Limitations and Production Capacities of Field and Horticultural Crops in Iran

B. Fakari Sardehae[1], N. Shahnoushi[1*], H. Mohammadi[1], and S. Rastegari Henneberry[2]

ABSTRACT

Planning for the agricultural sector requires identifying the limitations and capacities of field crops and horticultural production. Many studies in Iran have considered one or more dimensions of the agricultural sector; however, few studies have simultaneously examined the factors affecting the production of crops and horticultural products. For this study, data was gathered from 30 provinces in Iran during the period 2008-2016. First, PESTEL analysis variables were identified, and the I-Distance method was used to define the weight of each variable. Secondly, the PESTEL analysis dimensions were calculated by combining the variables of each index. Finally, the PESTEL analysis was combined with the econometric model of the spatial 3D panel. The resulting pattern was estimated by taking into account three dimensions, namely, time, province, and type of production (field and horticulture crops). The results showed that the indicator of environment is the most significant factor in the production of agricultural and horticultural products. Also, the investment factor and the supportive policies indicator are the most limiting factors in the production of field crops and horticultural products.

Keywords: Agriculture, I-Distance, Indicator of environment, PESTEL, Spatial 3D Panel model.

INTRODUCTION

The issue of population growth has always been highlighted as a significant factor in the agricultural sector of all countries. Also, the growing population of different countries, together with the rise in world prices for agricultural products, has led food security to be one of the most important priorities of the agricultural sector in developing countries. Accordingly, the policymakers of this sector have long been interested in self-sufficiency in the production of basic products and the development of agricultural exports (Salami and Mohtashami, 2014). Increasing agricultural production is possible in two general ways: either improving productivity by using and managing the inputs or increasing the total cultivated land area. Increasing the cultivated land area in most countries has been unsuccessful due to resource constraints such as water and land availability. Therefore, most researchers have focused on improving the productivity in agricultural production (Tekle, 2010).

Agricultural productivity depends on the interaction of all factors affecting agricultural production, and it requires a profound understanding of the ecology of agricultural systems and environmental conditions (Earles, 2005). High technology and ecological changes as a result of environment and climate changes need to be integrated with the production process for sustainable management (Pingali, 2007; Dercon, 2014). One of the most important factors influencing policymaking is the identification of effective factors in agricultural production. There is extensive literature in the world regarding the

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[1] Department of Agricultural Economics, College of Agriculture, Ferdowsi University of Mashhad, Mashahad, Islamic Republic of Iran.
[2] Department of Agricultural Economics, Oklahoma State University (OSU), USA.
*Corresponding author; e-mail: shahnoushi@um.ac.ir

identification of factors affecting agricultural production and its productivity. Studies by Asfaw and Admassie (2004) and Bingen *et al*. (2003) show that common factors such as the growth of investment, labor, and other production inputs alone cannot explain the entire spectrum of the production of the agricultural sector; the farmers' literacy plays a significant role in agricultural production. Chowa *et al*. (2013) considers knowledge and information as a prerequisite for the adoption of new technologies and the transformation of production methods in agriculture. Abrha (2015) investigated the factors affecting agricultural production using variables such as irrigated lands, chemical fertilizer use, high yielding seeds, and the characteristics of exploiters. Also, Berihun (2014) evaluated the factors affecting agricultural production using the variables of irrigation practices, row cropping, agricultural credits, and a number of agricultural associations. Gong (2018) explored the effects of inputs on China's agricultural production on the basis of provincial agricultural production in China.

On the other hand, according to Fathi *et al*. (2019), the population of Iran is expected to increase to about 97.5 million by 2050. This information shows the importance of increasing the food supply for this population. However, the country's environmental resources are in a critical condition, and the environment has been seriously damaged. Furthermore, according to the Ministry of Energy, the number of deep and semi-deep wells in the country increased from 347,000 wells in 1995 to 789,000 in 2015. This has led to an increase in the depletion of groundwater resources from 60 billion cubic meters in 1995 to 61 billion cubic meters in 2015. the increasing trend of depletion has led to economic, social, environmental, and other crises in the country (Ministry of Energy Yearly Report, 2000-2017). According to the Water and Soil Department of the Ministry of Agriculture Jihad, Iran's soil erosion is 2.5 times the average of soil erosion in the world, which is an alarming trend (Agricultural Statistics YearBook 2000-2017). All the above facts indicate that effective measures should be taken to protect the environment along with food production.

Mahmoodi Momtaz *et al*. (2020) indicated that the climate is changing and Iran agriculture sector is heavily dependent on climatic changes. Their results indicated that policymakers promote development of the necessary technical conditions, investment, and policymaking to achieve development of sustainable agriculture, thereby providing food security in a changing climate.

Amirnejad and Asadpour Kordi (2017) have explained that population growth in Iran and loss of environmental capacities for food production have rendered the realization of food security a more complicated task as compared to the previous decades. To cope with this crisis, sustainable agricultural development can play a remarkable role in improving food security.

Kan *et al*. (2019) showed that labor had a significant impact on the agricultural sector in Turkey and conduction of Support for Young Farmers Projects affected the number of agricultural enterprise and their profit significantly. They also indicated that skilled worker can increase the sustainability of the sector.

Petrick and Kloss (2013) explained agricultural production using the variables of the labor force, cultivated area, seed costs, machinery, labor costs, land rent, and interest rates. Most agricultural technologies are concerned about fertilizers, high yielding seeds, high yielding varieties, and methods for improving the quality of soil and water (Kamruzzaman and Takeya, 2008). The value of water in food production is obvious, as water plays perhaps the most important role in food production, food security, health, hygiene, and the environment (Hussain and Hanjra, 2004). Proper use and reduced waste of water resources in crop production are very important (Castro *et al*., 2010). Consideration of climatic factors,

such as precipitation, has also been significant in agricultural production. Rockström *et al.* (2010) pay special attention to water and rainfall and state that rainfall plays an important role in production by dry farming. The limitation of agricultural production resources is directly related to environmental factors, and environmental factors affect agricultural production. Expansion and intensification of agricultural productivity have also affected climate change. About 25-30% of greenhouse gas emissions come from agriculture (De Janvry, 2010; Kintomo *et al.*, 2008). All of the above studies show that there are many factors affecting agricultural production that need to be identified and considered in policymaking. In order to address all aspects of the factors affecting agricultural production, a comprehensive model is needed. Evaluating the specifics impact of the different inputs on production is a vital issue for framers, input providers, and governments. Moreover, policymakers can rely on this information to implement a suitable plan for input supply strategy and allocation.

Different aspects of these sub-sectors have been analyzed thoroughly to identify all the influential factors of crops and horticultural production in Iran. The crops and horticulture subsectors have been selected because they are based on arable land. In Iran, the total cultivated area of field crops is 14.7 million hectares, and 1.8 million hectares are horticultural areas (General Agricultural Census, 2017). Also, most of the water resources in Iran is used in the agriculture and animal husbandry sectors. This means that the highest amount of water and agricultural land is available to Iran's two subsectors of field and horticultural crops, which are expected to ensure the country's food security. The result of this study will show which factors have a significant effect on production and which have a meaningful effect on crops and horticultural production.

MATERIALS AND METHODS

Because of the expanded dimensions of agricultural sector, first, we need a method to cover all the affected variables and gather all the available information (Voros, 2012). Ziout and Azab (2015) study of PESTEL analysis provide a structure to include macro and environmental variables in evaluation and provide a clear vision with respect to these variables. PESTEL method is a simple and beneficial tool to evaluate the political, economic, socio-cultural, technological, environmental, and legal conditions and provide a better understanding of business environment (Heise *et al.,* 2015). Therefore, in this study, variables that were used in estimation procedure were extracted from PESTEL analysis and data availability. A considerable number of studies have used the PESTEL method to evaluate the agricultural sector, for example:

- The Agricultural and Horticultural Development Board (2014) in the UK explained the factors affecting agricultural production to determine the important factors in the business strategy of the agricultural sector.
- South Africa did this with the participation of Klynveld Peat Marwick Goerdeler (KPMG 2012), within the framework of New Growth Pathway (NGP), that aims at identifying agricultural capacities, sought to create jobs to achieve development goals.
- Janković and Jovović (2013) joined PESTEL categorization with SWOT analysis, to study the needs, potential, and development strategies of the fruit and vegetable sector in Montenegro.
- Ziout and Azab (2015) examined the Production Service System (PSS) in the Canadian agricultural sector.

The literature review identified a gap between studies of qualitative and quantitative data. Results showed that there is especially a lack of quantitative analysis of all the factors affecting agricultural output.

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The PEST analysis tool was first introduced in 1967, then, in 2005, the extension "EL" was added to the PEST method to form the PESTEL analysis tool. PESTEL analysis is a simple and useful instrument that helps to understand the environment in terms of political, economic, socio-cultural, technological, environmental/demographic, and legal aspects (Heise, 2015). This analysis provides a framework for the factors that are used to make an environmental assessment. This analysis is a useful tool for understanding the growth or decline of markets, businesses, capacities, and the strategic management of large sectors (FME, 2013). Therefore, this analysis tool brings together a summary of the driving forces in a macro environment. PESTEL analysis has long been used at the level of small businesses and enterprises. But in recent years, this analysis has been used on a larger scale, due to its comprehensive nature, to develop policies at the national level (Gregoric, 2014).

There are several methods to build the index. According to Jain *et al.* (2009), when different variables lie next to each other, their combination becomes complex in a pattern. Therefore, the researchers used an indicator to combine variables with different measurement units. The researchers refer to the index I_{ij} as a combined index, which is obtained by multiplying the weighted average w_t and the variables D_{ij} (PESTEL dimensions' variables).

$$I_{ij} = \sum_{i=1}^{n} w_i D_{ij} \qquad (1)$$

In Equation (1), D_{ij} is the PESTEL Dimensions of the index I_{ij}, which is calculated for province j and the variable i as well as two subsectors of crops and horticulture.

$$Dij = \frac{X_{ij} - Min(X_i)}{MAX(X_i) - MIN(X_i)} \qquad (2)$$

In Equation (2), x_{ij} is the value of variable for province j and variable i; the minimum and maximum values of the variable X_i are also calculated.

The I-Distance method is used to calculate the weight of each variable for building the indicators. It is the method used by Maricic

et al. (2016) to build a global food security index. OECD (2008) state that the method used to determine weight plays an important role in the process of creating composite indices. There has always been a discussion of weight among scholars (Cherchye *et al.*, 2007). The need for a statistical method that can transform variables into a composite index has been discussed since 1970s. Finally, Ivanovic introduced the I-Distance method in 1977, which allows each variable to have its own specific weight to combine with other variables and create a composite index. This method is based on calculating the distance between the target variables and also comparing this distance with the distance of other variables (Jeremić *et al.*, 2013). For the selected variables $X^T = (X_1, X_2,...,X_k)$, a vector with imaginary values is created that can be the minimum, maximum, or mean of the values of each variable (Milenkovic *et al.*, 2016). Then, the square of the I-Distance value is defined by the following equations for the two vectors $e_r = (x_{1r}, x_{2r},...,x_{kr})$ and $e_s = (x_{1s}, x_{2s},...,x_{ks})$. For a selected set of variables $X_t = (X1, X2,...,Xk)$ chosen to characterize the entities, the square I-Distance between the two $e_r = (x_{1r}, x_{2r},...,x_{kr})$ and $e_s = (x_{1s}, x_{2s},...,x_{ks})$ entities and is defined by Savić *et al.* (2016).

In order to rank the entities by using the I-Distance method, it is necessary to determine one entity as a referent in the observed set. The referent entity can be the minimal, maximal or average observed or fictive value (Milenkovic *et al.*, 2016).

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1}(1 - r_{ji,1,2...j-1}^2) \qquad (3)$$

In Equation (3), σ_i is the standard deviation of X_i, $d_i(r,s)$ is the distance of the variable X_i from the direction e_r and e_s, which is calculated by the following equation:

$$d_i^2(r,s) = (x_{ir} - x_{is})^2 \quad, i \in (1,...,k) \qquad (4)$$

Where, $r_{ji,1,2...j-1}^2$ is the partial correlation between X_i and X_j (Radojicic and Jeremic 2012). $d_i^2(r,s)$ represents the square value of I-Distance that is calculated for the

desired variable. In the next step, the weights of all variables are combined with each other, and the desired index is calculated for the two subsectors of crops and horticulture (Maricic *et al*., 2016).

According to Kumar (2019), the factors of the hypothesis testing process and the goodness of fit must be considered to select the statistical method based on the type of available data. Since the research objective is the identification of the capacities and limitations of the crops and horticultural production and their impact on the products over the past years in Iran's provinces, the best model should be selected according to available information. Information from 30 provinces throughout 17 years was available in the two subsectors of crops and horticulture. Therefore, the econometric model selected for these subsectors and periods was the panel model. Regarding the two dimensions of crops and horticulture information, the panel dimensions were enhanced from 2D to 3D (including time, crops, and horticulture). Given the fact that some variables such as temperature and precipitation show synchronous effects on the products of crops and horticulture, according to Balazsi (2017), using the three-dimensional panel would lead to a better result than the two-dimensional panel, which estimates for crops and horticulture separately. According to the geographical dimension of the provinces, the spatial 3D panel methods were selected.

However, given that access to large-volume and multi-dimensional information has increased in recent years, the panel data research literature, which had focused on developing patterns with 2D dimension components, is now beginning to use the multi-dimensional panel more often. Balazsi *et al*. (2018) have introduced the advantages of the 3D panel estimation with constant effects and have used it frequently. Also, Balazsi *et al*. (2016) derived proper estimates by General least squares (GLS) from the random effects approach. The multi-dimensional panel is expected to solve the complexity of the relationships between large data to address the problem. There are many studies that have achieved good results using the multi-dimensional panel, such as Feenstra (2003), Bertoli and Moraga (2013), and Gunnella *et al*. (2015) on the flow of trade, foreign investment, and migration, and studies by Kramarz *et al*. (2008) that examined the relationship between employee and employer, student and teacher, and so on.

Matyas (2017) points out that the multi-dimensional panel model is not as complex as the 2D panel and helps to simplify the problem. In case the panel data are asymmetric, the multi-dimensional panel results will be better. Hence, researchers need to take into account the available data and the type of model specification.

In the 3D panel, dependent variables are characterized by three indices such as y_{ijt} where i= 1,...,N_1, j= 1,...,N_2 and t= 1,...,T. It is assumed that the dimensions of i= 1,...,N_1 and j= 1,...,N_2 are different. In the 2D panel model, there are only two effects: variable and time. However, in the 3D panel, there are 22 probabilities. The conditions in the 3D panel are fundamentally different. In the 3D panel, those probabilities are more likely to be taken into account that were empirically used and gave the correct results (Matyas, 2017).

Many researchers have used the specification of fixed effects to estimate panel patterns. The generalization of a standard fixed effects panel model, in which there are mutual effects between two dimensions, is as follows (Baldwin and Taglioni, 2006):

$$Y_{ijt}= \beta'x_{ijt}+\gamma_{it}+\varepsilon_{jt} \quad i= 1, \ldots, N_1, j= 1,\ldots,N_2, t= 1,\ldots T$$

$$(5)$$

Where, γ_{it} is the special mutual fixed effects between i and j. Baltagi *et al*. (2012) also suggest random effects patterns that would have better outcomes:

$$Y_{ijt}= \beta'x_{ijt}+\mu_{it}+\varepsilon_{jt} \quad i= 1, \ldots, N_1, j= 1,\ldots,N_2, t= 1,\ldots T$$

$$(6)$$

In (6), $E(\mu_{it}) = 0$ and the random effects are not correlated. Common tests should be

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performed to select the proper specification between the fixed effects and the random effects (Mátyás and Balázsi, 2013). In the following, the presence of spatial mutual effects between the data will require the spatial panel pattern estimation. The effects such as endogenous interference effects (spatial delay on the explanatory variable Y), exogenous interference effects (spatial delays on independent variables X), and the mutual effects in disturbance components (for example, the use of the Spatial Auto-Regression (SAR) or the Spatial Moving Average (SMA) model in disturbance components) are considered in the calculation (Baltagi *et al.*, 2012). Assuming there are spatial effects, the panel model of Equations (5) and (6) varies as follows (Le Gallo and Pirotte, 2017):

$$Y_{ijt} = \beta' X_{ijt} + \rho \sum_{i=1}^{N_1} \sum_{j=1}^{N_2} w_{i,j,ig} y_{i,j,t} +$$

$$\sum_{i=1}^{N_1} \sum_{j=1}^{N_2} w_{i,j,ig} x_{i,j,t} \theta + \varepsilon_{ijt} \qquad (7)$$

In Equation (7), Y_{ijt} is the dependent variable of the study with three dimensions of j: crops, horticulture, and i: province and t is the period from 2000 to 2016, the index i represents the province varying from 1 to 30, and j represents the type of activity that is 1 and 2. X_{ijt} is the vector of independent and exogenous variables that are selected using PESTEL analysis presented in Table 1. To calculate the Social, Technological, Environmental, Policy, and Legal index, I-Distance method was utilized. In this method, e_r is vector of observed entity and e_s or referent entity is a vector that contains an elective value of the all sub-indicators. In our analysis, the referent entity was the one with the minimal values.

The parameters β, ρ and θ are estimated in the model. ε_{ijt} are the disturbance components of the model and $w_{(i,j,ig)}$ is the weight matrix. Where g is the standardized Adjacency matrix, and the sum of each row is equal to one. To calculate the weight matrix, a geodesic map of Iran's provinces was introduced in GeoDa 1.12 software, and the weight matrix was defined using the Queen's Neighborhood form in the software. Then, the weight matrix was transferred to the Stata 15 software. The Queen's Neighborhood Form is one of the most common types of neighborhood definition in the weight matrix (Lloyd,

Table 1. PESTEL Analysis of Iranian agricultural sector.[a]

Political	Economics	Social	Technological	Environmental	Legal
Training the farmers	Agricultural prices index	population	The rate of irrigation land area to total cultivated land area	Irrigation land area	Import tariffs
Guaranteed purchase products	Interest rate	Rural literacy rate	The rate of tractors to 1000 hectares of cultivated area	Crop and horticulture yield	Export tariffs
Number of insurance contracts for agricultural products	Exchange rate	Urban literacy rate	The rate of combines to 1000 hectares of cultivated area	Per capita cultivated area	
Compensation payments to farmers	Crop and horticulture area		The amount of electricity consumed in 1000 hectares of cultivated area	Chemical fertilizer use	
	Government investment		The amount of chemical fertilizer consumed in 1000 hectares of cultivated area	Discharge of groundwater resources	
	Agricultural sector labor			Temperature	
				Rainfall	

[a] Source: Research findings.

2010).

Levin, Lin, and Chu (LLC) was used to test the unit root (Levin *et al*., 2002). Also, Moran's I was used to test the spatial regression (Li *et al*., 2007). According to Lee and Ghosh (2009), the Akaike Information Criterion (AIC) and Schwarz Criterion (SC) criteria can be used to choose between different models of spatial regression such as Spatial autoregressive (SAR), Spatial Error Model (SEM), Spatial Durbin Model (SDM) and Spatial Autocorrelation Model (SAC). The STATA 15 software package was used in this study.

Data from 30 provinces of Iran during the period 2000-2016 was used to identify the capacities and limitations of Iran's field crops and horticultural production. Information was collected on the following subjects by the following agencies:

- The groundwater depletion rate and agricultural water consumption by the Ministry of Energy Yearly Report 2000-2017.
- The agricultural sector (cultivated area, yield, fertilizer use, etc.) from Agricultural Statistics YearBook 2000-2017.
- Employment rates, literacy, etc. from Iran Statistical Yearbook 2000-2017.
- Interest rates and exchange rates from Economic Time Series Database 2000-2017.
- Import and export tariffs from Annual Trade Statistics 2000-2017.
- Government assistance granted to the agriculture sector from BKI Annual Report 2000-2017.

Logarithms were taken of all variables. Therefore, the structure of this study was to identify the variables in the form of PESTEL classification and then to use the I-Distance method in order to weigh the variables in the form of PESTEL dimensions. Then, using the 3D panel data (time, province, crops and horticultural), we aimed to examine the effects of production factors on the amount of production.

RESULTS AND DISCUSSION

Then, on the basis of the results, policymakers can understand the factors that contribute to improving the production and those that do not play a positive role. In the future, policymakers can strengthen the capacities and diminish the limitations to crops and horticultural production and devise plans that improve the strengths of production in their proposed programs.

The Center of Research of the Islamic Parliament of Iran (2016) has used the PESTEL analysis to explain the sustainable indicators of agricultural production in Iran. Because of the importance of economic variables in policy decisions, those economic variables of the PESTEL analysis were introduced into the model. However, the rest of the variables were introduced into the econometric model by indexing. Also, due to the importance of climate variables such as temperature and precipitation and the amount of water consumed by the agricultural sector, these variables entered the model as part of the environment index. The variables used to build PESTLE indicators are listed in Table 1.

Using Table 1, the I-Distance index was created for social, technological, environmental, political and legal dimensions of PESTEL. Then, we examined the unit root of the variables using the LLC test. The unit root test results show that all variables are static at the 5% level and do not have a unit root. Therefore, the level of variables can be used to estimate the spatial 3D panel model. Table 2 shows the LLC test results of the study variables.

According to the results of Table 3, among the spatial patterns including SAR, SDM, SEM, and SAC, the SAC model was selected due to the incorporation of spatial effects in the disturbance components and the lower amounts of AIC and SC. The goodness of fit test results shows that R^2 of the estimated model is 0.74. All variables and statistics of the spatial model were significant, and the disturbance components

Table 2. LLC unit root test of variables.[a]

Variable name	t Value	Significant	Variable name	t Value	Significant
Horticultural and crop production	-2.8	0.00	Government investment	-23.5	0.00
Horticultural and crop cultivation area	-2.1	0.00	Agricultural sector workers	-4.5	0.00
Rainfall	-1.9	0.05	Social index	-29.5	0.00
Temperature	-9.5	0.00	Technology index	-8.1	0.00
Water used in agriculture	-5.4	0.00	Environmental index	-11.9	0.00
Agricultural prices index	-17.5	0.00	Policy index	-8.5	0.00
Interest rate	-10.5	0.00	Legal index	-2.5	0.00
Exchange rate	-2.29	0.01			

[a] References: Research findings.

Table 3. The results of goodness of estimated models.[a]

Model	SAC		SEM		SAR		SDM	
	t Statistic	Significant level	t Statistic	Significant level	t Statistic	Significant level	t Statistic	Significant level
R^2	0.90	-	0.76	-	0.76	-	0.76	-
Adjusted R^2	0.89	-	0.74	-	0.74	-	0.74	-
Log Likelihood Function	228.3	-	194.8	-	195.7	-	188.1	-
Rho	0.37	0.00	-	-	0.0001	0.16	0.098	0.00
Lambda	0.03	0.00	0.0005	0.7	-	-	-	-
Sigma	0.175	0.00	0.168	0.00	0.17	0.00	0.47	0.14
AIC	0.077	-	0.03	-	.31	-	.44	-
Schwarz Criterion	0.034	-	0.038	-	0.036	-	0.09	-
GLOBAL Moran MI	0.189	0.00	0.189	0.00	0.189	0.00	0.189	0.00
GLOBAL Geary GC	0.83	0.00	0.83	0.00	0.83	0.00	0.83	0.00
GLOBAL Getis-Ords GO	-0.88	0.00	-0.88	0.00	-0.88	0.00	-0.88	0.00
LM SAC	432.5	0.00	432.5	0.00	432.5	0.00	432.5	0.00
Augmented Dickey-Fuller Test	5.691	0.00	5.691	0.00	5.691	0.00	5.691	0.00

[a] References: Research findings.

of the estimated model had no unit root. The Moran's I test results show that there is a spatial correlation between disturbance components. The amount of Lagrange Multiplier (Anselin, 2013) indicates the existence of spatial interruption effects in the dependent variable. Given that logarithms are taken of all variables, the coefficients are interpreted as elasticity (Gujarati, 2004). According to the results presented in Table 4, the cultivated area has direct effects on crops and horticultural production. If the cultivated area increases by one percent, with other conditions remaining constant, the crops and horticultural production will increase by 0.78%. The precipitation has a positive and significant effect on the amount of crops and horticultural production in the country. However, the elasticity of this variable is lower than other variables, such that, if the precipitation increases by one percent, with other conditions remaining constant, the production value will increase by 0.88%. The crops and horticultural production has low elasticity toward precipitation, and it is one of the essential commodities for crops and horticultural products. One of the

Table 4. SAC model estimation (dependent variable is crop and horticultural production). [a]

Variable name	Coefficient	t Value	Significant
Horticultural and field crop cultivation area	0.78	32.98	0.00
Rainfall	0.08	2.65	0.00
Air Temperature	0.049	0.58	0.56
Water used in agriculture	0.02	0.82	0.41
Agricultural prices index	0.19	2.23	0.02
Interest rate	0.01	0.76	0.43
Exchange rate	0.16	1.73	0.08
Government investment	-0.08	-5.74	0.00
Agricultural sector workers	0.59	12.99	0.00
Social index	0.49	2.58	0.00
Technology index	0.26	7.7	0.00
Environmental index	1.61	16.51	0.00
Policy index	0.04	5.74	0.00
Legal index	0.41	0.59	0.55
Intercept	-6.3	-5.57	0.00
Rho	-	0.37	0.00
Lambda	-	0.03	0.00
Sigma	-	0.175	0.00
GLOBAL Moran MI	-	0.189	0.00
GLOBAL Geary GC	-	0.83	0.00
GLOBAL Getis-Ords GO	-	-0.88	0.00

[a] References: Research findings.

reasons for this fact is the cultivated area and yield of horticultural and field crops. In 2016, the area of irrigated field and horticultural crops constituted, respectively, 52 and 86% of the total cultivated area of the country. Another reason for the low impact of rainfall on crops and horticultural production is the variation in the rainfall pattern in the country, as discussed in Mafakheri *et al*. (2017). Babaei *et al*. (2014) reported that the coefficient of variation of the average annual precipitation of Iran in the recent decade (2004-2013) had increased, and the index of rainfall uniformity had declined during this decade. Therefore, significant regional and temporal redistribution of rainfall might be a reason for the lower than expected impact of this variable on crop and horticulture production.

In this study, air temperature did not have a significant effect on the crops and horticultural production. The reason for this is the short duration of the study (9 years), which does not consider a long-term trend for temperature. Koocheki (2015) studied the effects of temperature on the main

products during a 40-year period (1965-2005). It is reported for wheat that mean seasonal air temperature variations up to 1°C have no effect on the yield during the study prediction period (2005 to 2050). (Koocheki 2015).

Water is one of the most important production factors in Iran. Iran has suffered from drought and excessive use of groundwater resources for water supply in recent years. In the estimated model in this study, The reported volume of agricultural water consumption by the ministry of energy doesn't have a significant impact on the crops and horticultural production. About 90 percent of agricultural production is produced on irrigated lands. Information on agricultural water consumption is provided by Iran's Ministry of Energy. However, this information is not confirmed by the Ministry of Agriculture Jihad. The Ministry of Energy declares that the agricultural sector consumes 92% of water resources, while the Ministry of Agriculture Jihad believes that 70% of water consumption is used for agricultural purposes. The Ministry of

Energy has precise information on water use in the drinking and industrial sectors and attributes the rest of the water consumption to the agricultural sector. On the other hand, the agricultural sector calculates the water consumption on the farms, claiming consumption of 70%. Therefore, the insignificant effect of agricultural water consumption on Iran's agricultural and horticultural production is due to the inaccurate calculations in the country.

The agricultural products' price index is one of the positive and significant variables affecting the amount of crops and horticultural production in Iran. If the price index of Iranian agricultural products increases by one percent, with other conditions remaining constant, the amount of crops and horticultural production will increase by 0.19%, which is inelastic. Extensive studies have been carried out regarding the effect of the price index on the agricultural yield. For instance, Pishbahar *et al*. (2015) pointed out the importance of price for agricultural production. The interest rate variable did not have a significant effect on the yield of crops and agricultural and horticultural production. This is due to the determinative nature of the interest rate. Mehnatfar and Mikaely (2013) have shown that there is a significant correlation between the interest rate and the production rate in Iran, which is referred to as the gap between interest rates and production.

The exchange rate will affect agricultural production from the two dimensions of import and export. The exchange rate also affects the inputs needed by the Iranian agricultural sector, such as fertilizers and toxicants.

The government investment variable was introduced into the model separately from the support index due to its importance. Government investment includes the facilities granted to the farmers by the Agriculture Bank (such as subsidies, low interest loans, etc.). In this study, contrary to public expectations, the agricultural facilities have significant and negative effects on

production. Although the value of this coefficient is small, the reason for its negative value should be explained. According to Aghanasiri (2011), the rate of return on capital has been significantly reduced in agriculture due to a lack of significant change in agricultural management and technology in recent years. Gilanpour (2014) reviewed this issue and stated that the capital stock in Iran had not reached the baseline of the agricultural sector because of the low investment trap. As a result, the capital stock in the agricultural sector has not contributed to production, and, despite the investment, production has decreased in relation to the capital. Another study by Thamyipur and Shahmoradi Fard (2015) found similar results. They found that the productivity of the production factor was negative in Iran. In other words, capital productivity not only did not increase but also decreased the added value, which was due to inadequate investment. Therefore, the negative investment in Iran's agricultural sector is not surprising. This fact highlights the importance of investment and its shortage in Iran's agricultural sector.

Agricultural workers in the crops and horticultural production sector have had a huge impact on production. Thus, if agricultural workers in the country increase by one percent, with other conditions remaining constant, the agricultural and horticultural production will increase by 0.59%, indicating the low elasticity of agricultural products in relation to agricultural workers. The effect of the social index on crops and horticultural production should also be considered. The estimation results show that the social index has significant effects on Iran's crops and horticultural production, namely, a one percent increase in the social index will increase agricultural and horticultural production by 0.49%. The literacy rate is one of the dimensions of the social index. Regarding the relationship between the literacy rate and agricultural production, Seyedyaghoubi and Sadighi (2016) have

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shown that the literacy rate of the rural population as a social index causes 34% increase in the adoption of modern agricultural practices, and it has greatly increased agricultural production.

The technology indicator is a combination of the following variables: cultivated area under irrigation, cultivated area of irrigated products, agricultural sector's power consumption, and availability and use of tractors and combines and fertilizer. This indicator is weighted by I-Distance criterion, which is statistically significant and positive. Hence, if the technology indicator improves by one percent, it will result in an increase of agricultural and horticultural products by 0.26%. One of the most important indicators that affects crops and horticultural production is the environmental index. This indicator will bring about the sustainability of the agricultural sector. This indicator is composed of the variables including cultivated area of irrigated crops, the production of irrigated crops, the yield of crops and horticultural production, per capita crops and horticultural land, kitchen garden products, fertilizer use, and the depletion of groundwater resources. The weight of the variables was determined by using I-Distance criteria. If the environmental index improves by one percent, with other conditions remaining fixed, the agricultural and horticultural production will increase by 1.61%, indicating the elasticity of the environmental index in agricultural and horticultural production.

The policy index includes the variables of operators' training, the volume of government's crops and horticultural product purchase for the operators, the number of insurance contracts, and the price of compensation paid to the operators. The weights of the variables were calculated and combined by using the I-Distance criteria. The policy index has positive and significant effects on the products of the Iranian field and horticultural crops. Therefore, if the policy index increases by one percentage, with other conditions remaining fixed, crops

and horticultural production will increase by 0.04%. The low coefficient of this variable indicates the slight effect of supportive policies on the crops and horticulture sector. This indicator will have better effects in the long run. The legal index of the agricultural sector in Iran has no significant effect on field crops and horticulture production.

CONCLUSIONS

In each planning system, the long-term and short-term plans will lead to targeted strategies and operational projects. Identifying the factors affecting the plan is very important for creating a good plan. In this study, factors affecting the amount of crops and horticultural products, which are the main components of food security in Iran, were investigated by using PESTEL analysis. It was found that the environmental factor has the greatest effect on crops and horticultural production, a factor that would lead to sustainability of the agricultural sector. In this regard, the optimal use of chemical pesticides is recommended, where chemical pesticides have a negative effect on environmental factor.

The second important factor is the rural people's literacy rate, which incorporates the socio-cultural dimension of the PESTEL analysis. Most Iranian villagers are engaged, directly or indirectly, in agricultural activities. The effect of this factor on agricultural production is remarkable. Investment in operators' knowledge will have a very good return on crops and horticultural production. This issue is most significant when the current generation entering the agricultural area owns a higher education level and replaces the previous generation who has a lower literacy rate. According to the results of the census of agricultural operators in 2014, the proportion of literate farmers to illiterate was 1.91, while the same proportion was 1.2 in the previous census in 2003. Also, the proportion of university education to the literate population in 2003 was 0.66, which

increased to 1 in 2014. The higher education level of the operators will lead to the adoption of new technologies and innovation in this sector. Therefore, given the improved education level of the operators, investment in the transfer of new technologies into the agricultural sector will be significant.

The cultivated area of agricultural crops has significant effects on agricultural production, which is important in the economic index of the PESTEL analysis. However, a significant point is the lack of development of the cultivated area due to Iran's climatic conditions. Thus, less development policy should be considered regarding the development of the cultivated area, and the ratio of increased production productivity per unit area should be given a higher priority.

The technology indicator of the PESTEL analysis has had a relatively small effect. This indicates that the type of technology used in the agricultural sector should be taken into consideration. Given the new concepts of agriculture, such as smart, precision, and satellite agriculture, there is a need to revise the technologies in the Iranian agricultural sector. The agricultural sector's technology should be in line with the literacy level, arable land size, and the farmers' capital level.

The supporting index of the PESTEL model shows that there should be a fundamental revision in the support of the Iranian agricultural sector. The most important indicators in Iran's agricultural support index are the purchase agreement of products and the guaranteed price of the basic products. This kind of support has its own advantages and disadvantages. This kind of support is the easiest, most convenient, and the most frustrating type of support, because the guaranteed price is the same for all provinces of the country, but the production costs are different. The main cause of the low effectiveness of the agricultural sector supportive policies is that the supports are not purposeful, and the same type of support is provided for a wide range of operators, whether small or large-scale. This is also the case with insurance for agricultural products and compensation payments. As noted earlier, government agricultural investment has a negative impact on agricultural and horticultural production. This is rooted in the kind of support and attention given to the agricultural sector. The interest rate of capital in the agricultural sector is similar to that of industry and services. Hence, there is a capital flight from this sector due to the risky nature of the activity in the agricultural sector, with the result that the assistance granted to the agricultural sector is used in the industrial sectors, such as construction. If the government has a long-term perspective on the agricultural sector, it is essential to reconsider the type of granting facilities and their interest rates. The most important government service extended to the agricultural sector can be the transfer of responsibility for decision-making from the public sector to the private sector, while the government only has the task of oversight.

Finally, the present study showed that the use of the PESTEL analysis led to a comprehensive analysis of all aspects of the agricultural sector and to an estimation of all the factors affecting the model. The use of the spatial 3D panel greatly increased the accuracy of the coefficients and led to accurate results and conclusions consistent with the Iranian agricultural reality.

ACKNOWLEDGEMENTS

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محدودیت‌ها و ظرفیت‌های تولیدات زراعی و باغی ایران

ب. فکاری سردهایی، ن. شاهنوشی، ح. محمدی، و س. رستگاری هنبری

چکیده

شناسایی عوامل محدود کننده و ظرفیت تولید محصولات زراعی و باغی، منجر به برنامه‌ریزی صحیح علمی در بخش کشاورزی خواهد شد. مطالعات بسیاری به شناسایی عوامل اثرگذار بر تولید با تکیه بر یک یا چند بعد بخش کشاورزی پرداخته‌اند. در این مطالعه با تاکید بر تحلیل PESTEL به شناسایی عوامل اثرگذار بر تولید محصولات زراعی و باغی رپرداخته شده است تا ظرفیت‌ها و محدودیت‌های تولید بخش زراعت و باغبانی شناسایی شد. بدین منظور، از اطلاعات ۳۰ استان در طی دوره زمانی ۱۳۸۷ تا ۱۳۹۵ استفاده شد. ابتدا متغیرهای هر شاخص تحلیل PESTEL شناسایی شد و با بکار گیری روش I-Distance برای هر متغیر وزن تعریف شده و سپس با ترکیب متغیرهای آن شاخص مورد نظر تحلیل PESTEL ساخته شد. با استفاده از الگوی پانل سه بعدی فضایی و با در نظر گرفتن بعد زمان، استان و نوع تولید محصول (زراعی یا باغی) الگو تخمین زده شد. نتایج نشان می‌دهد که شاخص محیط زیست اثرگذارترین عامل بر تولیدات محصولات زراعی و باغی بوده و همچنین نرخ باسوادی بهره‌برداران روستایی ظرفیت بسیار خوبی برای افزایش تولیدات محصولات زراعی و باغی دارد. همچنین، عامل سرمایه‌گذاری و شاخص حمایت محدودکننده‌ترین عامل در تولیدات محصولات زراعی و باغی ایران است.