

TECHNOLOGICAL INNOVATION AND PRODUCTION EFFICIENCY: EVIDENCE FROM ARAB ECONOMIES IN A GLOBAL CONTEXT

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Abstract

This study explores the relationship between technological innovation and production efficiency across Arab economies within a comparative global framework. Utilizing panel data covering the period 2011-2024, the analysis assesses how innovation inputs, determined by the Global Innovation Index (GII) Input Sub-Index, impact economic performance, proxied by GDP per capita. The study implements fixed-effects econometric models to account for cross-country heterogeneity and incorporates key control variables such as research and development expenditure, trade openness, foreign direct investment, population size, gross capital formation, and political stability. The results indicate that technological innovation does not have a statistically significant direct impact on production efficiency across countries, recommending that innovation alone may not translate into immediate economic gains. Yet, the degree of this relationship differs between Arab and non-Arab economies, as well as between GCC and non-GCC countries, mirroring differences in institutional structures and innovation ecosystems. Robustness checks utilizing GII Output Sub-Index ensure the consistency of the results. This study contributes to the literature by offering empirical evidence on the role of innovation in forming economic performance in the Arab region within a global context. The results provide important policy implications for supporting innovation systems and improving productivity to support sustainable economic development.

Keywords: Technological Innovation; Production Efficiency; GDP per Capita; Arab Economies; Global Innovation Index; Panel Data Analysis

Introduction

Technological innovation is broadly identified as a key driver of productivity growth and economic development (Romer, 1990; Duguet, 2006). Development in innovation improves production process, enhances efficiency, and reinforces economic competitiveness. Yet, the relationship between innovation and economic performance is not uniform across countries (Crépon et al., 1998; Benavente, 2006). Variation in institutional quality, innovation capacity, and economic structure influence how effectively innovation contributes to productivity.

Arab economies offer a relevant context for assessing this relationship. Irrespective of increasing efforts to improve innovation systems, many countries in the region face structural challenges that limit the effective transformation of innovation inputs into economic performance. These contain limited research and development investments, different levels of technological absorption, and institutional inefficiencies.

This study examines the relationship between technological innovation and production efficiency across Arab economies within a comparative global framework. The analysis expands to non-Arab countries and distinguishes between GCC and non-GCC economies to capture structural differences.

The main objective of this study is to assess whether innovation inputs contribute to economic performance and whether these impacts vary across regions and economic groupings.

Technological innovation has become a central pillar of economic development strategies in both advanced and emerging economies. Governments increasingly invest in research and

development, knowledge-based industries, and digital transformation to improve productivity and sustain long-term growth. Yet, empirical evidence recommends that the effectiveness of these investments differs significantly across countries (Crépon et al., 1998), mainly in developing and transition economies.

In the case of Arab economies, this concern is particularly significant. While several countries have made progress in strengthening their innovation system, structural challenges continue to be there. These contain relatively low levels of R&D investment, limited private sector participation in innovation activities, and variations in institutional capacity. Hence, innovation inputs do not always interpret into improved economic performance.

Comprehending this relationship is vital for assessing the effectiveness of innovation-driven strategies. Production efficiency, mirrored via higher productivity and economic output, reflects a key channel through which innovation contributes to economic growth.

Empirical evidence from developing and emerging economies further supports the connection between innovation and productivity, while addressing differences across institutional and economic context (Chudnovsky et al., 2006; Kahn et al., 2022).

Methodology

This study implements a quantitative research design based on panel data analysis. The dataset includes the period from 2011 to 2024 and covers a broad cross-section of countries, with a particular focus on Arab economies within a global comparative framework.

2.1 Data and Variables: The dependent variable utilized in this study is GDP per capita, which serves as a proxy for production efficiency. This measure mirrors the overall level of economic productivity and output within a country.

The key independent variable is technological innovation, measured using the Global Innovation Index (GII) Input Sub-Index. This index depicts several dimensions of innovation, namely institutions, Human capital, market sophistication, infrastructure, and business sophistication.

To ensure robustness, various control variables are taken into consideration in the model:

- [1] Research and Development (R&D) expenditure (% of GDP)
- [2] Trade openness (sum of exports and imports)
- [3] Foreign Direct Investment (FDI) inflows (% of GDP)
- [4] Gross Capital Formation (GCF)
- [5] Population size (log)
- [6] Political stability (World Governance Indicators)

The data utilized in this study are collected from the World Development Indicators database (World Bank, 2024) and the Global Innovation Index (WIPO, 2024).

2.2 Econometric Model: The study utilizes fixed-effects panel regression models to account for unobserved heterogeneity across countries. This method allows the analysis to control for country-specific characteristics that remain constant over time.

The econometric model utilized in this study is as follows:

$$(1) \text{GDP}_{it} = \beta_0 + \beta_1 \text{GII}_{it} + \beta_2 \text{X}_{it} + \mu_i + \epsilon_{it}$$

Where:

- GDP_{it} : GDP per capita
- GII_{it} : innovation input
- X_{it} : control variables
- μ_i : country effects
- ϵ_{it} : error term

Furthermore, robustness checks are implemented using the GII Output Sub-Index to confirm the consistency of the outcomes.

Results and Discussion

The empirical results show that the relationship between technological innovation and production efficiency is not statistically significant across the overall sample.

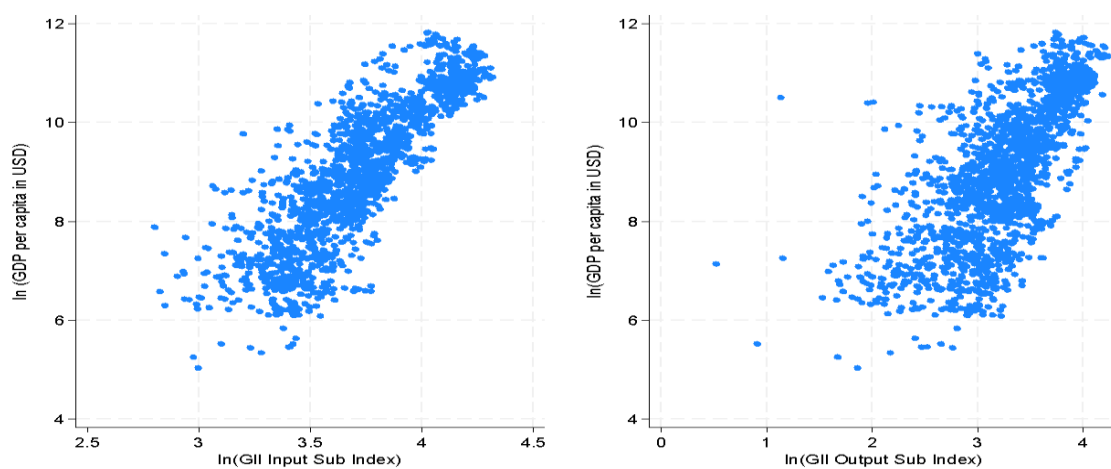


Figure 1: Relationship Between Innovation and GDP per Capita (Overall Sample)

Figure 1 displays a positive relationship between technological innovation and GDP per capita across the full sample, showing that higher innovation inputs are associated with improved economic performance.

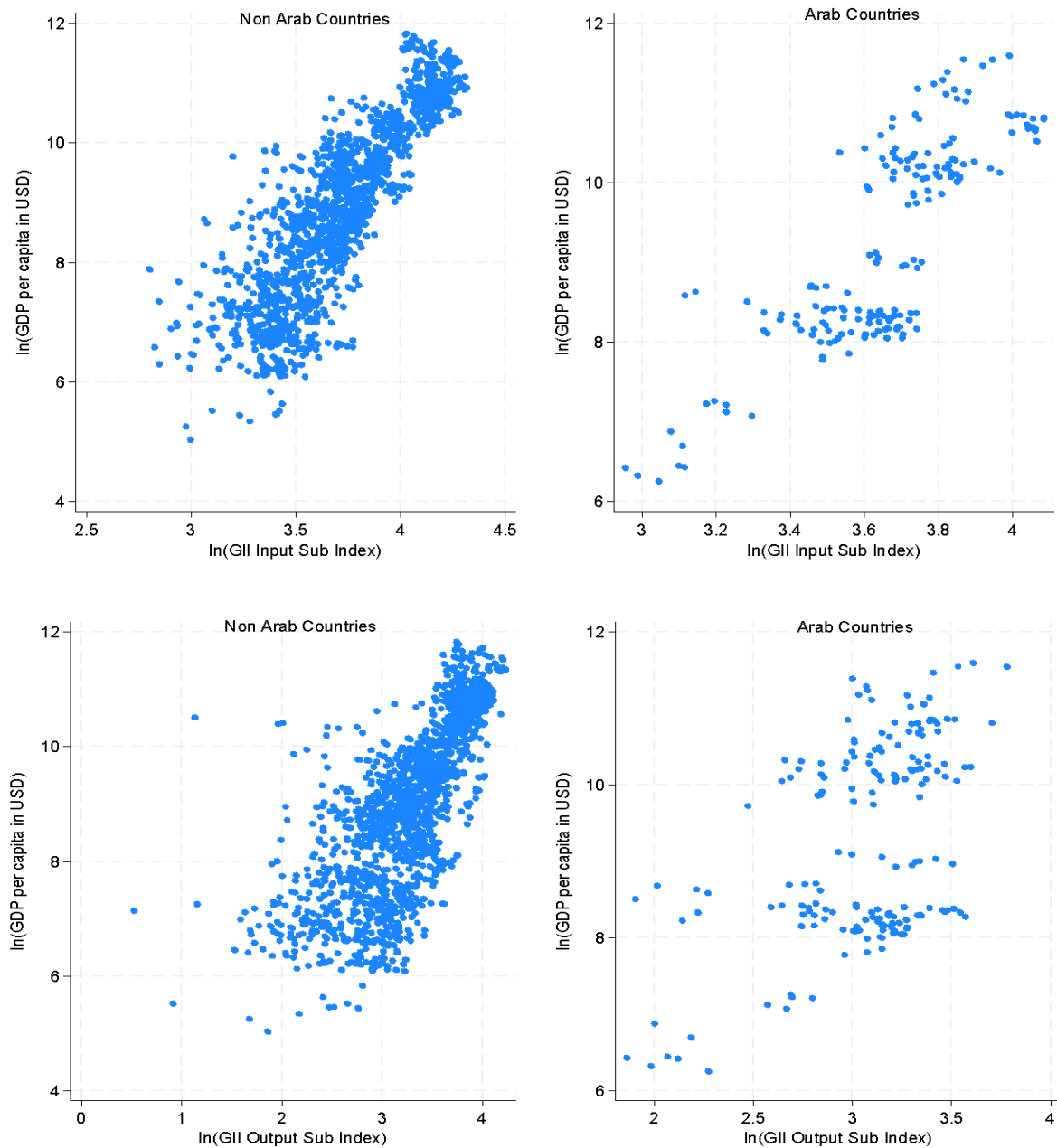


Figure 2: Innovation and GDP per Capita – Arab vs Non-Arab Countries

Figure 2 addresses variation between Arab and non-Arab countries. The relationship seems to be stronger in non-Arab economies, recommending differences in institutional and economic structures.

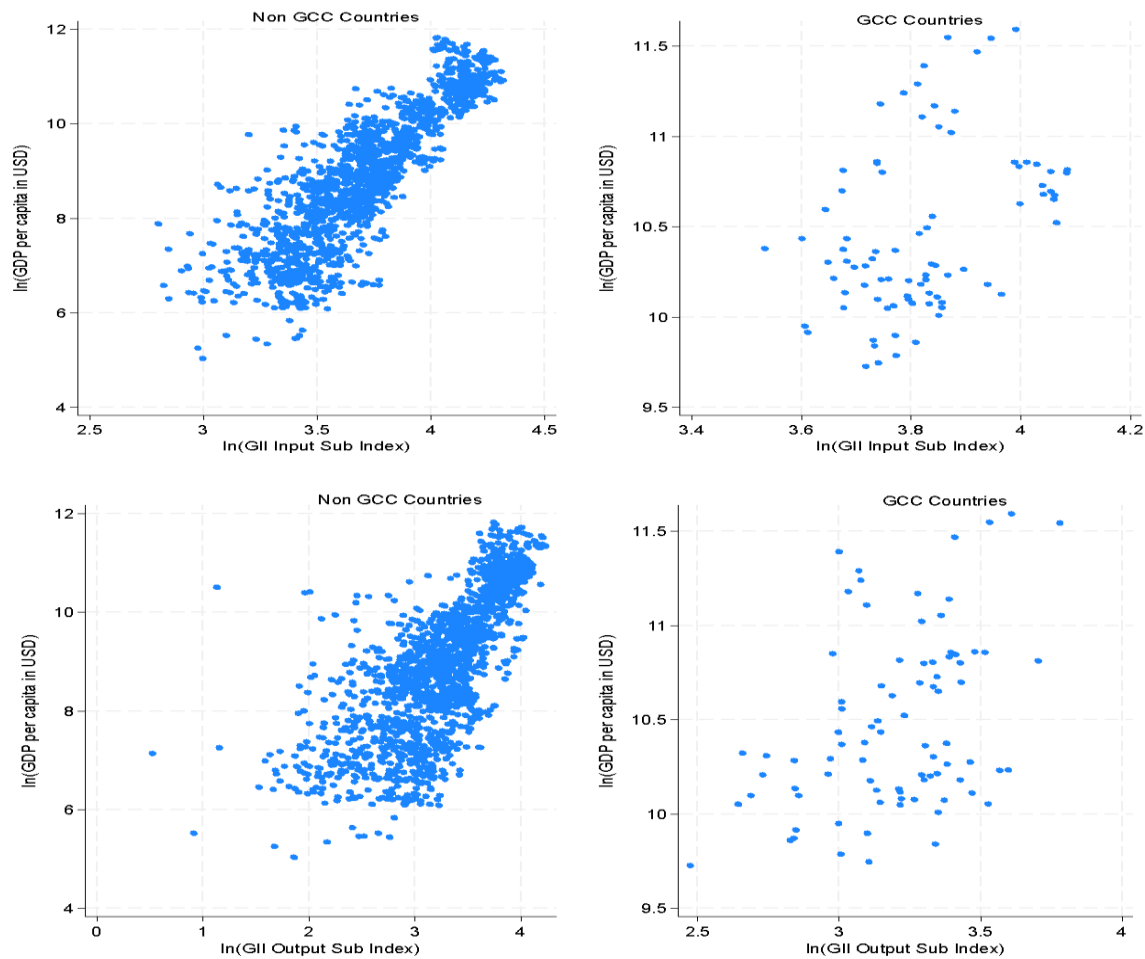


Figure 3: Innovation and GDP per Capita – GCC vs Non-GCC Countries

Figure 3 demonstrates the comparison between GCC and non-GCC countries. The findings recommend that economic structure plays a noticeable role in forming how innovation influences production efficiency.

This outcome is consistent with previous studies that recognize innovation as a key determinant of productivity growth (Benavente, 2006; Duguet, 2006).

Yet, the findings also reveal important variations:

- The impact of innovation is weaker in some Arab economies compared to non-Arab countries
- GCC countries display different dynamics due to resource-based economic structures
- Institutional quality and absorptive capacity play a vital role in determining outcomes

Similar variations have been noticed in prior research, where the effectiveness of innovation depends on institutional quality and economic structure (Chudnovsky et al., 2006; Kahn et al., 2022).

The robustness analysis confirms that these results remain consistent across alternative model specifications.

These findings recommend that innovation alone is not sufficient; complementary factors like institutional development and economic diversification are vital for interpreting innovation into productivity gains.

The findings recommend that while innovation plays a noticeable role in enhancing economic performance, its effect is not uniform across all countries. In Arab economies, the effectiveness

of innovation is impacted by structural and institutional factors. Countries with stronger institutional frameworks and higher absorptive capacity tend to benefit more from innovation investments.

Moreover, the analysis addresses the differences between GCC and non-GCC economies. GCC countries, despite having higher income levels, often tend to count on resource-based economic structures, which may limit the effect of innovation on productivity. On the contrary, non-GCC economies may benefit more from innovation due to the need for diversification.

These results focus on the fact that innovation should not be perceived as a standalone driver of growth. Instead, it must be supported by complementary policies, namely enhancement in governance, education, and economic diversification.

These results are consistent with previous studies connecting innovation to productivity (Benavente, 2006; Chudnovsky et al., 2006).

3.1 Descriptive Statistics: The descriptive statistics of the main variables utilized in the analysis are displayed in Table 1. These statistics offer an overview of the distribution and variation of the variables across countries over time.

The descriptive statistics offer an initial understanding of the data distribution prior conducting the economic analysis.

Table 1 - Summary Statistics of Key Variables

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
GDP per capita (USD)	1776	18,738	23,356	153.93	137,516.59
GII Input Sub-Index	1776	43.06	10.47	16.47	74.90
GII Output Sub-Index	1775	28.76	13.41	1.68	68.60
R&D expenditure (% GDP)	1023	1.10	1.03	0.013	6.02
Trade (% GDP)	1705	91.45	50.82	22.49	442.62
Gross Capital Formation (% GDP)	1671	23.11	8.27	1.43	53.21
FDI inflows (% GDP)	1772	5.57	27.66	-391.56	452.22
Population (log)	1776	16.46	1.61	12.67	21.10
Political Stability Index	1652	46.62	27.74	0.00	99.53

3.2 Regression Results: Table 2 presents the results of the fixed-effect regression model assessing the relationship between technological innovation and production efficiency.

Table 2 - Fixed-effects regression results for innovation and GDP per capita

```
. xtreg ln_GDPGPP_USD c.ln_GIIInputSubIndex Pop_Million FDI_PercGDP Trade_PercGDP RDexp_PercGDP  
      GDP_PoliticalStability GCF_PercGDP i.Year, fe robust
```

Fixed-effects (within) regression	Number of obs	=	995
Group variable: Country Code	Number of groups	=	107

R-squared:	obs per group:
Within = 0.3737	min = 1
Between = 0.0382	avg = 9.3
Overall = 0.0421	max = 13

```
corr(u_i, Xb) = -0.5865
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F(19, 106)	=	25.18
Prob > F	=	0.0000

(Std. err. adjusted for 107 clusters in Country_Code)

ln_GDPPC_USD	Coefficient	Robust std. err.	t	P> t	[95% conf. interval]	
ln_GIIInputSubIndex	-.1522276	.1838614	-0.83	0.410	-.5167507	.2122956
Pop_Million	.0027589	.0014107	1.96	0.053	-.0000378	.0055557
FDI_PercGDP	.0001396	.0001789	0.78	0.437	-.0002152	.0004944
Trade_PercGDP	-.0013354	.0008299	-1.61	0.111	-.0029809	.00031
RDexp_PercGDP	-.0140934	.0483929	-0.29	0.771	-.110037	.0818502
PoliticalStability	.0015666	.001159	1.35	0.179	-.0007313	.0038645
GCF_PercGDP	.0037731	.0032174	1.17	0.244	-.0026056	.0101519
Year						
2012	.0098644	.0120864	0.82	0.416	-.0140982	.0338269
2013	.0382343	.0111486	3.43	0.001	.0161311	.0603374
2014	.0525306	.0146202	3.59	0.000	.0235446	.0815165
2015	-.0597388	.0223042	-2.68	0.009	-.103959	-.0155186
2016	-.0755726	.0247953	-3.05	0.003	-.1247317	-.0264134
2017	.0125001	.0265637	0.47	0.639	-.0401651	.0651653
2018	.0731796	.0259456	2.82	0.006	.02174	.1246192
2019	.0700079	.0295995	2.37	0.020	.011324	.1286918
2020	.0087111	.0344716	0.25	0.801	-.0596321	.0770544
2021	.1718901	.0305941	5.62	0.000	.1112344	.2325458
2022	.2302169	.0339156	6.79	0.000	.1629759	.2947578
2023	.3011445	.0561165	5.37	0.000	.1898882	.4124009
_cons	9.808582	.699266	14.03	0.000	8.422219	11.19495
sigma_u	1.5387721					
sigma_e	.1212622					
rho	.99382818	(fraction of variance due to u_i)				

The results in Table 2 illustrate that the coefficient of the GII Input Sub-Index is negative and statistically insignificant. This shows that technological innovation inputs do not have a measurable direct effect on GDP per capita across the sample. This recommends that investments in innovation-related inputs alone may not be sufficient to create immediate economic returns, mainly due to inefficiencies in innovation systems, delayed impacts of innovation, or limited absorptive capacity within certain economies. The control variables usually display expected signs, supporting the overall consistency of the model.

These findings are consistent with previous studies recommending that innovation inputs do not automatically interpret into productivity gains without supportive institutional and economic conditions (Chudnovsky et al., 2006; Kahn et al., 2022).

Conclusions

This study offers empirical evidence on the relationship between technological innovation and production efficiency across Arab economies within a global framework. The results show that innovation inputs do not have a statistically significant direct impact on economic performance, recommending that investment in innovation alone may not be sufficient to generate immediate productivity gains. Yet, the effectiveness of innovation depends on structural and institutional conditions.

From a policy perspective, the results address the need for:

- Improving national innovation systems
- Expanding investment in research and development
- Boosting institutional quality
- Encouraging economic diversification

Additional research may further investigate sector-level dynamics and the role of digital transformation in forming productivity outcomes.

This study addresses the importance of aligning innovation policies with institutional and structural reforms to maximize their effect on economic performance, mainly in the context of Arab economies.

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