the study proceeded to conduct regression analysis based on the ordinary least squares methodology, as shown in Table (4.4).

Table 4.2
Estimation Results

Regressors	**Coefficients**	**t-Statistics**
GFCF	0.067**	1.343
EMP	0.161*	2.107
TO	-0.029	-1.188
GII	0.005***	5.681
R^2 = 0.44	Durbin-Watson stat=2.15	

Note: *, ** and *** denotes significance level at 10%, 5% and 1% respectively.

The table above shows the results of estimating the model's parameters. The results indicate that growth in capital accumulation positively impacts economic growth rates in Jordan. A 1% increase in capital accumulation contributes to a 0.067% increase in economic growth rates in Jordan, indicating Jordan's efforts to enhance investment and the investment environment, and develop the infrastructure of the Jordanian economy. The results are consistent with growth theories and the role of capital in stimulating economic growth rates. The greater the accumulation of capital, the greater the productive capacity of enterprises, which leads to an increase in the gross domestic product. Furthermore, the role of capital accumulation in improving productivity levels and its connection to the level of technology used in production processes is also evident. The results also demonstrate the positive relationship between capital accumulation and increased spending on research and development to achieve technological growth that enhances economic growth rates. The results are consistent with theoretical literature and previous studies (Al-Sabti, 2021). As for the employment growth variable, which refers to the labor force, the results showed a statistically significant positive relationship with economic growth rates. This means that a 1% increase in employment growth rates will increase growth rates by 0.16%. This result is consistent with theoretical literature and previous studies (Al-Sabti, 2021).

As for the growth variable in the rate of economic openness, it showed an inverse effect that was not statistically significant. This result contradicts economic theories. This may be due to the fact that countries with weak production structures rely on importing final goods rather than strengthening their local industries. Economic openness leads to external competition that emerging industries cannot tolerate, leading to a decline in local production and lower economic growth rates.

As for the innovation variable, it showed a statistically significant positive result. This means that a one-point increase in the value of the innovation index will increase economic growth rates by 0.005%. This result is consistent with endogenous growth theories. Innovation leads to the development of new production technologies or the improvement of existing ones. This contributes to increased total factor productivity (TFP), which increases economic output without the need for additional capital or labor. This is due to Jordan's efforts to strengthen its knowledge investment infrastructure and advance technological progress.

Diagnostic Test

This section evaluates the outcomes of the diagnostic tests performed on the third study model to verify the validity of the results and the appropriateness of the estimated model. The LM serial correlation test, the heteroscedasticity test, the normality test, and the CUSUM and stability tests were performed. The results are presented in Table 4.5 and Figure 5.1.

Table 4.5
Diagnostic Tests

	F-statistics
Serial Correlation X^2 (Breusch-Godfrey LM)	0.63 {0.58}
Normality X^2 (Jarque-Bera)	1.84 {0.39}
Heteroscedasticity X^2 (Breusch-Pagan-Godfrey)	8.23 {0..08}
CUSUM	S

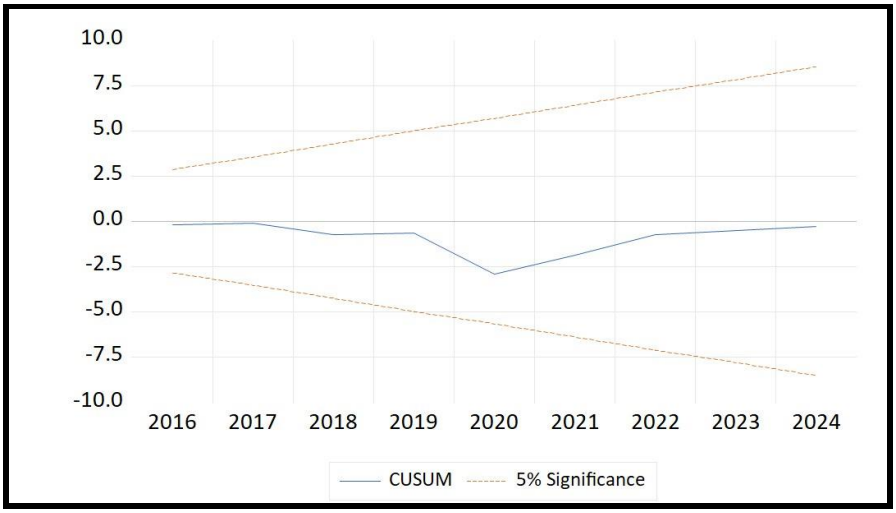

Figure **Error! No text of specified style in document.**.1
The plot of CUSUM for the Study model

Recomendation

After demonstrating the impact of innovation on economic growth rates, the study recommends that decision-makers enhance growth rates in capital accumulation by increasing production and shifting to a reliance on the technological element in production processes to increase labor productivity. The study also recommends spending on research and development and training workers in advanced work skills to equip them with new expertise and keep pace with global technological developments. Furthermore, the study recommends shifting reliance on imports of final goods to protect Jordanian products, strengthening Jordanian trade infrastructure, and shifting toward promoting Jordanian exports and increasing technological exports. It also recommends developing communications infrastructure and enhancing the technological investment climate. It also recommends enhancing innovation indicators, particularly Jordanian innovation inputs, and narrowing the gap between innovation inputs and outputs.

Conclusion

We demonstrated the nature of the relationship between innovation and economic growth in Jordan. Based on numerous previous studies in this field and their mixed results, we focused on the value of the Innovation Index from the Global Innovation Report as an indicator of innovation in economic growth models. Based on the production function, we constructed a model for the study that includes growth rates in capital accumulation to represent capital accumulation in the Jordanian economy (GFCF); growth in the number of employed persons to represent the Jordanian labor force (EMP); growth rates in trade openness (TO); and the value of the Innovation Index (GII) to determine the impact of innovation on economic growth in Jordan. The design of these indices maintains the advantages of data accessibility and aims to improve comparability at the country level. Unlike previous innovation indices based on patent data, these indices do not focus on innovation itself, but rather extract information from the patent system about knowledge creation and flow. Based on the ordinary least squares model estimation method, we can conclude that innovations, indicated by the value of the Innovation Index, enhance economic growth rates. A descriptive analysis of innovation components during the study period also revealed a gap between innovation inputs and outputs.

Furthermore, we identified a negative impact of growth in trade openness rates on economic growth, indicating that Jordan is shifting toward imports of final goods rather than raw materials and technologies used in production processes. Technological progress has shifted from tangible inventions to intangible improvements in daily operations. Further research is needed to narrow the gap between Jordanian innovation inputs and outputs through more appropriate measures of innovation, given its continuous evolution in content and form. We conclude that the study's indicators are sufficient to represent the role of innovation.

Furthermore, we did not track the number of patents granted from the patent applications included in our research. Given the heavy reliance of previous studies on innovation as an indicator of innovation and its low volume in Jordanian innovation inputs, one of the important questions raised by this research is: Does innovation actually contribute to stimulating economic growth? The study firmly believes that innovation and knowledge play a significant role in economic growth. These questions can be answered by focusing on

individual firms rather than economies as a whole. Nevertheless, our results appear consistent and may form the basis for further research.

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