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FUTUROLOGY OF CLIMATE CHANGE AND EXPORT STRATEGIES OF AGRICULTURAL PRODUCTS IN IRAN

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3 tables and 2 figures

Abstract

Aim of study: In recent years, the consequences of climate change in the form of long droughts have affected the trade of agricultural products. In the present study, changes in the cropping patterns of agricultural products were assessed with a futuristic approach to increase the

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perspective, prepare for the future water crisis, and also to formulate appropriate strategic policies.
Area of study: This study was carried out in Iran.
Material and methods: To develop appropriate strategies for cultivating commercial agricultural products; the export of agricultural products was classified according to the type of water requirement into two groups of high water-demand products (13 items) and low water-demand products (4 items) during the period 2001-2017, and the effects of two factors of precipitation and temperature on the panel data models in each group were tested.
Main results: The estimation results of the models showed that the sensitivity of exporting the selected products to the precipitation variable in both groups was positive, and the intensity of this sensitivity in the high water-demand group (22%) was higher than that in the low water-demand group (18%). The export sensitivity to the temperature index was also evaluated as very high and positive in both models. The export behavior of selected agricultural products in both groups in the face of climatic tensions was inversely U-shaped.
Research highlights: According to the findings, the export of agricultural products in droughts shifted to items that were more resistant to climatic tensions. Therefore, changing the cropping pattern reduces the risk of agricultural trade in the event of future climate crises.

Keywords: Futurology, Climate change, Export strategy, Agricultural products, water management.

Futurología del Cambio Climático y Estrategias de Exportación de Productos Agrícolas en Irán

Resumen

Los impactos acelerados del cambio climático, especialmente las sequías prolongadas, están transformando los patrones de comercio agrícola global y plantean desafíos críticos para economías dependientes de la exportación como Irán. A pesar de la creciente relevancia de esta problemática, los estudios cuantitativos integrales que analicen la sensibilidad diferencial de las exportaciones agrícolas según la intensidad de consumo de agua son todavía escasos en la literatura existente. Este estudio tiene como objetivo reducir esta brecha al prever las implicaciones de la variabilidad climática—en particular las fluctuaciones de precipitación y temperatura—sobre los patrones de exportación de productos agrícolas iraníes, enfocándose en fortalecer la capacidad adaptativa y proporcionar una base para la formulación de políticas estratégicas resilientes.

Para alcanzar este objetivo, los productos agrícolas se clasificaron en dos grupos según su intensidad de consumo de agua: productos de alta demanda hídrica (13 ítems) y productos de baja demanda hídrica (4 ítems), abarcando el periodo de 2001 a 2017. Mediante la utilización de modelos de regresión de datos de panel, se evaluó cuantitativamente la sensibilidad de los volúmenes de exportación frente a las variaciones de precipitación y temperatura en ambas categorías. Los resultados empíricos revelaron una elasticidad positiva de los volúmenes de exportación respecto a la precipitación en ambos grupos, con una mayor sensibilidad observada en los productos de alta demanda hídrica (22%) en comparación con los de baja demanda hídrica (18%). Además, la temperatura mostró una correlación positiva significativa con el desempeño exportador, subrayando su papel determinante como factor climático. El comportamiento exportador presentó una trayectoria en forma de U invertida frente al aumento de las tensiones climáticas, indicando un umbral a partir del cual las exportaciones se orientan hacia productos más resilientes al clima.

Estos hallazgos resaltan la necesidad de revisar los patrones de cultivo como una estrategia de adaptación proactiva para mitigar las vulnerabilidades comerciales ante futuras crisis climáticas. Los resultados ofrecen orientaciones prácticas para los responsables de la formulación de políticas y los actores involucrados en la planificación de exportaciones agrícolas, facilitando el desarrollo de estrategias alineadas con una gestión sostenible de los recursos hídricos y la resiliencia comercial a largo plazo.

Palabras clave: Evaluación de Impacto del Cambio Climático, Análisis de Sensibilidad de Exportaciones, Adaptación de Patrones de Cultivo, Resiliencia del Comercio Agrícola, Modelado de Datos de Panel.

Abbreviations used:
ARDL (the Autoregressive Distributed Lag models)
COVID-19 (the pandemic Coronavirus disease 2019)
DCGE (the dynamic computable general equilibrium model)
EKC (the Environmental Kuznets Curve)
FAO (the Food and Agriculture Organization of the United Nations)
IAAS (the International Association for Agriculture Sustainability)
JCPOA (the Joint Comprehensive Plan of Action)
MCS (the Monte Carlo Simulation method)
MENA (the Middle East and North Africa region)
SAM (the Social Accounting Matrix approach)
WUE (water-use efficiency)

Introduction

As one of the key drivers of current and future life on Earth, climate change has exacerbated some of the challenges and is strongly affected by some factors. The global temperature of the Earth and the oceans passing the twentieth-century average temperature (1.14 °C of increase) experienced the highest record of the past 141 years in January 2020 (Lindsey and Dahlman 2020). Different changes have happened in human life due to the development of industry and the mechanization of affairs in the nineteenth century and the increasing growth of human activities.

The overuse of stored resources and fossil fuels such as coal, oil, and gas has led to the formation and intensification of greenhouse gases in the Earth's atmosphere. In 2000, some parts of the Middle East and West Asia warmed by 1.5 to 2 °C. The whole planet changed by two degrees Celsius in 2020, turning this situation into a theory or prediction that is an acceptable concept to all. It is predicted that these changes will reach 4 degrees Celsius in 2040 with the current situation, and the world is extremely worried about that, which could cause problems in case of happening (Bates, Kundzewicz and Wu 2008).

Food crises caused by external shocks, such as global climate change and commodity market instability, make farmers vulnerable in different areas (Chhogyel, Kumar, Bajgai and Hasan 2020). Regarding this, the continuous population growth on the earth has led to an increase in agricultural and livestock activities as well as extensive changes in land, forests, and reserve resources and has other destructive and negative effects. The phenomenon of climate change is one of these effects with a key role in the agricultural sector (Angel 2008).
Given its very close relationship with natural resources and climatic conditions, the agricultural sector is vastly affected because of the severe changes in temperature and precipitation, and thus the changes in water available to farmers. The changes in climatic parameters, such as precipitation, affect the performance of agricultural products in addition to the water resources available to the agricultural sector, which consequently change the agricultural exports and imports. This is an issue that will pose a serious problem for the country's strategic system if not dealt with in policy-making.
One of the main consequences of drought and the reduction of water resources is the change in the cropping patterns of agricultural products based on their irrigation rate and their resistance to water shortage. The export of agricultural products in the country can be affected by changing the composition of these products. Switching to crops with higher water-use efficiency (WUE) could be the result of reduced annual precipitation and groundwater resources. Growth and increase in the value added of the agricultural sector in the current situation of Iran's economy; which faces numerous environmental, structural, and international constraints; could be one of the strategic ways to overcome the economic problems in the future.
The quadruple drivers of population growth, territorial resources, geographical conditions, and the growth of scientific and technical capabilities will be the key elements in shaping the world trade order in the future. Iran and, more broadly, the Islamic world have always been attacked by greedy countries and have lost the opportunity to perform a favorable role in the world trade order owing to their unique geopolitical position and also their territorial capacities and resources. Foreign trade is a source of foreign exchange earnings for investing in new technologies and increasing the country's productive capacities. Therefore, the present study examined the strategies for using the cropping patterns in proportion to water limitations for selected export agricultural products.

Theoretical Foundations and Study Background

The phenomenon of climate change, as it is affected by various human activities, has different effects on human activities. One of the key elements of climate change in recent decades is the intensification of the impact of human activities on the environment (Najafpour 2007, Trenberth 2018). Based on the statistics of the Ministry of Agriculture Jihad (2017), the average irrigation efficiency in Iran is less than 35%, and only 5% of the cultivated area is irrigated using pressurized irrigation systems. Nevertheless, the area of the rainfed agricultural lands is equal to the area of the irrigated agricultural lands. Around 11.77 million hectares of the crop area of the total harvested land in the 2015-2016 crop year were reported, 51.93% and 48.07% of which were irrigated agricultural land and rainfed agricultural land, respectively.
Considering the instability of climatic conditions, lack of uniform spatio-temporal distribution of precipitation, and erratic changes in air temperature in Iran; it is crucial to contemplate the

stability of water resources, the producing methods of agricultural products, land-use changes, and the approaches to deal with climatic stress and drought. Since one of the main objectives of the policy-making of governments in the agricultural sector is to increase production and expand exports; the rate of change in production, exports, and imports is of great importance, considering the climatic conditions.

According to the statistics reported by Iran Water Resources Management Company in 2018, Iran’s climate and geography have always been stated as a semi-arid and arid country with subtropical climates, and most of its regions (about 70%) are arid. Consequently, Iran has long relied more on groundwater and water supply networks through aqueducts and local inflows and also on water storage by cisterns. The total precipitation height from September 22 to November 9 of the water year 2016-2017 was over 12.5 mm. This much precipitation showed a decrease of 38.4% compared to the average precipitation of similar long-term periods (20.3 mm) and a decrease of 75.3% compared to the same period of the previous wet year (50.7 mm). Nonetheless, there was a relative increase in the average precipitation in the 2017-2018 water year. However, the average annual precipitation in Iran is one-third of the world’s average annual precipitation. It is also important to note that 70% of precipitation is lost because of evaporation. Given the conditions resulting from the geographical location of Iran, it is expected that the per capita water resources in Iran will reach 816 m^3 in 2025 (Qasemipour, Tarahomi, Pahlow, Malek Sadati and Abbasi 2020).

On the basis of the data reported by Iran’s National Agriculture and Water Strategic Research Center, the export rate of agricultural and food products in March-December 2019, in terms of value, accounted for 13.2% of Iran’s total non-oil exports. Major products of the total export agricultural products included different tree fruits (33.7%), various vegetables and kitchen garden plants (22.4%), and saffron (about 5%).

Iran's foreign trade flows depend heavily on the foreign exchange earnings from oil exports. This fact shows Iran's reliance on the export of petroleum products to earn foreign exchange earnings (Amiri H and S.A 2021). Over the past years, the share of the agricultural sector in the value-added of Iran’s economic activities has always been in the range of 6%, while the service sector has the largest share of the Iranian economy due to the Dutch disease. The industries and mines sector possesses the second largest share, which is mainly due to the high share of oil revenues in this sector. Figure 1 indicates that the potential of the agricultural sector has not been fulfilled in the Iranian economy.

Considering the severe oil sanctions against Iran along with the sharp decline in oil prices due to medium-term phenomena such as the Middle East tensions and the pandemic Coronavirus disease 2019 (COVID-19), the oil revenues will not meet the government’s expenditure in the near future. In a situation where the value of the national currency against other currencies has decreased; the export of agricultural products through the foreign exchange inflow can significantly promote farmers' welfare in addition to increasing the country's revenue sources if effective redistribution policies are implemented. Furthermore, the resulting overflow effects can be fruitful in other sectors of the economy.

The values of the non-oil exports of major sectors from 2011 to 2018 are given in Figure 2 based on the information published by the Trade Promotion Organization of Iran. The results

in Figure 2 reveal that after gas condensate, petrochemicals, and industry; the agricultural sector has the fourth-largest share of non-oil exports, which has not changed over the years. Despite the politicians' emphasis on agriculture and different subsidies in this sector, the share of production and exports in this sector is much lower than that in industry. A large part of this difference, which is incompatible with the comparative advantage of the agricultural sector in the Iranian economy, is because of inattention to the cropping patterns appropriate to the climatic conditions.
Several studies have been carried out on the climatic factors that affect the trade strategies of agricultural products. Khaleghi et al. (2015) examined the effect of climate change on agricultural production through the Social Accounting Matrix (SAM) approach. In this regard, the agricultural production function, in which climate (temperature and precipitation) was one of the effective elements, was estimated using the Autoregressive Distributed Lag (ARDL) models. The findings indicated a negative and significant effect (-5.37%) of climate change on agricultural production (Khaleghi S, Bazazan F and Sh 2015).
Pishbahar et al. (2016) evaluated the effect of reduced precipitation on the production, export, and import of the main items of foreign trade agricultural products from 1981 to 2011 using the Monte Carlo Simulation (MCS) method. The results indicated that with decreasing precipitation, the wheat supply decreased more than that of the other agricultural products, while the supply of apples declined less than that of the other products. In the case of the trade sector, the findings revealed that the value and export quantity of potatoes were the most reactive to decreased precipitation, whereas the value and import quantity of soybeans were the least reactive to this climatic condition (Pishbahar E, Bagheri P and Nasir Shoeibi 2016).
Ghaffari-Esmaili et al. in 2018 conducted a study to assess the effect of climate change on the economic growth of the agricultural sector of Iran as a dynamic computable general equilibrium (DCGE) model. The study results showed that considering the decreased precipitation rate in a twenty-year time horizon by 2030, the amount of production, consumption, investment, and export of the agricultural sector will decrease, yet the amount of imports in this sector will increase (Ghaffari-Esmaeli, Akbari and KashiriKalaei 2018).
In 2019, Jashari and Moradi formulated strategies for the development of agricultural economics in the province of Sistan and Baluchestan in Iran. By distinguishing the effective drivers for the development of the agricultural economics in the area; they found that the most likely scenario, among various scenarios, was that the strategies for promoting specialized and applied training and human resource empowerment, the advancement of pressurized irrigation systems, and the continuation of government investments in improving the regional infrastructures especially transportation, cold storage, and converting industries for the development of the province were suggested (Jashari and Moradi 2019).
Using climatic parameters in hot-humid and hot-dry regions, Aliahmadi et al. (2020) examined the effect of climate change on the risk and yield of dates production in Iran from 1982 to 2016. The resulting temperature and precipitation indices were 0.45 and 0.66 for hot-humid regions and 3.04 and 0.18 for hot-dry regions, respectively, which showed the regional effects on date production. Accordingly, annual climate changes created unfavorable conditions for the farmers (Aliahmadi, Hashmitabar and Hoseini 2021).
Bazi et al. (2020) explained the strategic model of E-commerce in the export of agricultural products with an emphasis on the resistance economy. According to the results; twelve indices

including developing telecommunications technologies and infrastructures, strengthening information security technologies, adaptability to technological changes, developing a knowledge-based economy, general training of E-commerce skills, facilitating tax and customs laws, developing electronic economy and banking, strategic orientation and risk management, improving commercial relations, transparency of E-commerce laws, export process flexibility, and developing complementary and converting industries had the biggest effects on the future of the agricultural exports with an emphasis on E-commerce (Bazi, Shojaee, Isfandyari Moghadam and Samiee 2020).

Among the international studies, Tekce and Deniz in 2016 investigated the effect of climate change on agricultural trade in the Middle East and North Africa (MENA) region. Introducing variables like temperatures and precipitation patterns as the indicators of climate change, the impact of changes in these indicators on agricultural imports and exports was assessed using a panel data analysis from 1980 to 2013. The analysis presented that the effect of temperature changes on agricultural imports was negative; however, precipitation levels, as the other indicator, did not indicate any significant effect on the export and import of agricultural products (Tekce and Deniz 2016).

Using evidence from various areas of Nepal, Barrueto et al. (2017) analyzed climate change with a new method to gain a deeper insight into the impact of this phenomenon on the steps of an agricultural market system. The findings of the spatial climate analyses displayed that the climate change variables, including precipitation levels and temperatures, varied according to the climatic conditions of each region. Furthermore, the market functions within and between each of the sub-sectors responded differently to climate change (Barrueto, Merz, Clot and Hammer 2017).

The effect of climate change on US agriculture was studied by Keane and Neal in 2018. They surveyed the productivity response of agricultural products to climate change using the panel data of the 1950-2015 period. Based on the results, the reduction of climate change had a huge impact on agricultural production, and adapting and equipping agricultural products with climatic conditions reduced 10-45% of the destructive effects of climatic stress on agricultural production (Neal and Keane 2018).

Khan et al. (2019) investigated the effect of climate change on agricultural exports in Pakistan by time series data analysis. This study evaluated the effect of CO_2 emissions on the export of Pakistani agricultural products during 1975-2017. The empirical evidence of the study demonstrated that climate change was the primary cause of declining the agricultural exports, and the CO_2 emissions impacted the trade negatively (Khan, Bin and Hassan 2019).

Chhogyel et al. (2020) studied the farmers' awareness of climate change in agricultural production, such as different strategies to deal with this phenomenon used in rural areas of the Himalayas. According to the findings, climate change for most farmers meant unpredictable climate change (79%), little precipitation or no precipitation (70%), and drying irrigation resources (55%). Also, the effects of climate change were estimated to be the cause of 10-20% of the damage to the products (Chhogyel, Kumar, Bajgai and Hasan 2020).

In a study by Srivastav et al. in 2021, the strategies for the resistance of agricultural products to climate change were evaluated. The findings exhibited that water management reduced the negative effects of climate change on the availability of water resources by increasing water storage capacity (or rainwater storage), equitable policies towards water supply and water

distribution, river health, and watershed management. Similarly; the development of crops resistant to climate change, water management in irrigation, the adaptation of the smart farming approach to climate, and the promotion of indigenous knowledge ensured food security by increasing agricultural efficiency. Moreover, technical intervention equipped farmers with the scientific analysis of climatic parameters required for sustainable agricultural management (Srivastav, Dhyani, Ranjan, Madhav and Sillanpää 2021).
Based on the literature, one of the significant differences between the present study and previous studies is that the main studies conducted in Iran have considered the export strategies of agricultural products affected by climate change as single-product productions or as activities in the agricultural sector. In the present study, the export values of agricultural products (arable and horticultural) were analyzed according to their water needs, and the way of adjusting the export policies of the agricultural sector in different climatic conditions was evaluated.

Materials and Methods

Data Analysis

Panel data models were used during the period 2001-2017 in the present study to evaluate the effect of climate change on the selection strategies for the export of agricultural products. Accordingly, the export of major arable and horticultural crops based on their irrigation rate as a dependent variable and the variables of annual precipitation and temperature changes (maximum and minimum temperature) as the main factors affecting the composition of agricultural exports were applied. Control variables were selected based on the study background and the statistical limitations.
In order to examine the effect of climatic conditions on the export of agricultural products, the export products were selected based on their export values and classified according to their water needs into two groups of high water-demand products and low water-demand products. Table 1 presents the classification of items based on their water needs. It should be noted that this classification is based on the information obtained from the Food and Agriculture Organization of the United Nations (FAO), the International Association for Agriculture Sustainability (IAAS), and the Statistical Center of Iran. The statistical information, definition, and data sources of the variables, considering their corresponding groups, are shown in Table 2.

Research Model

The low water-demand and high water-demand export items were estimated in separate panel data models to examine the effect of climatic conditions on the export of the selected agricultural products. In selecting the type of model based on the test performed (F-Limer test), a fixed effects model was preferred to a pooled effects model. According to the F-Limer test results of the high water-demand products, the values of statistics in the first group and the second group were 50.06 and 55.45, respectively. Additionally, the values obtained from the test results of the low water-demand products were 205.96 and 204.93 in the first group and the second group, respectively. All the statistics in the estimable groups were estimated to be significant at a 99% probability level.

On the other hand, in selecting between a fixed effects model or a random effects model based on the structural concept, it is better to use the fixed effects panel data model in this study because factors other than the independent variables can be considered to influence the dependent variables; which are in the error component, but they have the same effect on the independent variables over time. Moreover, if the variable in the error component is correlated with the explanatory variables, it is better to apply the fixed effects model (Baltagi 2008). In the present study, there are several key elements, such as the country’s foreign trade policies, that affect the export of the products and some explanatory variables. For instance, the international sanctions against Iran and the Joint Comprehensive Plan of Action (JCPOA) are of great importance. In case of significant improvement in Iran’s trade relations with other countries due to the JCPOA, this plan can lead to economic prosperity in the country and increase the export value of the products, which is always true. In other words, the effect of improving the trade relations on Iran's trade is always positive, which is not a random effect. As a result, it was justifiable to use the fixed effects model in this investigation.

As shown in Table 1, the number of samples in the model with high water-demand products was 13 (n=13), and it was 4 (n=4) in the model with low water-demand products in the same period (2001-2017). In each group; two types of regression were estimated, including the effect of average annual precipitation and the effect of average minimum and maximum temperature. The regressions used in each group of the export products can be defined as follows:

$$Lex_{it} = \alpha_i + \beta_1 Lrain_{it} + \beta_2 (Lrain_{it}^{\ 2}) + \beta_3 Lrex_{it} + \beta_4 Lp_{it} + u_{it} \qquad (1)$$

$$Lex_{it} = \delta_i + \gamma_1 Ltm_{it} + \gamma_2 (Ltm_{it}^{\ 2}) + \gamma_3 Lrex_{it} + \gamma_4 Lp_{it} + u_{it} \qquad (2)$$

In the estimated models, all variables were transformed logarithmically. In Equation 1 and Equation 2, Lex is the factor of the real value of the export of the selected products. The climate index in Equation 1 is Lrain, which is considered the average annual precipitation height. While, this index is shown in Equation 2 by Ltm, which is the average minimum and maximum temperature of the country. As can be seen in Equation 1 and Equation 2, both climate variables are also included in their respective equations in quadratic forms so that the dynamic effects of these factors on the export of various items can be measured. In both equations, Lrex and Lp are the real effective exchange rate and the market price of products, respectively. Also, U is the error component regression. It should be noted that all estimates were obtained using EViews 10 software.

Results and Discussion

The estimation results of the fixed effects panel regression models are displayed in Table 3. As it is evident in this table, different fittings were performed for the products in both the high water-demand and the low water-demand groups. In each group, two separate models were considered according to the climate variables of precipitation and temperature. The F-statistic in both groups of the products and the models confirmed the significance of the regression. The values of the coefficient of determination in the high water-demand group were estimated at 77% and 79% in the first model and the second model, respectively. On the other hand, the

values of this coefficient in the low water-demand group were estimated at 93% in both models. The values of the coefficient of determination obtained in both groups of the products and the studied models indicate a high explanation of the independent variables of the export value of the products.
As can be seen in Table 3, the sensitivity of the export of the high water-demand and the low water-demand items to the precipitation was high and positive, which was estimated at 22% in the high water-demand group and 18% in the low water-demand group. As the first group included the high water-demand export items, their response to precipitation fluctuations was higher than that in the low water-demand group. This conclusion can also be generalized to the square of the precipitation variable so that more sensitivity of the export to the precipitation variable was observed in the high water-demand group (-2.2%) compared to the second group (-1.8%). However, it should be noted that the squares of the precipitation variable were negative. The results of this study on the effect of precipitation on the export of various agricultural items are related to the results of the studies conducted by Barrueto et al. (2017) (Barrueto, Merz, Clot and Hammer 2017); Keane and Neal (2018) (Neal and Keane 2018); Ahmadi et al. (2020) (Aliahmadi, Hashmitabar and Hoseini 2021); and Chhogyel et al. (2020) (Chhogyel, Kumar, Bajgai and Hasan 2020).

Regarding the second climatic factor, temperature, the first and second groups with different coefficients had the same effect on the export in such a way that the export of the products in both groups increased to some extent with an increase in temperature. From a certain range, however, increasing the temperature led to a decrease in the export of these products. Several studies on the effect of temperature on the production and export of agricultural products reported different results (Koocheki, Nasiri Mahalati and Jafari 2015, Mahmoodi and Prhizkari 2015, Tekce and Deniz 2016, Xie, Huang, Wang, Cui, Robertson and Chen 2020). It can be concluded from these studies that the reaction of various agricultural products in production or export is highly sensitive to temperature fluctuations and leads to different results.
The squares of both climatic factors in the first and the second groups showed the existence of an inverse U-shaped relationship between the climate variables and the export of the products. This relationship is known as the Environmental Kuznets Curve (EKC), which has been discussed in the literature about the relationship between environmental decline and income (Kuznets 1955, Dinda 2004). This relationship in the present study shows that climatic factors increase export in the two groups of high water-demand and low water-demand arable and horticultural products up to a certain threshold level; thereafter, these factors reduce the export of the products.
As shown in Table 3, the precipitation affected the export of the products of the high water-demand group (22%) more than that of the low water-demand group (18%). Naturally, drought and the decrease in precipitation reduce the export of agricultural products. These results are in line with those of the study carried out by Ghaffari-Esmaili et al. in 2018 on the effect of reduced precipitation on agricultural exports in the Iranian economy (Ghaffari-Esmaeli, Akbari and Kashiri Kalaei 2018). Based on the results in the present work, the effect of drought on the composition of arable and horticultural products over the recent years has been such that the export of the agricultural sector has been shifted from the products of the high water-demand group to the products of the low water-demand group. In case of reduced precipitation, the

export of the selected products in the first group decreased by 22%; while the export of the products in the second group, more resistant to drought, was reduced by 18%. In other words, with the occurrence of drought and the depletion of water resources, the cultivation of crops that are considered low water-demand products can add more export value to the country. This phenomenon was also true for the temperature variable. The temperature stresses showed a greater effect on the products of the first group in comparison to the products of the second group. This reflects the fact that the fluctuation in the Earth's temperature leads us to the cultivation and consequently the export of low water-demand products.
Therefore, world-famous climatic cycles, such as El Niño, can affect the composition of crops and their trade. The important point here is to make strategic policies in the agricultural sector. The country's groundwater resources have been severely reduced in recent years. On the other hand, climatic fluctuations have a significant impact on the yield of different agricultural products. The results of this investigation indicate that with increasing emphasis on the cultivation of crops with lower water requirements and also with considering the diverse potential of different regions of the country, the share of the agricultural sector in the country's GDP can be increased.
The coefficients of the variable of the real effective exchange rate in both groups of products were estimated to be negative and significant. This shows the negative effect of the real effective exchange rate on the export of the selected products. It is noteworthy that the effective real exchange rate of a country is affected by the nominal exchange rate and the weight ratio of the general level of the prices of trade partners. In this work, the market price of the products in both groups had a positive effect on the agricultural exports.

Conclusions

This study was carried out using panel data models from 2001 to 2017 in Iran to examine the effect of climatic conditions on the export strategy of arable and horticultural products, considering the composition of the products based on their water needs. Thus, two types of agricultural products with various water requirements were used. After selecting and obtaining the panel data on 13 high water-demand export products and 4 low water-demand export products, the fixed effects models were empirically tested in both groups. It should be mentioned that in each group of the products, two models were estimated. In one model, the average annual precipitation height of the country was the climatic factor, and in the other model, the average annual minimum and maximum temperature was considered the climatic factor.
The results indicated that the elasticity of the real value of the selected exports to the average annual precipitation was 22% in the first group and 18% in the second. The increase in the exports in response to the increase in precipitation was up to a certain threshold, after which there was a decrease in the exports in both selected groups. The second climatic factor was the average annual minimum and maximum temperature of the country, and the sensitivity of the export of the products to this variable was very high in both groups. The pattern of the temperature factor was found to be an inverse U-shaped, similar to that of the precipitation variable. Considering the sensitivity of the export of the selected agricultural products to the climatic factors; it can be concluded that in drought conditions, the composition of Iran's agricultural exports shifts to the items that are classified as low water-demand products. In other words, in case of the climatic conditions that threaten the export of agricultural products,

the export of drought-resistant agricultural products decreases less than that of the other products.
The Earth always faces various atmospheric phenomena periodically, each of which alone is enough to discourage the economic growth of a country, especially in the agricultural sector. According to the statistical data, the share of the agricultural sector in the value-added of economic activities is very small. Besides, the financial and economic sanctions, as well as the decline in oil prices, have caused serious problems for the Iranian economy. Hence, the role of strategic policy-making in governing the country is of prime importance in these situations. Considering the results of this work, the country's economic officials should make policies in the agricultural sector in such a manner that it is possible to prevent the devastating consequences of climatic fluctuations for the economic structure of the country by relying on the production and export of climate-resilient agricultural products.

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The authors have declared that no competing interests exist.
Authors' contributions:
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Seyed Yaghoub Zeraatkish (Author 2): Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - Original Draft, Writing-Review & Editing
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Figure Captions:
Figure 1. The share of value-added of economic sectors in Iran’s economy
Figure 2. The values of non-oil exports of major sectors of the Iranian economy (2011-2018)

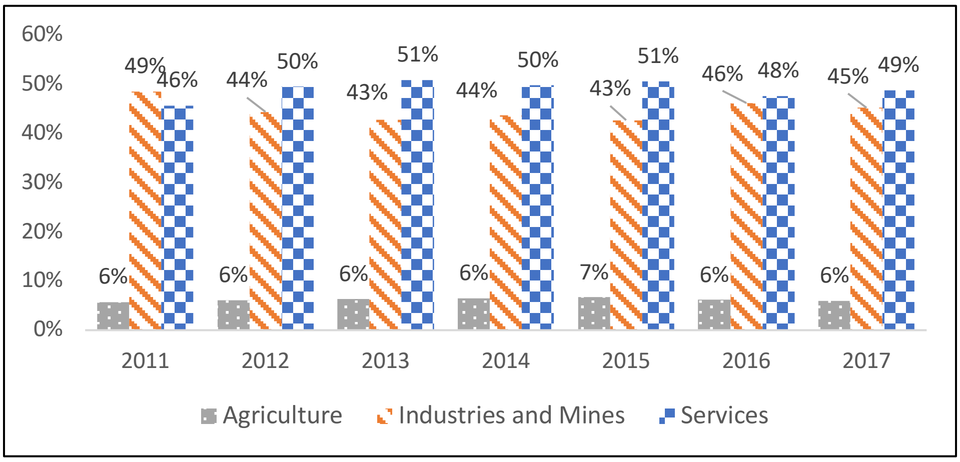

Figure 1. The share of value-added of economic sectors in Iran's economy

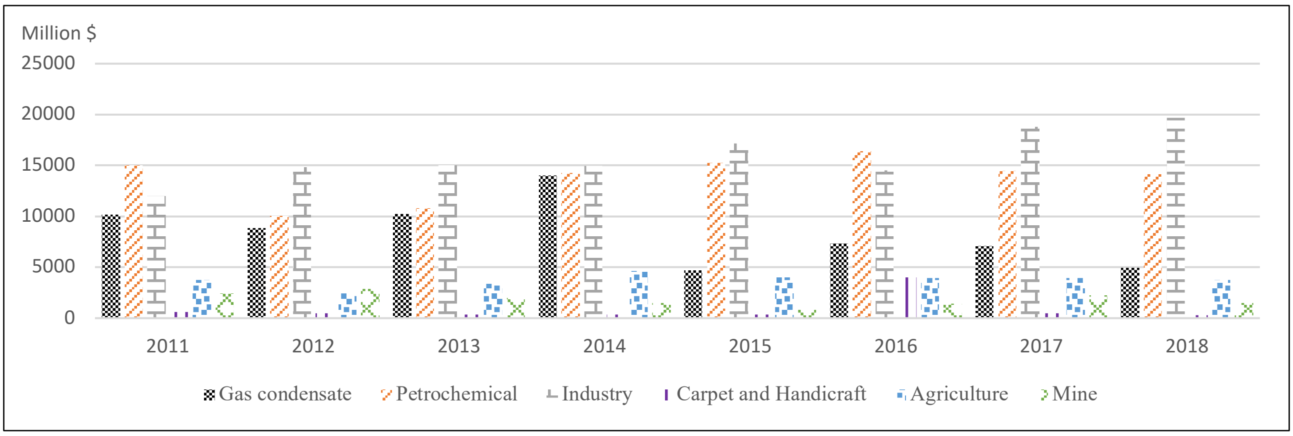

Figure 2. The values of non-oil exports of major sectors of the Iranian economy (2011-2018)

Table 1. Agricultural exports based on their water needs

High water-demand products	Tomato	Watermelon	Potato	Onion	Melon	Cucumber	Rice
	Tangerine	Orange	Peach	Kiwi	Apple		Tea
Low water-demand products		Saffron		Pistachio	Grape		Date

Table 2. Statistical information of the variables of the study (2001-2017)

Variables	Definition	Mean		SD		Min.		Max.		Data Sources
		High	Low	High	Low	High	Low	High	Low	
EX	Real value of exports (million Rials)	16,100	123,000	20,900	161,000	101	43	132,000	552,000	The Islamic Republic of Iran Customs Administration (IRICA)
RAIN	Average precipitation height (mm)	205.09	205.09	51.37	51.37	99.68	99.68	301.48	301.48	Iran Meteorological Organization
TM	Average country temperature (°C)	16.97	16.97	0.5746	0.5746	16.08	16.08	17.90	17.90	Iran Meteorological Organization
REX	Real effective exchange rate (2010-100)	105.52	105.52	50.42	50.42	70.29	70.29	296.28	296.28	World Bank
P	Market price of products (Rials)	5,655	3,241,895	6,223	7,476,967	423	874	39,732	30,083,567	FAO

Table 3. Estimation results of the fixed effects panel models

Product groups	The first group: high water-demand products		The second group: low water-demand products	
Models and variables	Model 1	Model 2	Model 1	Model 2
Precipitation	22.1613** (2.2942)	-	18.2803*** (2.7203)	-
The square of precipitation	-2.2212** (-2.3702)	-	-1.7746*** (-2.6650)	-
Real effective exchange rate	-1.2572*** (-5.2204)	-0.7948*** (-5.1468)	-1.3863*** (-3.9761)	-0.9729*** (-4.5873)
Price	0.5777*** (6.8331)	0.7384*** (8.3128)	0.3733*** (3.7531)	0.8614*** (3.6822)
Temperature	-	538.54*** (2.8654)	-	688.98* (1.8254)
The square of temperature	-	-95.4080*** (-2.8672)	-	-122.23* (-1.8253)
Fixed coefficient	-31.447 (-1.3164)	-739.82*** (-2.7785)	-20.341 (-1.2952)	-947.07* (-1.7798)
The coefficient of determination	0.77	0.79	0.93	0.93
F-statistic Statistic of probability	43.5140*** (0.000)	47.1105*** (0.000)	122.22*** (0.000)	120.12*** (0.000)
Fixed effects test	50.058*** (0.000)	55.4465*** (0.000)	205.985*** (0.000)	204.31*** (0.000)
Number of observations	221	221	68	68

The numbers in parentheses are t statistics; ***, **, and * show the significance of the coefficients at the level of 99%, 95%, and 90%, respectively.