Investigating the effects of environmental patents and climate change mitigation technologies on sustainable economic growth in the Middle East

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Abstract

Sustainable economic growth and identifying factors affecting it are among the important issues which have always received attention from researchers of different countries. Accordingly, one of the factors affecting economic growth, which has received attention from researchers in the developed countries over recent years, is the issue of environmental technologies that enter the economic cycle of other countries after being patented through technology transfer. The current research investigated the role of the environment-related patents and the effects of the patented technological innovations compatible with climate change mitigation on the economic growth and development in the Middle East countries within a specific time period. The required data were gathered from the valid global databases, including Organization for Economic Cooperation and Development and World Bank and have been analyzed using multi-linear regression methods and econometric models with Eviews 10 software. The obtained results with 95% confidence level show that the environmental patents (β = 0.02) and environment management (β = 0.04) and technologies related to the climate change mitigation (β = 0.02) have a significant positive impact on the sustainable economic development and growth rate in the studied countries. Such a study helps innovators and policymakers in policy decisions related to sustainable development programs from the perspective of environmentally friendly technologies by demonstrating the role of patents in three important environmental areas, namely environmental management, water-related adaptation and climate change mitigation, as one of the factors influencing sustainable economic growth.

Keywords: climate change mitigation; economic growth; environmental patents; sustainability; technology transfer

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1. INTRODUCTION

Technology transfer includes any process by which the people living in a country can access and use the technology developed in another country [1]. The first big wave of public concern for environmental problems arose in the pollution caused by industrialization in advanced economies. Environmental concerns have been raised in trade analysis and have become a significant subject in international negotiations since the late 1970s and early 1980s. Solow [2] argued that innovation directly affects economic growth in the long term. Different studies have confirmed this claim [3, 4, 5, 6, 7, 8, 9]. However, the negative effects of innovation and technology transfer on the environment and climate changes have become a main concern for researchers and policymakers. Accordingly, the United Nations established the Framework Convention on Climate Change to control the environmental effects caused by climate changes in 1990. This agreement was signed by 195 countries including Iran and has been enforced since 2020. The signers of this agreement are committed to perform practical steps for reducing the global
emissions of carbon dioxide and other greenhouse gases. Thus, the number of environmentally friendly innovations has significantly increased during the recent decades [10]. By considering this concept, different researchers aimed to recognize the role of innovation in minimizing the environmental effects which play a role in climate changes. Global statistics indicated that the Middle Eastern countries have various levels of economic growth. Due to the oil richness of such countries, the abundance of energy resources and their low price, the environmental quality is low because of the production and extraction of energy resources in this group. Based on the studies conducted in the Middle East, the solution to the existing economic fluctuations is achieving sustainable development. Considering environmental sustainability is one of the significant factors in this regard. Based on the definition, sustainable economic growth refers to any form of economic growth which causes no harm in the environment [11, 12]. According to this definition, attention to the environment is necessary to achieve sustainable economic growth, in the Middle East too and the type of relationship between these two issues from the perspective of environmentally friendly technological innovations, including water-related adaptation, environmental management and climate change mitigation technologies in these countries is the main subject of this research. A literature review of the existing scientific articles focusing on economic growth, the environment and the Middle East shows that research in Middle Eastern countries focuses on the role and functions of technology in reducing CO2 emissions and fossil fuel consumption and its effect on economic growth [13, 14, 15, 16]. As the issue of environment and its sustainability has a special place, one way to achieve environmental sustainability is to develop and disseminate environmentally friendly technologies and reduce environmental pollution. This research is important in terms of innovation, by presenting the results of the study of environmental technologies in three main categories: (1) environmental management; (2) water-related adaptation; (3) climate change mitigation, and their effects on sustainable economic growth in the Middle East. So the study of this issue is considered as an important and necessary research gap. Therefore, the main issue in this research is how the transfer of environmental technologies and climate change mitigation patents have an impact on sustainable economic growth in the Middle East. In this study, the statistical data collected from the countries by the Organization for Economic Co-operation and Development (OECD), as well as the World Bank were used for different periods. The data were analyzed by multilinear regression and econometric models in Eviews software.

2. EFFECT OF ENVIRONMENTAL TECHNOLOGIES TRANSFER AND CLIMATE CHANGES MITIGATION TECHNOLOGIES ON ECONOMIC GROWTH

The results of some studies indicated that innovation is the key to sustainable development in all societies [17, 18]. The expansion of globalization issues as well as the interconnectedness of countries has caused the transfer of advanced technologies from developed countries to other countries. Access to clean and environmentally friendly technologies in developed countries improves the quality of the environment around the world. Although most technologies throughout the world are created in developed countries, they can affect the pattern of climate changes in the countries with limited technological innovation through technology transfer [19]. Fagerberg [20] indicated that technology plays a critical role in the productivity and income of countries. Keller [21] mentioned that up to 90% of domestic productivity growth for most countries is supplied from foreign sources through technology transfer. Using the technological advances or technologies that absorb carbon dioxide is necessary for controlling climate changes [22, 23]. Grosman and Kreuger [24] studied the relationship between air pollution and economic growth empirically. The results indicated a hump-backed relationship between the per capita emission of sulfur dioxide and GDP per capita. The United Nations sought the mitigation of the intensifying effects of climate changes. Different authors considered it vital to understand the role of innovation for minimizing the environmental effects which lead to climate changes. A necessary part of this process is the different plans being created by governments to facilitate the development and dissemination of climate changes mitigation technologies [25, 26, 13, 12]. For example, investment in research and developing technologies of infrastructure and green products related to improve low-carbon level industry such as tourism promote the growth of economy [27]. Other researchers related the environmental issues to economic growth and productivity [16, 24, 15, 28, 14]. In addition, they predicted the effects of climate changes in different scenarios [18]. However, the literature has mainly focused on the relationship between green technologies and pollutant emissions from the perspective of the effect of technology on the pollutant emissions from a climate changes point of view. Statistics revealed that the countries with more efficient entities for enforcing the intellectual property rights have more power for enforcing the restrictions for regulating pollution and preserving the environment. Different studies sought to identify the key policy incentives which foster environmental innovation [29]. Solomon et al. [30] recommended the researchers to consider the role of environmental innovations in dealing with climate changes and promoting sustainable economic growth. In order to achieve this goal, professionals should always supervise the success and progress of such innovations and plans [31]. Therefore, dealing with the effects of climate changes through the mitigation and adaptation of technologies requires the research and development of new technologies, and also the soft dissemination of innovations [32]. One of the areas are technologies which are related to different green energy sources that have been applied to generate electricity and thermal energy for human beings, such as hydrogen, solar, wind and geothermal which are usable for different energy consuming purposes [33]. As the solar and geothermal energy have several advantages compared to other types of renewable sources of energy such as easy accessibility and superior predictability, researchers focused on technologies related to them.
due to their several benefits including emission of greenhouse gases and their inexhaustible nature [34, 35]. When countries use the technological capabilities and environmental innovations, their ability in mitigating to climate changes increases not only as the users of low-carbon technologies but also as innovative producers [36, 37]. Thus, sustainable innovation leads to favorable social results [38, 39, 40]. On the contrary, the option of importing and installing sustainable technology is a rapid solution which fails to help countries learn the process of creating sustainable innovation. Innovative participation in the production of fundamental technologies helps the ability of countries to guide and adapt such technologies in sustainable development and promotes economic growth [41]. Zollo et al. [42] stated that sustainability (i.e. how to promote sustainable innovation) should be considered rather than why (i.e. why we follow sustainable innovation) or what it is (i.e. what is sustainable innovation?). This issue leads to the question 'how can we promote the development and dissemination of sustainable technology transfer?' In this regard, it should be noted that the transfer of sustainable technology is normally considered a multidimensional process [43] which encourages and develops innovation and is completed while being disseminated and implemented [44]. Research also shows that high-tech imports in developed and developing countries affect domestic innovation and foreign technology has a higher effect than domestic technology for the growth of GDP per capita [45]. Technology transfer in the innovation ecosystem is one of the requirements of commercializing new technologies and paving the way for technology development in this ecosystem [46]. On the other hand, the transfer of appropriate technology can pave the way for the transformation of industrial production and achievement of economic growth. Hasan Gholiipour and Ghazi Nouri [47] studied the role of research and development activities of multi-national companies in the development of technological capabilities in developing countries by analyzing international patents. Based on this study, they came to the conclusion that many technological advantages can be obtained such as establishing research activities with universities, hiring workforce and joint ventures by leveraging the market and creating competition among foreign companies. Based on endogenous growth theories, knowledge, innovation and technology are considered as the most significant factors affecting economic growth. In addition, there is a standpoint that more facilities and financial resources are provided to entrepreneurs with the increase of economic growth and it can develop innovations and innovations. It should be noted that a circular flow exists between innovation and economic growth [48]. The purpose of this study is to investigate the impact of sustainable technology transfer, by the means of technological innovations that are environmentally friendly and contribute to environmental sustainability, on the economic growth of the Middle East and Iran. The review of the literature shows that no research has been presented on the impact of climate change mitigation technologies on sustainable economic growth in the Middle East, therefore the study of this issue is considered as an important and necessary research gap. Since the amount of budget allocation to research and development in developing countries has been always a challenging topic, the results of this study can help decision-making on the allocation of budgets to these sectors. Based on such standpoints, the hypotheses of this study are defined as follows:

Hypothesis 1: The transfer of the technologies related to environmental sustainability has a positive effect on economic growth.

Hypothesis 2: Climate changes mitigation technologies have a positive effect on sustainable economic growth.

3. METHODOLOGY

This study used the data collected in countries by the OECD and World Bank under the titles of environment, population, international trade and national accounts statistics during 2010–2016 for the Middle East including Iran, Jordan, Palestine, Egypt, Turkey, UAE, Lebanon, Saudi Arabia, Qatar, Bahrain, Syria, Iraq, Yemen and Oman. In other words, the present study used a balanced panel.

The econometric models used in a similar study in Europe [19] to assess the impact of patents, especially those related to environmental issues, on GDP growth have also been used in this study:

\[
\text{GDP}_{GR} = \alpha_0 + \alpha_1 \text{POP}_{GR} + \alpha_2 \text{GDP}_{PC} + \alpha_3 \text{TLF}_{GR} \quad (1)
\]

\[
\text{GDP}_{GR} = \alpha_0 + \alpha_1 \text{POP}_{GR} + \alpha_2 \text{GDP}_{PC} + \alpha_3 \text{TLF}_{GR} + \alpha_4 \text{PAT}_{ENV} \quad (2)
\]

\[
\text{GDP}_{GR} = \alpha_0 + \alpha_1 \text{POP}_{GR} + \alpha_2 \text{GDP}_{PC} + \alpha_3 \text{TLF}_{GR} + \alpha_4 \text{PAT}_{ENV\_MAN} + \alpha_5 \text{PAT}_{ENV\_WAT} + \alpha_6 \text{PAT}_{ENV\_CLIM} \quad (3)
\]

For all of these estimates, the existence of multicollinearity between exogenous variables (i.e. variance inflation factor (VIF)) was tested and strong standard errors for coefficients to eliminate the possibility of variance heterogeneity were calculated and the data were analyzed using Eviews 10.

Figure 1. Technological innovations related to the environment (source: OECD).
Table 1. Variables used in the analysis.

| Variables                              | Units                          | Hypothesis |
|----------------------------------------|-------------------------------|------------|
| **Dependent Variable**                 |                               |            |
| Real GDP growth (GDP_GR)               | Annual growth in percentage   |            |
| **Control Variables**                  |                               |            |
| Population growth rates (POP-GR)       | Annual growth in percentage   |            |
| GDP per capita (GDP_PC)                | In thousands of $ and constant prices |    |
| Total labor force growth rates (TLF-GR)| Annual growth in percentage   |            |
| **Predictor Variable**                 |                               |            |
| Sustainable Technology Transfer (Patent Variables) |   |            |
| Selected environment-related technologies patents (PAT_ENV) | Per million inhabitants | Hypothesis (1) |
| Environmental management patents (PAT_ENV_MAN) | Per million inhabitants |            |
| Water-related adaptation technologies patents (PAT_ENV_WAT) | Per million inhabitants |            |
| Climate Change Mitigation Technology   |                               |            |
| Climate change mitigation patents (PAT_ENV_CLIM) | Per million inhabitants | Hypothesis (2) |

Figure 2. Conceptual model.

**Dependent variable** including the Gross Domestic Product-Growth Rate (GDP-GR) were used as the criterion of economic growth [19], which means the total value of all products and final services produced in a country at a given period. GDP-GR is the amount of increase which occurs in the yearly economic outputs of a country. This rate specifies how fast the economy of a country is growing exactly. Many countries use the GDP-GR to calculate the growth rate for eliminating the effect of inflation on this rate.

**Control variables** were used in the analysis including population growth rate (POP_GR): It shows the amount of increase of population in an area within a year compared to 1000 or 100 people. GDP Per Capita ($ 1000): The share of each person from the GDP-GR and Total labor force Growth Rate (TLF_GR) [19].

**Predictor variables (patent variables)** (the number of inventions for a population of one million) As it is shown in Figure 1 including the number of patents related to environmental technologies (PAT_ENV), the number of patents related to environmental management (PAT_ENV_MAN), and the number of patents related to water adaptation technologies (PAT_ENV_WAT) as indicators for sustainable technology transfer and variable technologies related to climate changes mitigation (PAT_ENV_CLIM) (the number of patents per a population of one million people) were used as an indicator for the number of patents related to climate changes mitigation [19]. All of these variables are defined as standard on the OECD website and their information can be extracted. Variables and their relations are shown in Figure 2 as a conceptual model.

4. RESULTS

4.1. Statistics

Figure 3 shows a comparison of selected environment related patents percentage in each of the countries of the Middle East.
Figure 4. The number of selected-environment related patents in the Middle East from 2010 to 2016 (source: OECD).

Table 2. Number of environmental management patents by country and year in the Middle East.

| Country     | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|-------------|------|------|------|------|------|------|------|
| Iran        | 4.5  | 4.83 | 1.5  | 4    | 7.75 | 10.5 | 15   |
| Jordan      | 0    | 2    | 1.5  | 4.83 | 58.7 | 42.33| 2    |
| Turkey      | 29.25| 62.03| 24.42| 53.5 | 53.5 | 42.33| 61.58|
| Saudi Arabia| 36.33| 57.07| 56.13| 62.75| 62.75| 84.67| 63.65|
| Iraq        | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Oman        | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Kuwait      | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Palestine   | 67.6 | 15   | 16.5 | 3    | 3    | 6    | 5    |
| Qatar       | 0.5  | 6.5  | 3.83 | 0.5  | 7.33 | 3.83 | 11   |
| United Arab Emirates | 3.67 | 9.33 | 9.5  | 7.33 | 8.37 | 16.5 | 7.25 |
| Syrian      | 3    | 1.5  | 0.33 | 2    | 3    | 0    | 0    |
| Lebanon     | 3    | 4    | 0.5  | 9.5  | 1    | 2    | 4    |
| Yemen       | 3    | 4.73 | 8.07 | 2.63 | 5.5  | 7.83 | 1.58 |
| Egypt       | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Bahrain     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

Source: OECD

Table 3. Number of water-related adaptation patents by country and year in the Middle East.

| Country     | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|-------------|------|------|------|------|------|------|------|
| Iran        | 0    | 0.5  | 0    | 0.33 | 0    | 1.25 | 2    |
| Jordan      | 5    | 5.5  | 0    | 2.5  | 6.5  | 11.33| 11.33|
| Turkey      | 7.83 | 13.83| 9.33 | 14.83| 9.33 | 11.33| 12.92|
| Saudi Arabia| 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Iraq        | 0    | 0    | 0    | 3    | -    | 2    | -    |
| Oman        | 0    | 0    | 0    | -    | 0    | -    | -    |
| Kuwait      | 1.33 | 0    | 1    | 1    | 1    | 1    | 4    |
| Palestine   | 0    | 0    | 0    | 2    | -    | 2    | 6    |
| Qatar       | 0    | 1    | 0    | 2    | 0.5  | 5.5  | 0    |
| United Arab Emirates | 0.33 | 1    | 1.83 | 0.83 | 5.5  | 3.5  | 0.5  |
| Syrian      | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Lebanon     | 0    | 0    | 2    | 0.25 | 0    | 2.5  | -    |
| Yemen       | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Egypt       | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Bahrain     | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

Source: OECD
region between 2010 and 2016. As can be seen, Saudi Arabia with 37%, Turkey with 36%, Iran and the United Arab Emirates with 6% and Egypt with 5% have the largest share of environmental innovations in the Middle East. Undoubtedly, Iran, considering its scientific and professional capacities, can significantly increase this share with proper planning.

Table 2 shows the number of environmental management patents by country and year in the Middle East between 2010 and 2016. As can be seen, the political, economic and social conditions in different countries have a direct impact on the level of attention of these countries to innovations related to environmental management.

Table 3 shows the number of water-related adaptation patents by country and year in the Middle East region between 2010 and 2016. According to the data in the table, despite the importance of the issue in this region, most of the countries in the Middle East region are weak in the time period regarding innovations related to water adaptation.

Table 4 shows the number of climate change mitigation patents by country and year in the Middle East between 2010 and 2016. As can be seen, the innovations related to the climate change mitigation in the mentioned period have been given more attention than the other environmental innovations discussed.

Special Statistics of Iran.

Table 5 contains Iran's statistics during 2010 to 2016 and Figure 5 shows the situation of Iran in terms of environmental patents, by type in the period 2010–2016. As it is seen Iran's operation in innovations related to climate change mitigation and environmental management is far better than innovations in water-related adaptations.

Upgrading technology directly affects production growth. If the necessary training is conducted on technology innovations, such a factor will show itself more. In fact, technology management will increase the effect of technology on economic growth. Thus, some measures should be taken for training individuals and communities about the changes related to the creation of technology and its use. Universities as one of the significant and main centers can be effective in promoting technology by fostering innovators and approving some policies to support innovation [46]. Other studies indicated that combining independent venture capital and technological government venture capital affects the innovations which can be patented [46]. The process of innovation and invention fails to have a regular and sustainable pattern of economic growth in Iran as in other developing countries. The lack of a sustainable model in the macro management of the innovation ecosystem in Iran has made different components of...
this system not to interact appropriately with each other and the private sector cannot play its role well in the national potential for innovation. Research and development units in valid companies in the world seek to provide some solutions, support technological innovations and create a technology having a competitive advantage. Technological innovation indirectly, i.e. technological imitation, affects the growth of production. Such an effect can increase if environmental technologies are imported from developed countries. Therefore, successful steps can be taken in this field by designing an efficient and systematic system of innovation, establishing effective communication between related institutions and spending money on research and development to enter technologies suitable for the environmental needs of Iran, so that positive effects on the rate of innovation and economic growth can be achieved [49]. On the other hand the Iranian economy is highly dependent on oil exports and the price of oil, therefore by developing renewable energy sources and related technologies, Iran would be in a position to conserve its oil resources for export, thereby increasing its GDP [50].

Here are some suggestions for improving the performance of policy-making entities in the country:

1. Defining national research projects for identifying the specific environmental problems of Iran which require appropriate technological innovation
2. Having governmental support for international patents with an environmental approach

### Table 5. Data related to Iran from 2010 to 2016.

| Variable               | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  |
|------------------------|-------|-------|-------|-------|-------|-------|-------|
| GDP Growth Rate        | 5.80  | 2.65  | -7.44 | -0.19 | 4.60  | -1.32 | 13.40 |
| Population             | 73762519 | 74634956 | 75539862 | 76481943 | 77465753 | 78492215 | 79564016 |
| GDP per Capita         | 6.60  | 7.78  | 7.93  | 6.02  | 5.59  | 7.78  | 5.25  |
| Total Labor Force      | 24034962 | 24157199 | 24267244 | 24357605 | 24417864 | 25359406 | 26559651 |

Source: OECD and World Bank Database

### Table 6. Correlation matrix for variables used in experimental analysis.

| Variable          | Mean | SD  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
|-------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GDP_Gr            | 4.11 | 3.93| NC  |     |     |     |     |     |     |     |     |
| POP_Gr            | 3.46 | 2.25| 0.23| 4.97|     |     |     |     |     |     |     |
| GDP_PC            | 23.45| 23.57| 0.27| 0.48| 2.89|     |     |     |     |     |     |
| Tlf_GR            | 4.12 | 2.83| 0.37| 0.82| 0.46| 4.42|     |     |     |     |     |
| PAT_ENV           | 12.75| 9.90| 0.24| 0.06| 0.22| -0.18| 2.60|     |     |     |     |
| PAT_ENV_MAN       | 0.92 | 1.12| 0.19| 0.2 | 0.17| -0.21| 0.98| 2.42|     |     |     |
| PAT_ENV_WAT       | 0.18 | 0.28| -0.13| -0.06| 0.21| -0.14| 0.96| 0.93| 1.73|     |     |
| PAT_ENV_CLIM      | 1.12 | 0.99| 0.31| 0.28| 0.2 | -0.21| 0.99| 0.94| 0.94| 2.99|     |

Note: VIF bold on diameter; NC = not calculated

Result: The results show that there is a positive and significant correlation between environment-related, environmental management, water adaptation and climate change mitigation patents with real GDP index. Also, the variance inflation factor of independent and control variables was within its allowable limit and no variable with multicolinearity effects was found.

### Table 7. Results of unit root test of research variables.

| Variables       | Levin, Lin and Chu test results |
|-----------------|---------------------------------|
| GDP_Gr          | -10.67/(0.00)                   |
| POP_Gr          | -7.32/(0.00)                    |
| GDP_PC          | -2.13/(0.01)                    |
| Tlf_GR          | -6.12/(0.00)                    |
| PAT_ENV         | -4.72/(0.00)                    |
| PAT_ENV_MAN     | -3.40/(0.0003)                  |
| PAT_ENV_WAT     | -5.12/(0.00)                    |
| PAT_ENV_CLIM    | -2.12/(0.0169)                  |

Result: Considering that in the unit root test, the null hypothesis indicates the anonymity of the variables, in this case, if the probability value is less than the significance level of 0.05, the null hypothesis will be rejected. Thus, the results of the Mana test for composite data (panel) indicate that all the studied variables are Mana. The numbers in parentheses indicate the probability value.

1. Defining national research projects for identifying the specific environmental problems of Iran which require appropriate technological innovation
2. Having governmental support for international patents with an environmental approach
are explained. In this part the results of data analysis using Eviews 10 software are explained.

### 4.2. Data analysis

In this part the results of data analysis using Eviews 10 software are explained. Table 6 shows the descriptive statistics including the central mean index and the scattering index of standard deviation and correlation coefficients for the internal variables used in econometric modeling. Before estimating the model, examining the correlation of the model variables can be very appropriate. Pearson correlation coefficient varies between 1 and 1. The correlation indicates the collinearity of the model components. If the Pearson correlation is more than 0.7 and significant, then there is a possibility of collinearity in the model. In addition, the positive coefficients indicate a direct relationship between them, i.e. if one of the variables increases (decreases), the other increases (decreases), and the negative coefficient indicates an inverse relationship between them, i.e. if one variable increases, the other variable decreases and vice versa. As can be seen, in some cases the correlations are significant, so the possibility of collinearity in the model cannot be ruled out, which is determined by PCA analysis.

Numbers on the diameter indicate the VIF. Collinearity means that there is a strong relationship between the independent and control variables in the model. If there is collinearity, the estimation coefficients of the model will have a high standard error and as a result this will reduce the number of significant variables in the equation. In this equation, the VIF was used to check for the absence of collinearity. When the variance inflation index is less than 10, it indicates no collinearity.

One of the major problems in data analysis is the existence of a unit root (Table 7). The existence of unit roots means that the data is anonymous and this leads to problems in the validity of the tests performed. In other words, if the variables are not constant, we will experience false regression; therefore, before estimating the model, to ensure that it is not fictitious and has unreliable results, it is necessary to make sure that the variables are meaningful. The unit root test is one of the most common tests used to determine

| Table 8. Kao test result. |
|---------------------------|
| T-statistics | P-value | Result |
|----------------|---------|--------|
| -2.60         | 0.004   |        |

The results indicate the presence of cointegration in the model ($P < 0.05$), in other words, the hypothesis $H_0$, which indicates the absence of cointegration, is rejected. Therefore, it can be said that there is a long-term relationship between dependent variables and independent variables.

| Table 9. Jarque–Bera Test result |
|----------------------------------|
| T-statistics | P-value | Result |
|--------------|---------|--------|
| 4.64         | 0.09    |        |

In this test, it is assumed that the modeling errors are not normal unless proven otherwise. Therefore, according to the results, because the probability value for all research models is more than 0.05, so the null hypothesis is not rejected for them and the modeling errors are normal. (Figure 6)

3. Facilitating and reducing the process of establishing private companies based on patents and supervising their activities
4. Creating patent consulting companies in the fields related to the environment
5. Making professors and students familiar with domestic and international patents
6. Creating an active and dynamic structure at universities for performing the affairs related to domestic patents, especially in the international field with an environmental approach
7. Creating some courses related to patents at the universities in the country
8. Appropriate international relations in different fields of intellectual property, especially in the fields related to the environment
9. Reviewing some patent laws for accelerating the process of patent
10. Approving a law for granting privileges to the people who have innovated or invented in the field of environment in the process of their higher education, employment or promotion
11. Reducing bureaucracy and facilitating rules in relation to university and industry
12. Strengthening expert human resources in the field of environmental innovations

| Table 10. Results of F-Limer (Chow) test. |
|----------------------------------------|
| T-statistics | P-value | Result |
|--------------|---------|--------|
| 1.7          | 0.123   |        |

The results show that the fixed effect is not confirmed against the least squares method ($P > 0.05$), in other words, the consolidated data against the panel data and the homogeneity of the intercepts confirming.

| Table 11. Results of different models estimated for the whole sample. |
|---------------------------------------------------------------|
| Econometric model-regression coefficients (standard error) | Model 1 | Model 2 | Model 3 |
|---------------------------------------------------------------|
| POP_GR                                                        | 0.48 (0.16) | 0.77 (0.35) | 0.45 (0.18) |
| GDP_PC                                                        | -0.2 (0.08) | -0.16 (0.07) | -0.17 (0.08) |
| TLF_GR                                                        | -0.1 (0.1) | -0.16 (0.25) | -0.08 (0.11) |
| PAT_ENV                                                      | -0.02 (0.04) | -        |        |
| PAT_ENV_MAN                                                   | -        | -        | 0.04 (0.01) |
| PAT_ENV_WAT                                                   | -        | -        | -0.13 (0.02) |
| PAT_ENV_CLIM                                                  | -        | -        | 0.02 (0.03) |
| n                                                            | 105      | 105      | 105     |
| R²-adjusted                                                  | 0.7      | 0.39     | 0.71    |

The adjusted coefficient of determination $R^2$ is a measure that describes the strength of the relationship between the dependent variable and the independent variables. The value of this coefficient actually determines what percentage of the variables of the dependent variable is explained by the independent variables.

Note: The probability value less than 0.05 is a significant sign of the relevant variable.
the significance of variables, for which the Levin, Lin and Chu method has been used.

Examining the existence of cointegration is also very important in panel data (Table 8). If the model variables are not static, the model estimate may lead to a false regression. In the cointegration test, the null hypothesis indicates the lack of cointegration between the variables in all cross-sectional units and the opposite hypothesis indicates the cointegration of the variables.

Jarque–Bera test (Figure 6 and Table 9) is used to check the normality of modeling errors due to the importance of normality of modeling errors in the research model.

Before estimating the models, it must first be determined whether there is a need to consider the structure of the data panel (differences or country-specific effects) or whether data from different countries can be compiled using the pool method and use it in model estimation. In single equation estimates, the F-Lim test statistic (Table 10) is used to make the decision. In this test, H0 hypothesis shows the use of pool data method as opposed to H1 hypothesis, i.e. the use of panel data method.

5. CONCLUSION

In general, the variables related to the transfer of the technologies related to environmental sustainability have a significant positive effect on economic growth. In this regard, different authors stated that climate changes during the recent decades are an evidence for environmental degradation because most of the countries which pursue economic growth and population expansion exploit the natural resources as much as possible. This process has made countries ignore their environment in planning to achieve superior technologies [51, 52, 53].

Due to the positive value of regression coefficient in environmental patents (PAT_ENV) ($\beta = 0.02$) and environmental management (PAT_ENV_MAN) ($\beta = 0.04$), it can be concluded that the transfer of the technologies related to environmental sustainability have a significant positive (direct) relationship ($P < 0.05$) with GDP-GR in the Middle Eastern countries. Thus, the first hypothesis is confirmed. However, water adaptation patents (PAT_ENV_WAT) indicate a direct, significant but negative relationship with GDP-GR in the countries of this region. In the statistics section, the data indicated that the rate of water adaptation innovations is very little and the water issue is one of the most significant environmental problems in the region. Different researchers forecasted that the environmental effects of the economic activities which consume natural resources is one of the problems leading to the collapse of social, biological and economic systems during the second half of the 21st century [54]. In addition, the dimension of environmental sustainability in response to the need for reducing the use of natural resources has caused an economy perspective which can be performed by mixing new technologies instead of changing the use of older technologies [55]. Technological innovations can be regarded as an approach for optimizing the efficient and clean use of vital resources in social, biological and economic systems [56]. The results of the present study confirmed that economic growth is feasible without environmental degradation, providing that the progress is achieved through innovation and sustainable knowledge transfer. Table 11 indicates that the effects of the coefficient of climate changes mitigation patents (PAT_ENV_CLIM) ($\beta = 0.02$) on GDP-GR for the studied countries are direct, positive and significant ($P < 0.05$). Thus, the second hypothesis is confirmed. Regarding the climate changes mitigation due to increased demand for less carbon dioxide and environmentally friendly technologies will cause new opportunities and jobs in the market. Fankhaeser et al. [57] indicated that job creation, innovation and economic growth are among the positive outcomes of mitigating the effects of climate changes. Therefore, there is a strong relationship between green innovation and employment for innovative companies [56]. The present study confirmed that environmental technological innovations can help the economic growth while mitigating the effects of climate changes.

This study provided a deeper understanding for the effects of technology transfer related to environmental sustainability and climate changes mitigation on economic growth and development in the region by explaining how environmental patents affect the economic growth rate of selected countries in the Middle East. Furthermore, the findings of this study contribute to technology transfer policies in the Middle East. Nevertheless, this study failed...
to confirm the positive effect of water adaptation patents on the economic growth of the countries in this region. In terms of the technologies related to environmental management and climate changes mitigation, the results indicated that both types of patents have a significant positive effect on economic growth in the Middle East. Thus, the present study can facilitate the development of technology transfer and innovation strategies which mitigate climate changes and promote economic growth. Since the transfer of innovation related to climate changes has increased during the recent years, a question arises here: how can this process be accelerated more? The present results include no evaluation on the potential of different policies. Nevertheless, the pollutants emissions rules are clearly a factor which strengthens the market for environmentally friendly technologies and encourages companies to acquire new technologies. Such a conclusion was confirmed by Lanjouw and Mody [58]. On the other hand, the development of technology requires investment from the public and private sectors. In addition, such investments should be made in the key industries and the public sector to mitigate carbon dioxide emissions. Environmentally friendly technologies are developed through strong government support in form of tax incentives, research and development subsidies, favorable regulatory frameworks, and budget policies. On the one hand, the widespread public participation in such technologies can provide governments with sufficient leverage for spreading innovations more to serve the larger public interest. On the other hand, such policies may create an effective cooperation between countries to facilitate technology transfer and sustainable technology transfer.

The goal of mitigating the greenhouse gas emissions is a key to stimulate private investment in research and development in the future. As a result, human resources and organizational development are vital for facilitating the use of technology [19]. Climate changes mitigation and environmental sustainability capabilities in countries can be improved when environmental technological policies are integrated with national sustainable development strategies. Such technological capabilities improve innovation and market access and also strengthen competition. Therefore, the most significant strong driver for climate changes innovation may not be climate changes or even environmental quality parameters, but the main driver of economic development and growth related to the efforts to minimize and reverse climate changes [19]. Like any other study, there are some limitations which should be addressed in future studies. The present study focused on the data related to three specific kinds of environmental patents in the Middle East. Thus, future studies may apply this framework in other contexts, evaluating other variables or regions. It seems that further studies are required for understanding how different kinds of stakeholders affect the process of sustainable technology transfer or how different policy factors may affect the number or efficiency of environmental patents. In addition, the extent and form of the role of developing countries in innovative cooperation leading to the creation of environmentally friendly patents are some significant points which should be addressed.

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