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The impact of research and development output and advanced technology exports on economic growth in Arab countries during the period (1990-2020)

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***Abstract*---**This study aimed to measure the impact of R&D outputs and advanced technology exports on the economic growth of a group of Arab countries during the period (1990-2020) using PANEL data, while it was found that there is a positive and significant effect of the scientific publications index on economic growth, and the results also showed a positive and insignificant effect of the advanced technology exports index on economic growth.

***Keywords*---**R&D outputs, Advanced technology exports, economic growth.

1. Introduction:

Developing countries strive to acquire the essential elements of technological progress to achieve advancement across various fields and enhance long-term, sustainable economic growth. Like other developing nations, Arab countries seek to diversify their exports beyond the hydrocarbons sector to improve individual and societal living standards. Pioneers of economic theory have consistently studied and analyzed various economic models to identify the key variables influencing economic growth rates.

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Numerous empirical studies have emphasized that high-technology exports, supported by research and development (R&D) outputs such as patents, are among the most significant explanatory variables in the economic growth function. These exports represent a vital source of foreign currency and form the foundation for all factors that enhance productive capacity. Their outcomes manifest in higher levels of gross domestic product (GDP) and gross national income (GNI), thereby increasing real individual income. Consequently, they play a pivotal role as the primary driver of development and the engine of economic growth.

Building on this framework, this study focuses on the impact of R&D outputs and high-technology exports on economic growth in Arab countries through the following research question:
To what extent do research and development outputs and high-technology exports influence economic growth in Arab countries?

Study Hypotheses:

To address the research question, the following hypotheses are proposed:
H1: Patents positively affect economic growth in Arab countries.
H2: Scientific publications positively affect economic growth in Arab countries.
H3: High-technology exports positively affect economic growth in Arab countries.

Study Objective:

This study aims to measure the impact of research and development (R&D) outputs and high-technology exports on economic growth in Arab countries during the period (1990–2020) by analyzing the status of high-technology exports and R&D outputs in these countries.

Methodology:

To accomplish this study and achieve its objectives, a **descriptive-analytical approach** was adopted to diagnose the status of high-technology exports, R&D outputs, and their relationship with economic growth in Arab countries. Additionally, an **experimental approach** was applied through the use of standard econometric models aligned with the requirements of this study.

Previous Studies:

Numerous studies have explored the relationship between research and development (R&D) outputs, high-technology exports, and economic growth across various countries. Key studies include:
Ebru & Pakize (2021):
This study examined the causal relationship between technological development (measured by R&D expenditures and patent applications) and economic growth in G7 countries (1996–2018) using Panel VAR. The findings revealed a **bidirectional causal relationship** between technological advancement and economic growth.

Charutawephonnukoon, P., Jermsittiparsert, K., & Chienwattanasook, K. (2021):
Aiming to measure the impact of high-technology exports, patent applications, and R&D expenditures on economic growth in Asian countries over 26 years using dynamic panel data, the study found a **positive and statistically significant effect** of high-technology exports and R&D expenditures on economic growth, alongside a **positive but statistically insignificant effect** of the patent index.

Makhzoumi, Abdellaoui, & Bahi (2020):
This paper analyzed the relationship between R&D and economic growth in 17 advanced industrial countries (1996–2018) using panel data. Results showed that **resident patent applications** had a **positive and significant impact** on economic growth, while the number of R&D researchers had a **negative and significant effect**.

Hedrouk (2020):
Focusing on Algeria (1990–2016), this study employed an Autoregressive Distributed Lag (ARDL) model to assess the impact of technological R&D on economic growth. Long-term growth was driven by traditional factors (physical capital and labor), while R&D outputs (scientific publications and patents) showed **statistically insignificant effects**. Short-term results highlighted a **positive relationship** between economic growth and physical capital alone.

Kabaklarlı, E., Duran, M.S., & Üçler, Y.T. (2018):
Investigating the long-term relationship between high-technology exports and economic growth in selected OECD countries (1998–2015), the study confirmed a **long-term linkage**. Patent applications and foreign direct investment (FDI) were critical drivers of high-technology exports, while economic growth and FDI negatively impacted such exports.

Özkan, G., & Yılmaz, H. (2017):
Analyzing panel data from Turkey and 12 EU countries (1996–2015), the study identified a **positive and significant impact** of R&D expenditures (as a % of GDP) and high-technology exports (as a % of total exports) on GDP.

Yıldız (2017):

Using a fixed-effects panel model (2005–2014), this study demonstrated a **positive and significant effect** of high-technology exports on economic growth in BRICS countries and Turkey.

Inglesi-Lotz, Chang, & Gupta (2015):
Examining causality between economic growth and R&D outputs (measured by published papers) in BRICS countries (1981–2011) via Panel VAR, the study found **no causal relationship** between research output and economic growth, except in India.

Al-Bajouri (2015):
Analyzing six Arab countries (2000–2012) with a fixed-effects model, the study concluded that scientific research had a **positive but statistically insignificant effect** on economic growth. It emphasized the need for increased R&D investment in Arab nations to enhance growth and prioritize socially impactful research.

2. Research and Development (R&D) Outputs and High-Technology Export

2.1. R&D Outputs:

These refer to indicators measuring the outcomes of scientific and technological activities, primarily including **patents** and **scientific publications**.

2.1.1. Patents:
Patents serve as a key indicator of a country's technological standing, enabling cross-national comparisons of technological performance. A patent is defined as an exclusive right granted by governments to inventors for a limited period to prevent others from manufacturing, using, or selling processes or products derived from the invention. The primary function of patents is to incentivize innovation by granting monopoly rights to intellectual property holders while balancing creativity with the dissemination of knowledge (Pavitt, 1980).

2.1.2. Scientific Publications:
Scientific publications are a measure of scientific and technological outputs, though this metric faces criticism. It often excludes journals from developing countries due to language barriers and limited control over technical standards and international databases (UNCTAD, 1991).

2.2. R&D-Linked Economic Performance Indicators:
These indicators illustrate how R&D activities influence economic performance. Key examples include:

Trade-Related Indicators: Used to gauge a country's technological capacity and R&D effectiveness. A primary example is **export performance**, measured by the ratio of foreign trade to GDP. Technological intensity in trade can be assessed by focusing on advanced technology products, which demand high R&D investment, skilled labor, international collaboration, and entail elevated risk and growth potential (Nashwa Mohamed, 2000).

3. The Relationship Between R&D Outputs, High-Technology Exports,and Economic Growth

The **export-driven growth strategy**, which emerged in the late 1970s as an alternative to import substitution policies, aims to enhance productive capacity through foreign trade. However, many countries adopting this strategy struggled to meet their goals due to disparities in export patterns and shifts in dynamic export sectors. Some nations achieved rapid success, while others lagged, largely due to differences in the **value-added content of exports** (Yıldız, 2017).

Producing advanced technology entails creating high-value-added, high-productivity goods. Consequently, developed nations dominate global high-technology exports. For countries pursuing export-oriented growth strategies, producing and exporting high-tech goods is critical for financing development through increased export revenues (Konak, 2018).

Technology's dynamic structure serves as a benchmark for classifying nations and shaping industrial policies. A strong positive correlation exists between high-technology production and economic growth, making technological advancements indispensable in any evaluation of growth strategies.

Countries gain international competitiveness by exporting high-tech goods based on innovations and inventions protected by patents derived from R&D activities (Özçelik, Ö.; Aslan, V.; Özbek, R., 2018). A study on OECD countries by Kabaklarlı, Duran, and Üçler (2018) revealed that patent applications are a key driver of high-technology exports: a **1% increase in patent applications** boosts exports by approximately **3.5%**, enhancing domestic economies and attracting foreign direct investment (FDI). The study also emphasized that a nation's technological capacity can be quantified by its annual patent count, and that patents, internet usage, technological diffusion, and high-technology exports are global determinants of economic improvement.

4. Analysis of the Current State of Research and Development in Arab Countries

4.1. Scientific Publications

The number of published papers rose from approximately 8,000 in 2001 to around 84,000 in 2020—a tenfold increase. This growth is not unique to Arab countries but reflects a global trend driven by increasing interest in developing scientific measurement tools in the economy. The evolution of research measurement tools and technologies is attributed to the worldwide revolution in communication and transportation. Global scientific output increased from 747,855 papers in 2001 to 2,047,897 in 2020 (Mouza bint Mohammed Al-Riyan, 2021), nearly tripling. However, most global output comes from countries that have reached or are nearing a plateau in their growth curves, unlike developing nations still striving to expand their research output. **Table (1)** compares the number of research papers published in Arab countries with those from Iran and Turkey between 2001 and 2020.

Table (1): Comparison of Research Papers in Arab Countries vs. Iran and Turkey (2001–2020)

Rank	Country	Published Papers	Papers per Million Population
1	Saudi Arabia	175,957	6,282
2	Egypt	171,355	1,987
3	Tunisia	58,842	5,445
4	Algeria	46,934	1,247
5	Morocco	40,069	1,214
6	UAE	35,776	5,423
7	Jordan	28,373	3,680
8	Iraq	23,862	740.7

Rank	Country	Published Papers	Papers per Million Population
9	Qatar	21,986	12,578
10	Lebanon	21,545	3,984
**	Arab World	601,426	1,660
**	Turkey	475,972	6,409
**	Iran	464,554	6,176
**	Global	25,600,368	3,671

Source: (Mouza bint Mohammed Al-Riyan, 2021, pp. 4, 6)

The table shows that Arab countries produced 601,426 papers during 2001–2020, while global output reached 25,600,368 papers. The Arab world's contribution thus represents approximately **2.35%** of global output, despite Arab populations constituting **5.2%** of the global population (World Bank data). This highlights a significant gap in scientific productivity relative to the Arab demographic weight. Saudi Arabia and Egypt lead Arab countries in research output, producing over 8,568 papers annually. However, the Arab world's output remains far below the global average and lags behind Iran and Turkey, whose contributions approach or slightly exceed double the global average.

4.2. Patents

Data from the World Bank on patents granted to residents in Arab countries reveal strikingly low numbers, with limited time-series data available for most Arab states.

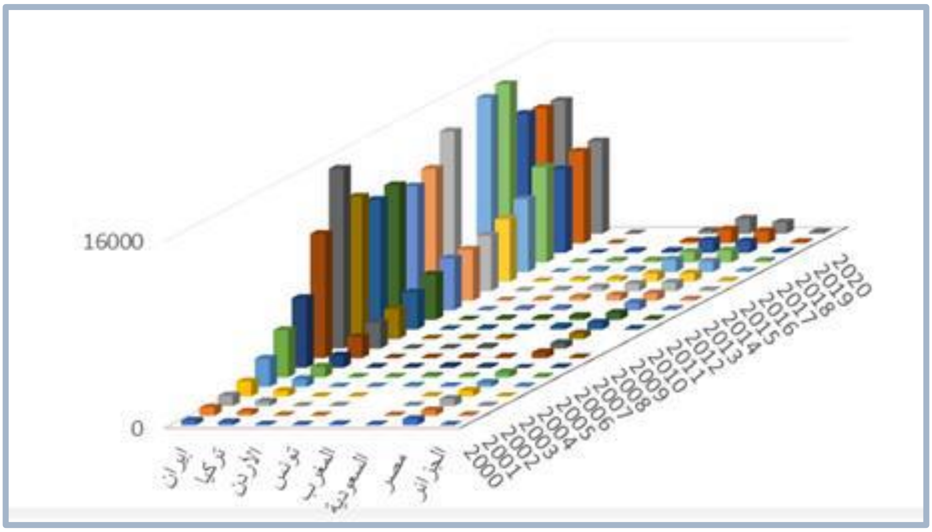

Figure (1) compares patents in select Arab countries with Iran and Turkey between 2000 and 2020.

Source: Researchers' compilation based on World Bank data

The figure illustrates that Arab countries rank last compared to Turkey and Iran in patents granted to residents. For instance, in 2003, Arab output was nearly equal to that of Turkey and Iran. However, the latter two saw rapid and significant growth thereafter, while Arab countries experienced stagnant or minimal progress. This lag is attributed to weak R&D spending and inadequate protection of intellectual property rights in Arab nations, where many ideas are exploited abroad. Addressing this requires urgent efforts to bridge the gap.

4.3. High-Technology Exports
The World Bank defines high-technology exports as "products with high research and development intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery." Data on Arab countries' performance in this sector show minimal figures and a lack of consistent time-series data, with most available statistics covering 2011–2020.

Table (2): Comparison of High-Technology Exports (in billion USD)

Year	Arab World	Malaysia	Turkey
2011	--	66.49	2.20
2012	--	66.46	2.32
2013	--	67.07	3.78
2014	3.19	70.92	4.29
2015	3.10	64.45	3.87
2016	2.70	63.19	3.42
2017	2.84	74.12	4.06
2018	--	90.49	3.73
2019	--	86.90	4.28
2020	--	92.10	4.17

Source: Researchers' compilation based on World Bank data0

Through our analysis of available data on the performance of Arab countries in advanced-technology exports, as shown in Table (2) for the period (2011-2020), it became evident that their performance is extremely weak, with total exportsnotexceeding3.19billion,overthepastdecade.Incontrast,totalArabmerchandiseexportsduringthesameperiodreached3.19billion,overthepastdecade.Incontrast,totalArabmerchandiseexportsduringthesameperiodreached**1.088 trillion**. When comparing Arab countries' performance to Turkey, Turkey surpassed all Arab countries combined in advanced-technology exports during this period, achieving between 2.2billionand **4.29 billion**.

The table's data also highlights that Malaysia relies heavily on advanced-technology exports, which accounted for **53.1%** of its manufactured goods exports during this period. Malaysia achieved between 66.49billion*and***92.1 billion** in advanced-technology exports. The modest presence of Arab countries in this field can be attributed to the fact that technology production is linked to multiple factors, including education levels. Unfortunately, the Arab world still suffers from high illiteracy rates among those aged **15 and above**, as well as widespread school dropout rates across all educational stages—particularly in low-income Arab countries. These challenges hinder the development of a skilled workforce capable of producing advanced-technology goods.

Additionally, Arab countries' industrial policies have not prioritized technology production. Instead, they have largely relied on importing technology, as no Arab industry produces its own production lines or spare parts. Even when some institutions adopted technology production, these efforts were isolated individual initiatives rather than part of a state-led national project. Consequently, skilled professionals and innovators often migrate abroad in search of entities willing to support their creative ideas and transform them into tangible economic goods.

5.Econometric Analysis of the Impact of R&D Outputs and High-Technology Exports on Economic Growth

5.1. Model Specification and Study Variables

The study sample includes six Arab countries: Algeria, Tunisia, Morocco, Egypt, Saudi Arabia, and Jordan. The study period spans from 1990 to 2020, selected based on data availability for the variables under investigation. Data sources include the World Bank's *World Development Indicators (WDI)* and the World Intellectual Property Organization (WIPO) database.

Variable selection was guided primarily by economic theory and secondarily by prior studies. To analyze the impact of R&D outputs and high-technology exports on economic growth in Arab countries, we employ a production function incorporating variables representing R&D outputs (e.g., patents, scientific publications) and high-technology exports. Control variables include labor and capital, as these are key determinants of economic growth in economic literature. The model is structured as follows:

$$LGDPPCt=\beta 0+\beta 1LKt+\beta 2LLt+\beta 3LPATt+\beta 4LHTECt+\beta 5LJRNLt+\varepsilon t(t=1990,\ldots,2020)$$

Variable Definitions:

LGDPPC: Logarithm of real GDP per capita (constant 2010 USD) to measure economic growth.

LK: Logarithm of physical capital, measured by gross capital formation (constant 2010 USD).

LL: Logarithm of labor force size (total workers in thousands).

LPAT: Logarithm of patents granted to residents.

LHTEC: Logarithm of high-technology exports (current USD), defined as products with high R&D intensity (e.g., aerospace, computers, pharmaceuticals, scientific instruments).

LJRNL: Logarithm of scientific and technical journal articles published in fields such as physics, biology, chemistry, mathematics, clinical medicine, engineering, and earth sciences.

Given the panel data structure (cross-sectional data for 6 Arab countries and time-series data for 1990–2020), we evaluated three panel models: pooled regression (PRM), fixed effects (FEM), and random effects (REM) (Baltagi, 2013).

5.2. Model Estimation and Results Analysis

To determine the most appropriate model, two tests are relied upon. The first test is used to choose between the **pooled model** and the **fixed effects model**, which is **Fisher's restricted F-test**. If Fisher’s test indicates the suitability of the **pooled model** for the data, the process stops here, and the pooled model is considered the most appropriate. However, if Fisher’s test favors the **fixed effects model** over the pooled model, the second test—**Hausman’s test (Hausman, 1978)**—is conducted to choose between the **fixed effects model** and the **random effects model**.

Appendix (01) shows the results of estimating the **static panel model** using the following methods:

- **Pooled regression** (Pooled),
- **Fixed effects method** (Fixed),
- **Least Squares Dummy Variables (LSDV) method**, whose estimation results are identical to the fixed effects method but include **country-specific intercepts**,
- **Random effects method**.

Table (1): Panel Model Selection Tests

Test	Statistic Value	Probability	Decision
Pooled vs. Fixed (F)	255.19	0.0000	Fixed Effects
Pooled vs. Random	0.000	1.0000	Pooled
Hausman Test	-18.48	---	Fixed Effects
Hausman-Sigmamore	158.29	0.0000	Fixed Effects

Source: Researchers’ analysis using Stata16.

Based on **Table (01)**, the most suitable model for estimating the **static panel model** is the **fixed effects model (Fixed)** compared to the **pooled regression model (Pooled)**. The **F-statistic** is significant at the **1% level**, leading to the rejection of the null hypothesis, which assumes **homogeneity of country-specific intercepts**. To compare the **pooled regression model** with the **random effects model**, the **Breusch-Pagan test** was applied. The test result indicates acceptance of the null hypothesis, favoring the **pooled regression model (Pooled)**.

When comparing the **fixed effects model** and the **random effects model** using the **Hausman test**, a negative value was obtained. Consequently, the **Hausman-Sigmamore** adjustment was employed, which showed significance at the **1% level**, leading to the rejection of the null hypothesis. Thus, the **fixed effects model (Fixed)** is deemed the most appropriate for estimating the static panel model.

Table (02) presents a set of statistical and econometric tests to verify the validity and adequacy of the **fixed effects model**:

- The **Wooldridge test (2002)** rejects the null hypothesis at the **1% significance level**, indicating the presence of **autocorrelation**.

- The **Modified Wales test for groupwise heteroskedasticity** (Greene, 2000) accepts the alternative hypothesis, confirming **heteroskedasticity issues**.
- Both the **Breusch-Pagan LM test** and the **Friedman test** reject the null hypothesis, suggesting **autocorrelation between cross-sections** (Pesaran, 2004).
- The **Pesaran CD test** also indicates autocorrelation between cross-sections. However, when the number of observations (years: 31) exceeds the number of cross-sections (countries: 6), the **Breusch-Pagan LM test** is preferred over the **Pesaran CD test** (De Hoyos & Sarafidis, 2006). Given our dataset, we prioritize the **Breusch-Pagan LM test**, confirming **autocorrelation between cross-sections**.

Table (2): Diagnostic Tests for Fixed Effects Model

Test	Statistic Value	Probability
Wooldridge Autocorrelation	87.328	0.0000
Modified Wald Heteroskedasticity	81.32	0.0000
Friedman Cross-Sectional Dependence	96.294	0.0000
Breusch-Pagan LM	138.868	0.0000
Pesaran CD	9.716	0.0000

Source: Researchers' analysis using Stata16.

To address the issues of autocorrelation, heteroskedasticity, and cross-sectional dependence, we employed the **(Driscoll & Kraay, 1998) standard error correction method**. This approach adjusts parameter standard errors, effectively resolving all three econometric issues in the fixed effects model.
The **maximum lag length** was set to **1**, following **(Hoechle, 2007)**. The estimation results using **Driscoll & Kraay's method** are presented in **Appendix (08)**.
Findings Based on Appendix (08):

- **Fisher's F-statistic** indicates that the estimated model is statistically significant.
- **Patents (PAT)** have a **negative and insignificant** effect on economic growth in Arab countries.
- **Scientific publications (JRNL)** have a **positive and significant** impact on economic growth—a **1% increase** in publications leads to a **0.17% rise** in economic growth.
- **High-tech exports (HTECH)** show a **negative and insignificant** effect on economic growth.
- **Fixed capital (K)** has a **positive and significant** impact—a **1% increase** in capital formation raises economic growth by **0.1%**, reflecting Arab countries' efforts to improve investment climates and infrastructure.
- **Labor force (L)** has a **positive and significant** effect—a **1% increase** boosts economic growth by **0.59%**.

Overall, R&D outputs have **almost no effect** on economic growth in Arab countries, while high-tech exports show **no measurable impact**.

6. Conclusion

This study examined the impact of **R&D outputs** and **high-tech exports** on economic growth in **six Arab countries (1990–2020)** using panel data. The **Hausman-Sigmamore test** confirmed the **fixed effects model** as optimal. To address **autocorrelation, heteroskedasticity, and cross-sectional dependence**, we applied **Driscoll & Kraay's (1998) standard error correction**, resolving these econometric issues.

Key Findings:

- ❖ **Rejection of Hypothesis 1:** Resident patents (**PAT**) have a **negative, insignificant effect** on growth, reflecting low patent filings in the Arab world compared to peers like Turkey and Iran. This raises critical questions about:
- Weak industrial property protection systems.
- Lack of domestic innovation or foreign interest in patenting in Arab economies.
- Structural gaps in R&D incentives and absorptive capacity.
-
- ❖ **Validation of Hypothesis 2:** Scientific publications (**JRNL**) significantly boost growth, with **Saudi Arabia and Egypt leading** (8,500+ published papers). However, **citation impact** (e.g., h-index) remains a better quality metric than volume alone.

- ❖ **Rejection of Hypothesis 3:** High-tech exports (**HTECH**) show **no meaningful impact**, highlighting a **disconnect between academia, R&D, and industry** in Arab states. Reliance on **imported technology** (rather than domestic R&D) perpetuates dependency on foreign industrial economies.

Appendices:

Appendix (1): Estimation of the Static Panel Model

```
. estimate table pooled lsdv fexed random, star stats(N r2 r2_a F sigma_u sigma_e)
```

Variable	pooled	lsdv	fexed	random
ll	-.5185409***	.59516502***	.59516502***	-.5185409***
lk	.58470829***	.10231281**	.10231281**	.58470829***
lpat	-.2468385***	-.03515338	-.03515338	-.2468385***
ljrn	.28330839***	.17817104***	.17817104***	.28330839***
ltech	.05851969*	.01236508	.01236508	.05851969*
id				
EGY		-1.3140717***		
JOR		1.1864773***		
MARO		-.30347862**		
SAOU		1.3836582***		
TUN		.69947228***		
_cons	.49966215	-5.3615829***	-5.08624***	.49966215
N	186	186	186	186
r2	.59600372	.95127344	.84199342	
r2_a	.5847816	.94848906	.83296447	
F	53.10973	341.64703	186.50976	
sigma_u			1.0173988	0
sigma_e			.18340165	.18340165

legend: * p<0.05; ** p<0.01; *** p<0.001

Appendix (2): Estimation of the Fixed Effects Model with F-test for Comparing Pooled and Fixed Effects Models

```
Fixed-effects (within) regression               Number of obs     =        186
Group variable: id                              Number of groups  =          6

R-sq:                                           Obs per group:
     within  = 0.8420                                         min =         31
     between = 0.0004                                         avg =       31.0
     overall = 0.0805                                         max =         31

                                                F(5,175)          =     186.51
corr(u_i, Xb)  = -0.5868                        Prob > F          =     0.0000
```

lgdppc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ll	.595165	.1184207	5.03	0.000	.3614485	.8288815
lk	.1023128	.0344989	2.97	0.003	.0342253	.1704004
lpat	-.0351534	.0235184	-1.49	0.137	-.0815696	.0112629
ljrn	.178171	.023921	7.45	0.000	.1309603	.2253818
ltech	.0123651	.0146703	0.84	0.400	-.0165885	.0413187
_cons	-5.08624	1.460415	-3.48	0.001	-7.968533	-2.203947
sigma_u	1.0173988					
sigma_e	.18340165					
rho	.96852717	(fraction of variance due to u_i)				

F test that all u_i=0: F(5, 175) = 255.19 Prob > F = 0.0000

Appendix (3): Test for Choosing Between the Pooled Model and Random Effects Model

Breusch and Pagan Lagrangian multiplier test for random effects

```
        lgdppc[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
```

	Var	sd = sqrt(Var)
lgdppc	.6529907	.8080784
e	.0336362	.1834016
u	0	0

```
        Test:   Var(u) = 0
                             chibar2(01) =     0.00
                          Prob > chibar2 =   1.0000
```

Appendix (4): Test for Choosing Between Fixed Effects and Random Effects Models

```
. hausman fexed random

                  ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fexed        random        Difference          S.E.
-------------+----------------------------------------------------------------
          ll |     .595165    -.5185409        1.113706        .0980016
          lk |    .1023128     .5847083       -.4823955               .
        lpat |   -.0351534    -.2468385        .2116851               .
        ljrn |     .178171     .2833084       -.1051373               .
       ltech |    .0123651     .0585197       -.0461546               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =   -18.48    chi2<0 ==> model fitted on these
                                        data fails to meet the asymptotic
                                        assumptions of the Hausman test;
                                        see suest for a generalized test
. hausman fe re, sigmamore

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
          ll |     .595165    -.5185409        1.113706        .3295768
          lk |    .1023128     .5847083       -.4823955        .0799726
        lpat |   -.0351534    -.2468385        .2116851        .0470785
        ljrn |     .178171     .2833084       -.1051373        .0506348
       ltech |    .0123651     .0585197       -.0461546         .034564
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      158.29
                Prob>chi2 =      0.0000
```

Appendix (5): Autocorrelation Diagnostic Tests

```
. xtserial lgdppc ll lk lpat ljrn ltech

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,       5) =     87.328
           Prob > F =      0.0002
```

Appendix (6): Heteroskedasticity Diagnostic Tests

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (6)  =       81.32
Prob>chi2 =      0.0000
```

Appendix (7): Tests for Detecting Cross-Sectional Dependence

Correlation matrix of residuals:

	__e1	__e2	__e3	__e4	__e5	__e6
__e1	1.518344					
__e2	.1644384	1.888018				
__e3	.7119637	.2252284	.5483716			
__e4	.6978994	.2551283	.3704755	.7034853		
__e5	.7405902	-.2835769	.4822865	.4075626	.7965518	
__e6	.428927	-.029439	.3420705	.2506598	.4662775	.4315585

	__e1	__e2	__e3	__e4	__e5	__e6
__e1	1.0000					
__e2	0.0971	1.0000				
__e3	0.7803	0.2214	1.0000			
__e4	0.6753	0.2214	0.5965	1.0000		
__e5	0.6734	-0.2312	0.7297	0.5445	1.0000	
__e6	0.5299	-0.0326	0.7032	0.4549	0.7953	1.0000

```
Breusch-Pagan LM test of independence: chi2(15) =   138.868, Pr = 0.0000
Based on 31 complete observations over panel units

. xtcsd, pesaran abs


Pesaran's test of cross sectional independence =     9.716, Pr = 0.0000

Average absolute value of the off-diagonal elements =     0.486

. xtcsd, friedman


Friedman's test of cross sectional independence =    96.294, Pr = 0.0000
```

Appendix (8): Estimation Results Using Driscoll-Kraay Standard Errors

```
. xtscc lgdppc ll lk lpat ljrn ltech, fe lag(1)

Regression with Driscoll-Kraay standard errors   Number of obs     =       186
Method: Fixed-effects regression                 Number of groups  =         6
Group variable (i): id                           F(  5,     5)     =    126.60
maximum lag: 1                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.8420
```

lgdppc	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
ll	.595165	.1477884	4.03	0.010	.2152629	.9750672
lk	.1023128	.0348415	2.94	0.032	.0127499	.1918757
lpat	-.0351534	.0271386	-1.30	0.252	-.1049153	.0346085
ljrn	.178171	.0179593	9.92	0.000	.1320052	.2243369
ltech	.0123651	.0157453	0.79	0.468	-.0281094	.0528395
_cons	-5.08624	1.561507	-3.26	0.023	-9.100222	-1.072258

References

Baltagi, B. (2013). *Econometric Analysis of Panel Data (VOL. 5).* Chichester,UK: Wiley.

De Hoyos, R., & Sarafidis, V. (2006). Testing for cross-sectional dependence in panel-data. *The Stata Journal, 7*(2), 442-446.

Driscoll, J., & Kraay, A. (1998). Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. *Review of Economics and Statistics (80)*, 549-560.

Ebru, T. D., & Pakize, Y. (2021). The Causal Nexus Between Technological Development And Economic Growth: An Evidence From G7 Countries. *Journal of Economics and Administrative Sciences Faculty, 8*(2), 1008-1019.

G, Özkan.&H, Yilmaz. (2017). The Effects Of R&D Expenditures On High Technology Export And Per Capita Income: A Practice For Turkey, And 12 Member Countries Of The European Union (1996-2015). *Bilgi Ekonomisi ve Yönetimi Dergisi*, Cilt: XII Sayı: I.1-12.

Greene, W. (2000). *Econometric Analysis.* Upper Saddle River, NJ: Prentice–Hall.

Hausman, J. (1978). Specification tests in econometrics. *Econometrica (46)*, 1251–1271.

Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional. *The Stata Journal, 7 (2)*, 281- 312.

Kabaklarlı,E., Duran, M.S., Telli Üçler, Y. (2018). High-Technology Exports And Economic Growth: Paneldata Analysis For Selected Oecd Countries. *Forum Scientiae Oeconomia*, 48-60.

Konak, A. (2018). The Effect Of Product Export Of Hıgh Technology On Export Volume And Economıc Growth; Selected OECD Countrıes And The Case Of Turkey. *JOMELIPS - Journal of Management Economics- Literature Islamic and Political Sciences*, 56-80.

Özçelik, Ö; Aslan, V; Özbek, R. (2018). The Relationship Between High-Technology Exports and R&DExpenditure: Panel Data Analysis for Selected 10 OECD Countries. *Kastamonu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 20*(3), 57-66.

P, Charutawephonnukoon.&K, Jermsittiparsert.&K, Chienwattanasook. (2021). Impact of high technology exports, patent applications and research and development expenditure on economic gowth : growth: evidence from asean countries. *Psychology and education*, 1986-1972.

Pavitt, K. (1980). *Technical Innovation And British Economic Performance.* (1, Ed.) London: The Macmillan Press LTD.

Pesaran, M. (2004). General diagnostic tests for cross section dependence in panels. *CESifo Working*, 1229.

UNCATAD. (1991). *Technology indicators activties and devloping countries.* 18-19: united nations.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data.* Cambridge, Massachusetts: The MIT Press.

Yıldız, u. (2017). Panel data analysis of the relationship between hightechnology export and economic growth for brics countries. *Dumlupinar üniversitesi sosyal bilimler dergisi*, 26-34.

- أحمذ هدروق. (2020). أثر أنشطة البحث والتطوير التكنولوجي في النمو الاقتصادي :دراسة قياسية لحالة الجزائرباستخدام نموذج ARDL. *معارف*، *15*(1)، 01-22.
- خالد عبد الوهاب البنداري الباجوري. (2015). تأثير البحث العلمي على النمو الأقتصادي في الدول العربية. *كليةالاقتصاد والإدارة ، جامعة مصر للعلوم والتكنولوجيا*.
- لطفي مخزومي، عقبة عبداللاوي، و وفاء باهي. (2020). أثر البحث والتطوير على النمو الاقتصادي-دراسة قياسية لعينة من الدول الصناعية 1996 - 2018. *المجلة العلمية المستقبل الاقتصادي*، 95-110.
- مصطفى عمي نشوى محمد. (2000). أثر البحوث والتطوير عمى صادرات الإلكترونيات في الدول الآخذة في النمو- دراسة مقارنة(رسالة ماجيستير). كلية التجارة، مصر: جامعة حلوان.
- موزه بنت محمد الريان. (2021). البحث العلمي العربي (2001-2020)،نظرة عامة على البحث العلمي العربي خلال عشرين عاما. *منظمة المجتمع العلمي العربي،وحدة الدراسات والبحوث*، 1-10.