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(علوم و صنایع کشاورزی)

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The Effect of Socio-Economic Dimensions on Deforestation: Application of Spatial Econometrics

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Abstract

In the second half of the twenty-first century, economic change, population growth and globalization were the main factors driving the deforestation in the South Asian countries. To identify the effects due to socio-economic factors affecting deforestation in such countries, this study applied the spatial econometrics model based on data from 18 selected countries for the period between 2005 and 2015. The spatial correlation tests were showing that ignoring the effects of spatial correlation cause bias in results. The results of the model also confirmed the environmental Kuznets curve hypothesis for the selected countries with a turning point of $ 5,107. Our findings illustrated that increasing GDP per capita in neighbouring countries through interregional mobility of inputs of production will increase deforestation in the target country. The increase in the exchange rate in neighbouring countries due to the increase in imports of forest products and the non-cutting of domestic forest resources will reduce deforestation in the target country. Increased population density and unemployment in neighbouring countries due to reduced job opportunities and increased migration to the target country, followed by increased demand for food and increased land demand, led to increased deforestation in the target country. Finally, increasing the human development index variable has reduced deforestation in the target country. However, changing this variable in neighbouring countries has not affected the deforestation of the target country. Therefore, in a world with increasing economic growth, it is suggested that to prevent deforestation by improving the human development index, eradicating the problem of unemployment, and eradicating poverty redouble efforts. As the results of this study showed, the population had a direct and significant effect on deforestation in selected countries. Due to the increase in population growth in different years, it is recommended that the population issue be given more attention by looking at the requirements of sustainable development to reduce environmental degradation, mainly deforestation. Because according to the results of this study, the lack of rapid population growth reduces deforestation in selected countries.

Keywords: Deforestation, Spatial econometrics, Spatial Kuznets curve, Sustainable economic development

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Introduction

Increased human activity has led to a significant reduction in forest areas through deforestation (Lewis *et al*., 2015). Deforestation began about ten thousand years ago with the advent of agriculture and ancient civilizations, but its speed has increased with the increasing population (Angelsen, 1999). Today, deforestation is one of the most critical environmental issues of the 21st century, causing drastic climate change (Van der Werf *et al*., 2009). Estimates show that deforestation is the second-largest source of greenhouse gas emissions after fossil fuels (Stern and Stern, 2007). According to the FAO in 2015, population growth, and increasing demand for food products, has reduced the world's forests in the last 25 years from about 4.1 billion hectares to less than 4 billion hectares, which means a 3.1 Percentage reduction (FAO, 2015). Because of the issue's importance, the United Nations has recently stepped up its efforts to prevent deforestation, rehabilitate degraded forests, and achieve the Sustainable Development Goals by 2030 (Morita and Matsumoto, 2017).

According to global statistics, in the 1980s about 15.4 million hectares (FAO, 2015) and from 1990 to 1995, 12.7 million hectares (FAO, 1997) and in the 1990s to 2000, 9.391 million hectares (FAO, 2003) and from 2000 to 2015, 7.6 million hectares (FAO, 2015) of tropical forests were lost annually. Given that 80% of the world's known plant and animal species live in forests (FAO, 2003), deforestation is undoubtedly a severe crisis. Asia has 571577 thousand hectares or 18.5% of the world's forests. Overall, between 1990 and 2005, Asia lost 0.5 percent of its forests (FAO, 2005). World forest per capita decreased from 0.8 hectares in 1990 to 0.6 hectares in 2015, while the forest per capita in Asia is only 0.2 hectares. Figure (1) shows the trend of net deforestation as a percentage of gross national income from 1980 to 2018 for different world regions. As can be seen, this trend is increasing with a steeper slope for sub-Saharan Africa and with a lower slope for South Asia (World Bank, 2020).

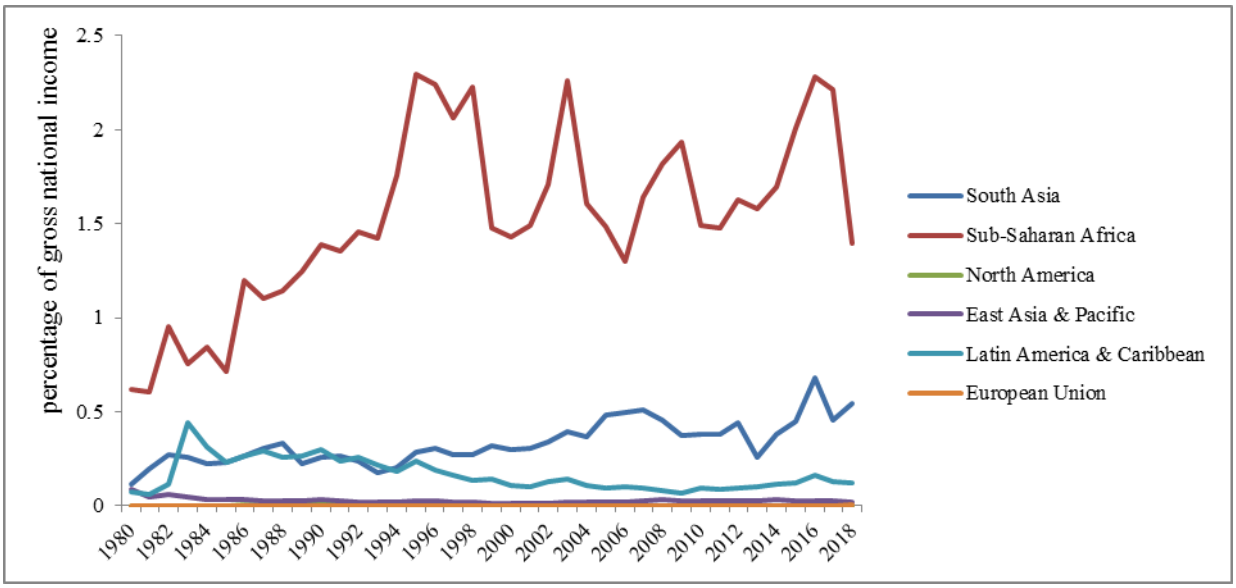

Figure 1- The trend of the net forest depletion from 1980 to 2018

In addition, deforestation reduces the value of the forest as a source of environmental diversity, carbon storage, and timber production and alone causes an annual reduced emission of 25% of carbon dioxide and 15% of greenhouse gases (Heerink *et al*., 2001). Accordingly, various studies worldwide have been conducted in different ways on the causes of deforestation, some of which are mentioned.

Koop and Toole (1999) examined the relationship between economic development and deforestation using panel data from developing countries, including Asia, Latin America, and Africa. They used two models with fixed effects for 66 countries from 1962 to 1986 and one model with random effects for 76 tropical developing countries from 1961 to 1992. Explanatory variables used in the model include GDP per

capita, population distribution, population change rate, and GDP growth rate. Their results did not confirm the existence of the Environmental Kuznets Curve (EKC) for deforestation. Mahapatra and Kant (2005) investigated deforestation in the tropics using multiple logistics models. They obtained more results than the dual logistics model and the ordinary least squares (OLS) method using this model. Finally, they concluded that population growth, agriculture, and road construction are the main factors of deforestation.

Culas (2007) examined the impact of institutional factors and deforestation and analyzed the environmental Kuznets curve across Latin America, Africa, and Asia. The explanatory variables studied were agricultural production, population, economy and government policies. The results show that better property rights and environmental policies reduce deforestation rates without hindering economic growth. Boubacar (2012) examined the determinants of deforestation in 24 sub-Saharan African countries using spatial econometric methods from 1990 to 2004. The results showed a positive correlation between deforestation of a country and neighboring countries. In Indonesia, Wheeler *et al.* (2013) investigated deforestation using spatial econometric analysis. Their study aimed to examine short-term changes in prices, demand for wood products, exchange rates, interest rates, the opportunity cost of forest land, quality of government, poverty, population density, infrastructure, and transportation costs. The results showed that all economic variables are significant on deforestation. Faria and Almeida (2016) examined how international trade has affected deforestation change in the Brazilian Amazon. Their analysis was based on the expansion of agricultural products, livestock activities and GDP per capita. Using panel data from 2000 to 2010 and spatial econometrics, they found that international trade increased deforestation; also, property rights significantly impact deforestation, and deforestation increases with increasing GDP. Reddy *et al.* (2018) assessed deforestation in South Asia since the 1930s using satellite data and remote sensing. The region includes seven countries: India, Bangladesh, Bhutan, Nepal, Pakistan, Afghanistan, Sri Lanka, and the Maldives. The results showed that 29.62% of forest cover was lost in these countries.

A study of the existing literature shows that before 2004 no study has been conducted to investigate the relationship between environmental quality and economic growth in Iran. The oldest research in this field is the study of Sadeghi and Saadat (2004). Using time-series data from 1987 to 2001 and the causality test method, these two researchers estimated the causal relationships between economic growth, population growth, and environmental pollution. After that, much research was done on economic growth and environmental degradation. These include the studies of researchers such as Salimifar and Dehnavi (2010), Daryani (2015), Alishiri *et al.* (2017), Hoseini *et al.* (2018), and Mansorabadi and Khodaparast (2019) to study the effect of economic growth on quality the environment has done using modern econometric methods.

A review of past studies shows that the study of socio-economic factors of deforestation in Iran using spatial econometrics has not been studied; however, studies in this field have been done by examining the environmental Kuznets curve and specifying the deforestation function as a panel by Nasirnia and Esmaeili (2009, 2008). In the first study, based on Kuznets environmental theory, the definition of deforestation function for Iran and five neighboring countries was done as a panel. The results of this study showed that in Asia, the hypothesis of the existence of the environmental Kuznets curve for selected countries is rejected, and the only variable affecting the deforestation process in this function is the population variable. Also, in the second study, using environmental Kuznets curve theory, the factors affecting deforestation were examined for 71 selected countries. The results showed that the environmental Kuznets curve hypothesis is not valid for selected countries.

There is disagreement about the factors affecting deforestation. Culas (2007) believes that in many low-income countries, high population density and extreme poverty are the leading causes of deforestation and increasing demand for forests and agricultural products. Allen and Douglas (1985) showed that deforestation results mainly from high population growth and timber exports. Bohn and Deacon (2000), Ferreira (2004), and Mendelsohn (1994) argue that high deforestation rates in countries are linked to weak institutions and a lack of definition of property rights. Humphreys (2004) believes that the influx of multinational corporations and the intensification of foreign debt will increase the gap between rich and emerging countries and lead to more deforestation in poorer countries. Lopez and Galinato (2005) identified income, trade,

macroeconomic policies, population, and geographical conditions as essential and immediate causes of deforestation.

According to the World Bank, in 2018, about 766 million people in Asia live below the poverty line ($ 1.9 per day) (World Bank, 2016). Therefore, given the high population, high poverty, and low forest per capita, preventing deforestation is a vital issue that needs to be examined. Accordingly, given that a large proportion of deforestation has taken place in the southern half of Asia (FAO, 2015). In this study, the socio-economic factors affecting deforestation will be examined in Japan, China, Singapore, Indonesia, Bangladesh, Thailand, Philippines, Malaysia, Vietnam, India, Iran, Pakistan, Uzbekistan, Tajikistan, Kazakhstan, Kyrgyz Republic, Azerbaijan and Armenia with the use of spatial econometrics. Other countries in the southern half of Asia were not surveyed due to a lack of data.

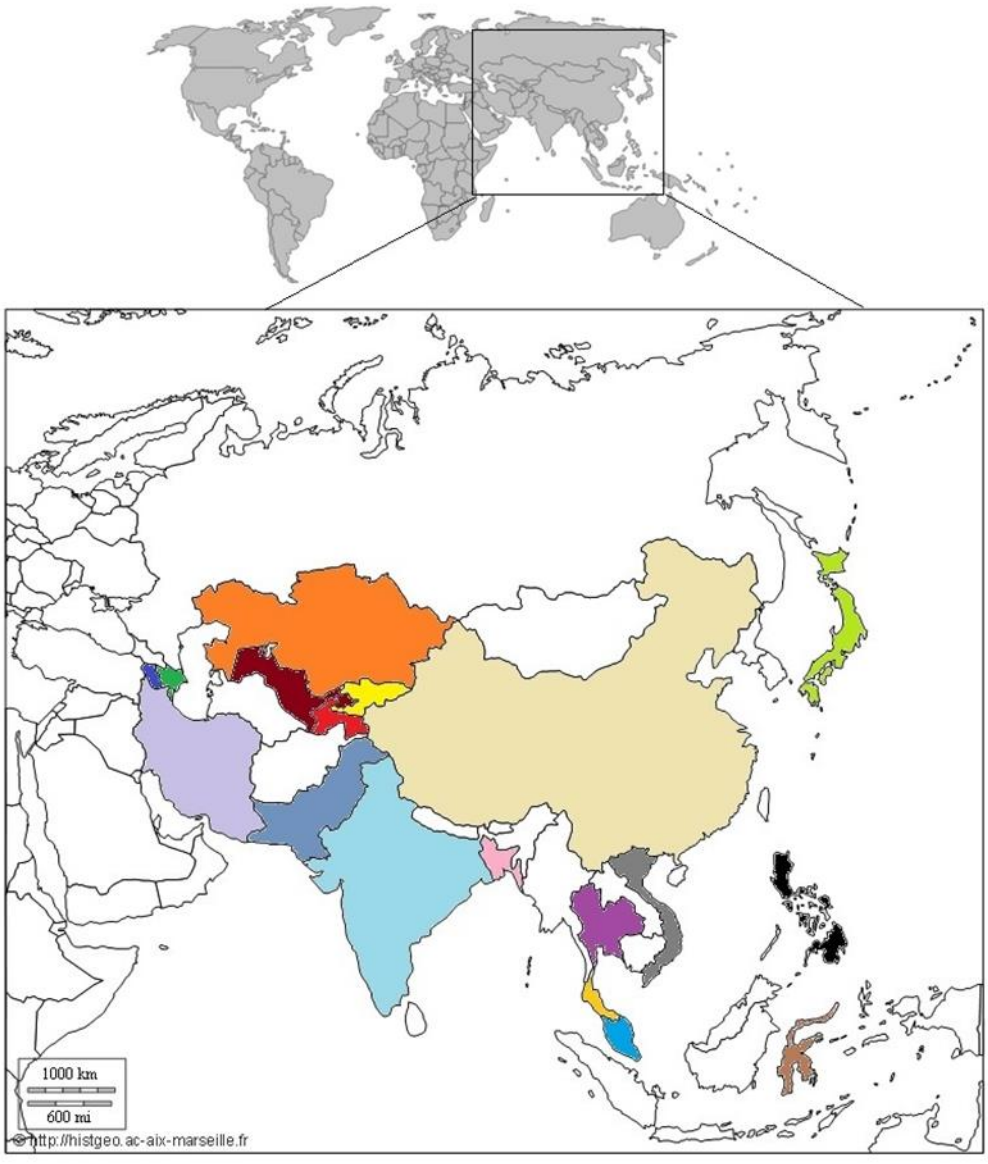

Figure 2- Spatial distribution map of 18 selected countries in the South Asia

Materials and Methods

The general form of the cross-sectional deforestation function for N countries is according to the equation (1) (Allen and Douglas, 1985).

$$i = 1, 2, \ldots, n$$

$$F_i = a + \sum_{j=1}^{k} \beta_j X_{ij} + \varepsilon_i \qquad (1)$$

where, F_i is the forest area of the country i, X_{ij} is the explanatory variable j affects the deforestation process in country i, α and β are the constant and the slope, respectively.

According to Anselin and Bera (1998), the conventional econometric method based on Gauss–Markov theorem is not suitable for regional studies because the explanatory variables are constant in a repetitive sampling. There is also an individual linear relationship between the observations in the data. Such assumptions are consistent with time-series data, but regional study data encounter two phenomena and the problem of spatial dependence between observations and spatial heterogeneity in the model. Spatial dependence violates the first hypothesis (The average error term is zero), and spatial heterogeneity leads to violation of the second hypothesis (lack of autocorrelation between error terms). Conventional econometrics largely ignores these two issues. Therefore, three standard spatial econometric models were introduced that explain the y-changes as a linear combination of adjacent areas and consider what is happening in adjacent areas as important. These models are the spatial lag model (SLM), spatial error model (SEM), and spatial Durbin model (SDM) (LeSage and Pace, 2009; Hao *et al*., 2016; Lv and Li, 2021). The SLM is expressed as Equations (2) and (3) when the dependent variable is spatially correlated with its lags.

$$y = \rho W y + X\beta + \varepsilon \quad (2)$$

$$\varepsilon: N(0, \sigma^2 I_N) \quad (3)$$

When the dependent variable is spatially correlated with the error term of the equation, the SEM is expressed as Equations (4), (5), and (6).

$$y = X\beta + u \quad (4)$$

$$u = \lambda W_u + \varepsilon \quad (5)$$

$$\varepsilon: N(0, \sigma^2 I_N) \quad (6)$$

Finally, when the dependent variable is spatially correlated with its lags and the error terms, the spatial Durbin model is expressed as Equations (7) and (8).

$$y = \rho W y + X\beta + WX\theta + \varepsilon \quad (7)$$

$$\varepsilon: N(0, \sigma^2 I_N) \quad (8)$$

In the above equations, y is a vector $(n\times 1)$ of dependent variables. X is a matrix $(n\times k)$ of explanatory variables. λ is a spatial lag parameter. β and θ are a vector $(k\times 1)$ of trend parameters. ρ is a spatial auto regression parameter. W is also a spatial weight matrix $(n\times n)$ with elements W_{ij} , defined as equation (9):

$$S_0 = \sum_{i=1}^{n} W_{ij} = 1 \quad (9)$$

The elements of this matrix are such that they take the number one and otherwise the number zero for both countries with a common border. Since a country cannot be its own neighbor, the elements of the original diameter are all zero. To show the spatial correlation, Moran's I and Wald tests are used, such as equations (10) to (13) (Florax *et al*., 2003).

$$I = \left[\frac{n}{S_0}\right] \times \left[\frac{(z'Wz)}{z'z}\right] \quad (10)$$

$$t_1 = tr\left(W \times B^{-1}\right) \quad (11)$$

$$t_2 = tr\left(WB^{-1}\right)^2 \quad (12)$$

$$t_3 = tr\left(W \times B^{-1}\right)' \left(W \times B^{-1}\right) \quad (13)$$

In the above equations, z is a vector $(n\times 1)$ of observations. Also, B is equal $(I_n - \lambda W)$ and, λ represents the maximum likelihood estimator. Moran's test has two interpretations: A) the positive value of the Moran test statistic indicates positive spatial autocorrelation, and the closer the values are to +1, the more complete the correlation. B). The negative value of Moran's test statistic indicates the phenomenon of negative autocorrelation, and the closer the values are to -1, the more complete the scattering indicates. Also, the values of zero represent a random spatial pattern. The null Hypothesis of the Wald test also shows spatial autocorrelation. Lagrange Multiplier Lag and Lagrange Multiplier Error tests also are used to detect spatial correlation independent variable observations and spatial correlation in error terms, respectively. Suppose the null hypothesis of spatial non-correlation is rejected in the observations of dependent variables. In that case, the spatial lag model is used, and if the null

hypothesis of spatial non-correlation in error terms is rejected, the spatial error model is used. If both null hypotheses are rejected, the spatial Durbin model is used to estimate (Hamidi, 2015; Mahmodpor *et al.*, 2018, Hao *et al.*, 2016).

The most important application of the SDM is in the study of spatial spillover; because, according to the study of Anselin (1988), the direct effect is obtained by using the partial derivative, the effect of increasing the explanatory variable in country *i* on the dependent variable of country *i* (the partial derivative is equal to $\frac{\partial y_i}{\partial x_i}$). Also, in this model, in addition to the spatial lag variable, the product of the standardized spatial weight matrix in the vector of explanatory variables creates a new variable that shows the average effect of explanatory variables of other countries on the dependent variable of the target country. In other words, it shows the effects of spatial spillover of neighboring countries. The total effect of increasing the explanatory variable on all study areas equals the sum of direct and indirect effects.

Taking into consideration the spatial relationships between the variables in the equation, the relationship between economic development and deforestation will also be dependent on the location of environmental impacts. If the relationship between deforestation and economic growth is confirmed, three turning points can be estimated as Equations (14), (15), and (16) (Balado-Naves *et al.*, 2018; Caravaggio, 2020; Khezri *et al.*, 2021).

$$GDP = e^{-(\beta_1 / 2\beta_2)} \quad (14)$$

$$GDP = e^{-(\rho_1 / 2\rho_2)} \quad (15)$$

$$GDP = e^{-((\beta_1+\rho_1) / 2(\beta_2+\rho_2))} \quad (16)$$

$$\hat{\eta} = \frac{\partial LnF}{\partial LnGDP} = \hat{\beta}_1 + 2\hat{\beta}_2 LnGDP \quad (17)$$

Equation (14) represents a direct turning point that can only be estimated by considering the GDP of the target country. Equation (15) represents the indirect turning point which is estimated only by considering the GDP of neighboring countries, and finally, Equation (16) represents the total turning point which is obtained by considering the GDP coefficients of the target country and neighboring countries. Equation (17) is also used to calculate income elasticity. $\hat{\beta}_1$ and $\hat{\beta}_2$ represents the coefficient of variable *LnGDP* and $(LnGDP)^2$ respectively.

In this study, according to the studies of Boubacar (2012), Miyamoto (2020) and Santiago and do Couto (2020), this model was used as a relation (18):

$$\ln F_{it} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 (\ln GDP_{it})^2 + \beta_3 \ln EXC_{it} + \beta_4 \ln POP_{it} + \beta_5 \ln UNEM_{it} + \beta_6 \ln HDI_{it} + \beta_7 \ln AGRI_{it} + \varepsilon_{it} \quad (18)$$

In equation (18), F_{it} Forest area of country *i* at year *t*, GDP_{it} GDP per capita of country *i* at year *t*, $(GDP_{it})^2$ GDP per capita square of country *i* at year *t*, EXC_{it} exchange rate of country *i* at year *t*, POP_{it} population density of country *i* at year *t*, $UNEMP_{it}$ unemployment rate of country *i* at year *t*, HDI_{it} Human Development Index of country *i* at year *t*, $AGRIP_{it}$ Agricultural product price index of country *i* at year *t* and ε_{it} indicates error term. To achieve accurate results, natural logarithms were taken from all variables used. Data on forest area, GDP per capita, exchange rate, population density, and unemployment from the World Bank, agricultural price index from the FAO database and data on the Human development index were collected from hdr.undp.org. The above data were analyzed in MATLAB software.

Results and Discussion

To estimate the model according to the latitude and longitude coordinates of observation, a standardized spatial weight matrix is defined, which indicates the spatial dependence between the selected countries. Each row of this matrix represents a set of spatial dependencies related to one of the countries (Figure 2).

Rows and columns 1 to 18 in the top matrix represent Japan, China, Singapore, Indonesia, Bangladesh, Thailand, Philippines, Malaysia, Vietnam, India, Iran, Pakistan, Uzbekistan, Tajikistan, Kazakhstan, Kyrgyzstan, Azerbaijan, and Armenia, respectively. If a country is spatially related to another country, it is indicated by the number one in the matrix. Since no country can have a spatial dependence on itself; therefore, all numbers on the original diameter of the matrix are zero.

Moran and Wald tests are used to determine the existence or absence of spatial effects, and the outcomes of these two tests are shown in Table 1.

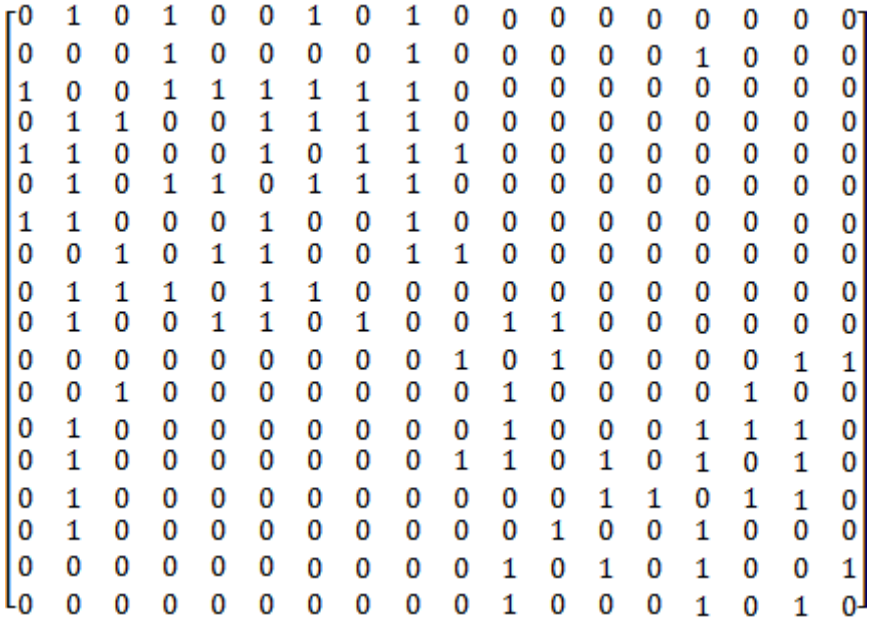

Figure 2- Representation matrix of selected countries in the southern half of Asia

Table 1- Moran's I and Wald test results

Statistics	Statistics value	Statistics	Statistics value
Moran's I	0.9535	Wald	1593.8
Average I	-0.0177	Significant level	0.0000
Variance I	0.0020	χ^2 distribution	6.63
Significant level	0.0000		

Source: Research findings

The rejection of null hypothesis of Moran's I and Wald tests confirmed the spatial autocorrelation effects. As can be seen, the null hypothesis has been rejected in both tests; Therefore, spatial econometrics should be used. According to the results of Table 1, it is observed that the value of Moran test is 0.9535, positive and shows a positive spatial autocorrelation in selected countries.

Table 2- Results of Lagrange Multiplier (LM) tests

Statistics	Statistics value	Significant level	X^2 distribution
LMERROR	83.79	0.0000	**6.64**
LMLAG	324.93	0.0000	**6.64**
LMERROR(Robust)	33.82	0.0005	**6.64**
LMLAG(Robust)	244.96	0.0000	**6.64**

Source: Research findings

Table 2 displays the results of Lagrange Multiplier testing showing that all test statistics are considerably greater than the critical value of 6.64; therefore, the SDM should be used to estimate the model.

Outputs of the SDM

The results of estimating the SDM are presented in Table 3. The estimated coefficients for GDPPC and $(GDPPC)^2$ indicate that the environmental Kuznets curve hypothesis is confirmed for selected countries. First, by increasing GDP per capita, deforestation increases by maximum level, and then decreases.

Table 3- Results of estimation of Spatial Durbin Model (SDM)

Variables	Significant level	Coefficients
Ln(GDPPC)	0.000000	1.673***
(Ln GDPPC)^2	0.000000	-0.700***
Ln(Exchange rate)	0.000000	0.486***
Ln(Population density)	0.000979	0.233***
Ln(Unemployment)	0.000000	0.740***
Ln(HDI)	0.003157	-0.060***
Ln(Agricultural price index)	0.538625	0.056ns
R-squared	0.9378	

*** Indicates significance at 1% level. ns indicates that the desired variable is insignificance
Source: Research findings

As presented in Table 3, the effect of the exchange rate on deforestation is positive and significant; in other words, the weakening of the national currency increases the export of forest products and reduces the area of forests.

The coefficient of the population density variable is statistically positive and significant. It makes sense that population growth would reduce forest land; because population growth represents an increase in demand for food and an increase in demand for residential land.

In this study, the unemployment variable also had a positive and significant effect on deforestation; thus, unemployment and ultimately poverty increase deforestation in the selected countries.

The negative and significant coefficient of the human development index on deforestation indicates a decrease in forest degradation due to improving this variable. As economic growth grows, so do government expenditures on health, education, and health, fostering human development. The conviction in the idea of capital, which encompasses solely physical capital, is thus a hazy term. Therefore, human capital should be addressed for environmental improvement (reduction of deforestation).

The estimated coefficient of the price index of agricultural products is not significant; this shows that the change in the price of agricultural products does not affect deforestation in selected countries.

Direct and indirect effects (spillover) for 18 selected countries in South Asia

The direct effect of each variable on deforestation shows that if that variable changes in country *i*, on average, what effect it will have on deforestation in that country. The indirect effect (spillover) of each variable on deforestation shows that if that variable changes in other countries, on average, what effect it will have on deforestation of the target country, which means the spatial spillover of that variable on deforestation in the target country. The total effect is also obtained from direct effects and indirect effects (Anselin and Bera, 1998).

Table 4- Direct and indirect effects in the form of spatial regression for 18 selected countries of South Asia

Variables	direct effect	Indirect effect	Total effect
Ln(GDPPC(-1))	0.1050***	0.0060*	0.1110**
	(0.0000)	(0.0652)	(0.0256)
(Ln (GDPPC))^2(-1))	-0.0200*	0.0040**	-0.0160**
	(0.0721)	(0.0234)	(0.0478)
Ln(Exchange rate(-1))	0.0730***	-0.0025**	-0.0705***
	(0.0003)	(0.0344)	(0.0004)
Ln(Population density(-1))	0.0200***	0.0002**	
	(0.0000)	(0.0424)	
Ln(Unemployment(-1))	0.0440**	0.00028**	0.0442**
	(0.0384)	(0.0221)	(0.0440)
Ln(HDI(-1))	-0.0800*	-0.0002ns	-0.0802*
	(0.0521)	(0.3522)	(0.0511)
Ln(Agricultural price index(-1))	0.0138ns	-0.0042ns	-0.0096ns
	(0.6720)	(0.3563)	(0.7524)

***, **and * indicate significance at the level of 1, 5 and 10%, respectively. ns indicates that the desired variable is insignificance
Source: Research findings

According to the results presented in Table 4, the direct effect of GDP per capita variable is positive and significant; this means that by increasing this variable by one percent, deforestation in the target country increases by 0.1050 percent. This is because economic growth is one of the most important factors in the source of environmental effects and increasing economic growth stimulates demand for agricultural and forestry products and increases deforestation. Exchange rates, population density, and unemployment have also had a positive and significant effect on deforestation. By increasing each of these variables by one percent, forest degradation in the target country increases by 0.0730, 0.0200, and 0.0440 percent, respectively. A change in the exchange rate causes a change in the export and import of various goods and services. One of these goods is the production of wood and its products for use in domestic markets and its export to international markets; In other words, increasing the exchange rate reduces the import of wood and more use of domestic forest resources and increases deforestation. In the literature on environmental economics, population growth is one of the most important factors in environmental degradation. As the population expands, the demand for agricultural land, energy resources, and water resources increase, increasing deforestation. In addition, the growing population will provide a large workforce that will affect the labor market with downward pressure on wage rates, leading to higher unemployment and further increased pressures on forests. Also, the direct effect of the human development index variable is negative and significant, which indicates that by increasing this variable by one percent, the amount of forest destruction decreases by 0.08 percent in the target country.

The results of estimating the indirect effects (spillover) show that the variable of GDP per capita in other countries has a positive and significant effect on deforestation in the target country. Increasing the economic growth of a country makes neighboring regions benefit from access to labor, capital, and knowledge; therefore, the growth of a region can increase the economic growth of the target country through trade communication channels, demand communication, and interregional mobility of production factors. As a result, if economic growth increases in other countries, it will spread to the target country.

Population growth reduces job opportunities and increases migration from neighboring countries to the target country, and this increase in migration will increase the demand for food, increase the demand for land for shelter, and cut down trees illegally to generate income, followed by an increase in deforestation in the target country. Also, spillover of population density and unemployment variables in neighboring countries has shown a positive and significant effect on deforestation in the target country; this means that the weighted average of the above explanatory variables has affected the deforestation of the target country. In countries of the southern half of Asia, the spillover of variable exchange rates in neighboring countries has a negative and significant effect on deforestation. Therefore, it is concluded that the increase in exchange rates in neighboring countries causes the country to import forest resources from neighboring countries instead of cutting down forest resources, reducing deforestation in the target country. Similarly, the total effect was significant for all variables except the price index of agricultural products.

Table 4 shows that the coefficients *lnGDPPC* and $(lnGDPPC)^2$ for the total effects are positive and significant and negative and significant, respectively. As a result, the relationship between deforestation and GDP is inverted U-shaped, and the environmental Kuznets curve hypothesis is confirmed. According to Equation (16), the GDP per capita for selected countries was estimated at $ 5,107 per year. This number indicates the turning point of the environmental Kuznets curve; this means that to prevent the increase of deforestation in selected countries and be in the descending part of the environmental Kuznets curve, the amount of GDP per capita must exceed this amount. According to Equation (17), the income elasticity at the turning point for the selected countries was estimated at 8.53. Using the average GDP per capita over the past 30 years, the income elasticity values and the location of selected countries before or after the turning point are shown in Table (5).

Table 5- Average of GDP per capita, lnGDP and income elasticity for the studied countries

Countries before the turning point of the Kuznets curve				Countries after the turning point of the Kuznets curve			
Name of countries	**Average GDP per capita**	**LGDPPC**	**elasticity**	**Name of countries**	**Average GDP per capita**	**LGDPPC**	**elasticity**
Bangladesh	2627.953	7.8739603	0.008638	Azerbaijan	9110.992	9.1172368	-0.007524
India	3639.464	8.1995917	0.004405	Armenia	7443.296	8.9150689	-0.004895
Kyrgyz Republic	3917.208	8.2731343	0.003449	China	7004.509	8.8543094	-0.004106
Pakistan	3697.538	8.2154224	0.004199	Indonesia	7513.041	8.9243955	-0.005017
Tajikistan	2208.393	7.7000202	0.010899	Iran	11561.7	9.3554534	-0.010620
Uzbekistan	4126.207	8.3251137	0.002773	Kazakhstan	16849.37	9.7320688	-0.015516
Vietnam	4279.099	8.3614978	0.002300	Philippines	5568.791	8.6249332	-0.001124
				Thailand	12568.92	9.438982	-0.011706
				Japan	36739.66	10.51161	-0.025650
				Malaysia	18767.14	9.8398629	-0.016918
				Singapore	67012.98	11.112641	-0.033464

Source: Research findings

Bangladesh, India, Kyrgyzstan, Pakistan, Tajikistan, Uzbekistan, and Vietnam are ahead of the turning point of the Kuznets curve (Table 5). Estimates also show that Azerbaijan, Armenia, China, Indonesia, Iran, Kazakhstan, Philippines, Thailand, Japan, Malaysia, and Singapore are behind the turning point of the Kuznets curve, indicating an inverse relationship between economic growth and deforestation. Ullah *et al.* (2022) believe that the reason for not stopping the deforestation process in Bangladesh is the lack of government understanding of the factors affecting deforestation in this country. Bera *et al.* (2020) state that rapid urbanization and population growth are vital factors in deforestation in India. Ahmed *et al.* (2015) consider the need for agricultural land and urbanization as the leading cause of deforestation in Central Asian countries such as Kyrgyzstan, Pakistan, Tajikistan, and Uzbekistan. In a study, Cochard *et al.* (2020) stated that unemployment and poverty, lack of monitoring, and efficient management are essential factors in deforestation in Vietnam.

Finally, the estimation results confirm that when the spatial correlation is fully considered in the sample data range, the turning point of the spatial environmental Kuznets curve occurs at a higher level than when the spatial correlation is ignored (calculation 2.62 by equation (14)). These results are consistent with the findings of Hao *et al.* (2016) and Lv and Li (2021).

Conclusion and Suggestions

In this study, the effect of socio-economic variables on deforestation has been investigated. The study includes data from 18 Asian countries from 2005-to 2015. Although many studies have examined the impact of various factors on deforestation, the spatial econometric approach has rarely been used; therefore, the present study investigated the effect of socio-economic variables on deforestation using the spatial panel data model to prevent deviation of the estimated coefficients. Experimental results showed a positive spatial correlation between countries regarding deforestation. This means that deforestation in a country depends not only on the socio-economic variables of that country but also on the socio-economic variables of neighboring countries. This result is consistent with the study of Boubacar (2012) and Wheeler *et al.* (2013).

The positive and significant total effect of GDP per capita and the negative and significant total effect of GDP per capita square confirm the existence of the environmental Kuznets curve hypothesis. In addition, the results of direct effects showed that the increase in GDP per capita due to stimulating demand for agricultural and forestry products, increasing the exchange rate due to reduced wood imports and greater use of domestic forest resources, increasing population density and unemployment due to increase demand for agricultural land and downward pressure on wage rates in the labor market increase deforestation and improving the human development index due to improving the level of literacy and human capital will reduce deforestation.

Some policy recommendations can be made based on the findings of this research. First, the main findings of the spatial Durbin model can

point policymakers to pay attention not only to socio-economic activities on deforestation in their own country but also to the impact of these activities on deforestation in neighboring countries. Second, the environmental Kuznets curve has not been approved in some countries, so the incomes of some of the target countries will not reach a turning point shortly. This shows that these countries will experience deforestation for a while due to economic growth, Like Brazil, which has destroyed large rainforest areas to achieve high economic growth and agricultural expansion. Therefore, until the environmental Kuznets curve hypothesis is accepted, practical efforts to reduce deforestation in the path of economic development are essential. In this regard, stricter rules should be enacted on the illegal exploitation of forests, such as the prevention of timber smuggling and forest exploitation capacity thresholds to curb deforestation associated with economic growth.

As observed, the exchange rate variable has a direct and significant effect on deforestation; therefore, it is suggested that in the framework of bilateral and multilateral business models, priority be given to the export and import of environmentally friendly goods. Given that population has a direct and significant impact on deforestation in selected countries and given the increase in population growth in different years, it is suggested to pay more attention to the issue of the population by looking at the requirements of sustainable development to reduce environmental degradation, mainly deforestation. Because according to the results of this study, the lack of rapid direct population growth reduces deforestation in selected countries.

Unemployment variable after the economic growth variable has the most impact on deforestation in selected countries; therefore, governments should anticipate the occurrence of long-term unemployment among job seekers by providing more effectual assistance, such as self-employment facilities and job creation to employers, to those most at risk of unemployment. Also, pay special attention to people who have advantages in finding a job, such as university education and technical and vocational training; therefore, efforts to eradicate unemployment to preserve forest lands, and eradicate poverty must be a priority for countries.

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مقاله پژوهشی

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تأثیر ابعاد اقتصادی-اجتماعی بر جنگل‌زدایی: کاربرد اقتصادسنجی فضایی

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چکیده

فعالیت‌های انسان قرن‌هاست که منجر به تخریب جنگل‌ها شده است. در قرن بیست و یکم، جنگل‌زدایی یکی از عوامل اصلی تغییرات آب‌وهوا بوده است؛ چراکه جنگل‌ها از دلایل اصلی کاهش انتشار گازهای گلخانه‌ای هستند. در نیم‌قرن گذشته کشورهای نیمه جنوبی قاره آسیا به دلیل تغییر ساختار اقتصادی، افزایش جمعیت و گسترش جهانی‌شدن، متحمل خسارت‌های عظیمی از مناطق جنگلی شده است. بر همین اساس در این پژوهش، عوامل اقتصادی اجتماعی مؤثر بر تخریب جنگل با توجه به داده‌های موجود در ۱۸ کشور منتخب در نیمه جنوبی قاره آسیا بین سال‌های ۲۰۰۵ تا ۲۰۱۵ با استفاده از اقتصادسنجی فضایی بررسی شد. نتایج آزمون‌های همبستگی فضایی نشان داد که نادیده گرفتن اثرات همبستگی فضایی باعث خطای تخمین برازش می‌شود؛ همچنین نتایج برآورد مدل، فرضیه منحنی محیط‌زیستی کوزنتس برای کشورهای منتخب را با نقطه عطف ۵۱۰۷ دلار تأیید می‌کند. مطابق با یافته‌های تحقیق، افزایش تولید ناخالص داخلی سرانه در سایر کشورها از طریق تحرک بین منطقه‌ای نهاده‌های تولید موجب افزایش جنگل‌زدایی در کشور مورد نظر می‌شود. افزایش نرخ ارز در سایر کشورها به دلیل افزایش واردات محصولات جنگلی از سایر کشورها و عدم قطع منابع جنگلی داخلی موجب کاهش جنگل‌زدایی در کشور مورد نظر می‌گردد. افزایش تراکم جمعیت و بیکاری در سایر کشورها به دلیل کاهش فرصت‌های شغلی در سایر کشورها و افزایش مهاجرت به کشور مورد نظر و به‌دنبال آن افزایش تقاضا برای غذا و افزایش تقاضای زمین باعث افزایش جنگل‌زدایی در کشور مورد نظر شده است. در نهایت افزایش متغیر شاخص توسعه انسانی باعث کاهش جنگل‌زدایی در کشور مورد نظر شده است؛ ولی تغییر این متغیر در سایر کشورها تأثیری بر جنگل‌زدایی کشور مورد نظر نداشته است؛ لذا در دنیایی با رشد اقتصادی فزاینده، پیشنهاد می‌شود به‌منظور تضمین جلوگیری از تخریب جنگل‌ها در بهبود شاخص توسعه انسانی؛ ریشه‌کن‌کردن معضل بیکاری و ریشه‌کن‌کردن فقر تلاش‌ها مضاعف گردد. همانطور که نتایج این مطالعه نشان داد جمعیت تأثیر مستقیم و معنی‌دار بر جنگل‌زدایی در کشورهای منتخب داشت و با توجه به افزایش رشد جمعیت در سال‌های مختلف، پیشنهاد می‌شود به مسئله جمعیت با نگاه به الزامات توسعه‌ی پایدار توجه بیشتری شود تا کاهش تخریب محیط‌زیست به‌خصوص جنگل‌زدایی را به همراه داشته باشد. چراکه بر اساس نتایج این مطالعه عدم رشد سریع جمعیت موجب کاهش جنگل‌زدایی در کشورهای منتخب می‌گردد.

واژه‌های کلیدی: اقتصادسنجی فضایی، توسعه پایدار اقتصادی، جنگل‌زدایی، منحنی کوزنتس فضایی

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Effects of Water Resource Reduction on Employment in Agricultural and Non-Agricultural Sectors Based on the Social Accounting Matrix

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Abstract

Water is one of the main basic resources for development and is the most significant factor in Iranian agriculture production. The agricultural sector has an important role in production, employment, and gaining exchange and drastically affects other sectors of the economy. The purpose of this study was to evaluate the effect of water resources` reduction on agricultural sub-sector and other sectors` employment. The employment data were collected from SAM, 2011 and the employment generated by the economic activities of the economic sectors and the contribution of each of these sectors to employment was examined. The service sector ranked first with 24.99% employment creation and agriculture ranked second with 19%. Construction, industry, commerce, and transportation sectors ranked third to sixth, with 82.4% of the total employed working in these six sectors. The results showed that with water resources reduction by 10, 20 and 30%, the total employment decreased to 416334, 769472 and 1044114 people, respectively. In agricultural sub-sectors, the highest decrease was in farming and horticulture subsectors with an average of 14.17%. According to the results, water saving technology was a solution to reach the major goals of agricultural development, especially for employment.

Keywords: Agricultural sector, Employment, Social Accounting Matrix
Classification JEL: E24, C67, Q16

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Introduction

Water is one of the most significant resources for development of the country and one of the greatest human challenges of the present century, which can be the origin of many positive and negative developments in the world. Water is the most important element in agriculture production, and agriculture has a significant role in the production, employment, acquisition of foreign exchange and has a drastic effect on the other sectors of the economy. With about 11% of GDP, 23% of employment and providing food to more than 80% of the population, agriculture has a critical role in the Iranian economy (Federation of International Trade Association (FITA), 2006). With less investment compared to the other sectors, this sector has a more critical role in modifying unemployment problems than the other sectors. To understand the importance of this sector in the national economy, the best practice is to calculate and estimate its sub-sectors through SAM.

Although Iran icludes one percent of the world's population, and more than 50 million hectares of agricultural land which accounts for about 18% of the total cultivation land area in the world. Even in the case of water, about 90 billion cubic meters of water are harvested in the country, which accounts for more than 3% of the total amount of harvested water in the world.. The problem is that the water is not used optimally, as only 5% of the stated lands (about 18.5 million hectares) are under aquaculture. In other words, millions of cubic meters of water, which is worth over billions of Rials, is wasted.

The problem our society has faced, especially in recent years, has been the decrease in rural incomes due to the decrease in production and the low price of agricultural products given the continuing droughts, which has led to an unmanageable migration of villagers to cities and, consequently, a decrease of population of producers and an increase in the population of consumers, as well as increased unemployment and social problems. The statistics on the potential and actual states of the country in the agricultural sector show that there are still many potential sources in the country that will resolve some of the concerns in employment and production, if properly planned. During the years of 1976 to 2006, job creation in cities was 5.25% more than in rural areas. During this period, although more than 36.6% of the added unemployed were allocated to rural areas, but only about 16% of employment belonged to these areas. Given the role of employment in reducing economic, social and political inequalities in urban and rural areas of the country and the adjustment of rural migration, a balanced expansion of job opportunities between these areas is essential (Panahi and Morseli, 2007).

The water sector is one of the basic infrastructures of the country that can act as a growth engine in the economy and increase the growth of other sectors, particularly the agricultural sector and its related activities. Moreover, water sector is one of the key sectors of the economy that should be paid special attention for the growth of other sectors of the economy. In this study, with the understanding of the importance of the issue, the effect of reducing water resources on the employment of agricultural sub-sectors and other sectors have been examined. By analyzing this, SAM has been used to improve this sector and examine the positive strategies and effects.

Literature Review

The studies on the effect of various economic sectors on employment and their ranking within the country and abroad have all emphasized the effect of these sectors on employment. However, Esfandiari and Tarhimi (2009) have studied the employment-generation potential of Iranian economic sectors with an emphasis on the agricultural sector. The results of the study indicated that the agricultural sector, oils and other food products and construction rank first to third among the economic sectors. Comparison of the production potential and total employment growth shows that out of 35 sectors of Iran, only 7 sectors have more potential to create employment than production, stating that despite the high growth of production in Iran, employment growth rate is negligible. Zand *et al*. (2019a) investigated the socio-economic impacts (direct and indirect effects) of the investment development policy on the agricultural sector and its sub-sectors in Iran in 2011 using a social accounting matrix (SAM). The results included three scenarios including a 15% increase in investment in the agricultural sector, a 10% increase in the investment in the farming and gardening sub-sector, a 15% increase in the investment in the farming and gardening sub-sector, and a 10% increase in the investment in the

other sub-sectors. They indicated that the total income of the economy was increased when these scenarios were implemented; however, the first scenario had a greater impact on the total income of the economy (13.12%) compared to the other scenarios. Furthermore, it can be said that the sectors of agriculture (2.98%) and industry (0.36%) were most influenced by the first scenario and the sub-sector of farming and gardening and the industrial sector were most influenced by the second and third scenarios. Scott *et al*. (2008) examined the energy technology programs in buildings and their effect on employment, income, and investment. The results showed that if these programs could be developed, employment would increase by more than 446,000 jobs. Amirnezhad et al. (2015), in a paper entitled "Examining the effect of value added and investing on agricultural employment in 1986-2012" using econometric method and autoregressive distributed lag (ARDL), concluded that investment in agriculture, both in long and short terms, has a positive and significant effect on agricultural employment. Peng *et al.* (2011) examined the effect of higher education on increasing incomes and employment in the form of a report. The increasing income and employment ratios showed an increase in income and employment due to an increase in sales to other sectors. In the study by Zand *et al*. (2019b), the analysis of the effects of the policy of investment growth in agriculture based on the method of Social Accounting Matrix (SAM) was considered. The effects of applying this policy (including net, open and closed effects) have been analyzed in three scenarios. The results of net effects showed that the incomes of production activities would be increased in each of these scenarios. The findings also showed that the closed effects of the aforementioned scenarios on the industries, services, and commerce were more than the agricultural sector itself and its sub-sectors, indicating a strong link between these sectors and the agricultural sector and its sub-sectors.

Poursafar and Mohammadi (2015) examined the effect of investment in Iran's agricultural sector on employment and value added of this sector using the Johansen Johansen's method. They eventually concluded that investment had the highest positive effect on employment and value added of the agricultural sector. Dehgan Shourkand and Misaghifar (2017) studied the significance of educational services in Iran's economy using SAM approach. The study has examined the importance of the role of educational subdivisions using SAM in Iran's economy. According to the studies conducted in the educational sub-sections, higher education has far more effect on production, the income of production factors, employment and consumption of inputs compared to other educational subdivisions. The results of this study showed strong links between the educational sector and the wholesale, retail and repairing sectors of vehicles and goods. Sorudi and Mirzaei (2013) have analyzed the effects of increasing the price of energy carriers on the employment of Iranian economic sectors, with an emphasis on the agricultural sector. The results of the study on the employment effects of final demand components after adjusting 100% of carriers' prices showed that the increase in the price of energy carriers has a very small effect on the employment of these components in the agricultural sector. Salami and Ansari (2009) have examined the role of agricultural sector in creating employment and income distribution. In doing so, they developed Iran's accounting matrix according to the last output table in 2001 and by calculating the increasing coefficients of labor and income within the framework of this matrix, they analyzed these factors by structural analysis of the route and studying the role of agricultural sector in creating employment and reducing inequality in income distribution. The results showed that the agricultural sub-sectors have a high short-term potential in generating employment, and the development of these sub-sectors will generate significant household income growth. Sharifi *et al*. (2012) sought to specify the status of activity of different production sectors in creating employment and adding value in the country and its causes. Input-output coefficient analysis was used for this purpose. The results showed that one of the most important factors in creating employment and value added is the increasing coefficient of total employment in the past. Accordingly, only agriculture, horticulture and forestry sectors ranked among the top five in terms of increasing rates, value added and employment creation given the provision of inputs for the economic sectors. In a study using input-output analysis in 2006, Kureski and Rolem (2012) estimated the employment rate and direct and indirect income to differentiate the level of employment at the educational level. According to the results, the highest growth factor was found in employment in other service sectors and in the manufacturing sector in metallurgy of non-ferrous

metals. Kohansal and Perme (2014) examined the effect of reduction of agricultural sector subsidies on production and employment using the method of social accounting matrix of 2006. His results showed that one of the important effects of reducing agricultural sector subsidies is its effect on reducing the production of this sector and thus reducing its job creation. Mehrali Tabar (2013) examined the structure of the formal and informal sectors of Iranian economy with an emphasis on employment using SAM. The study examined the structure and dimensions of the informal sector of the economy with a general equilibrium approach in SAM framework of 2006 using peripheral statistics to distinguish between formal and informal sectors. The results showed that the employment potential of the informal sector is higher than the formal sector, showing the importance of this sector in the economy of the country. Mirbagheri and Ethnaashari (2016) examined the effect of private sector investment on employment using the multivariate linear regression model and data panel in 2000-2014. The results showed that private sector investment with a coefficient of 0.019 has a positive effect on employment. Valizadeh *et al.* (2015) determined employment and its relationship with investment in transportation in the region's economic growth using the theory of a dynamic labor demand approach. The results showed that investment should be made at the proper time to have positive effects, affect regional employment, and bring about economic growth.

Other studies have been done in this regard by (Khaleghi *et al*., (2015); Perme and Karbasi, (2012); Faridzad *et al*., (2012); Hosseinzadeh and Yaghoubi, (2016) and Khani *et al*. (2012).

Methodology

This study sought to use the information obtained on employment from SAM in 2011 and the employment generated by the economic activities of the economic sectors to examine the effect of reducing water resources on each of these sectors in creating employment.

To differentiate between different economic sectors in terms of employment creation in society, they were examined separately.

Table 1 summarizes the social accounting matrix. According to this table, this matrix shows the relationships between production activities, the income distribution of these activities among the factors of production, and the distribution of income among socio-economic institutions (Parmeh *et al*., 2011).

To calculate the average propensity to consume matrix in the SAM model by dividing each of the elements of the T_{nn} matrix into the sum of the corresponding column, another matrix called the average propensity to consume matrix is used (Salami and Parmeh, 2001; Zand *et al*., 2019a).

$$T_{nn} = A_n \ddot{Y}_n \quad (1)$$

$$A_n = \begin{bmatrix} A_{11} & O & A_{13} \\ A_{21} & O & O \\ O & A_{32} & A_{33} \end{bmatrix} \quad (2)$$

In the equation 1, it is a matrix of diameter whose elements on its main diameter are Yi (i = 1, ... n). Similarly, the relation 3 can show the Txn matrix (Salami and Parmeh, 2001; Zand *et al*., 2019a):

$$T_{Xn} = A_l \ddot{Y}_n \quad (3)$$

In relation 3, A_l is called matrix of average propensity to leak. According to the definition of two matrices An and A_l, l and n can be represented as follows:

$$n = A_n . Y_n \quad (4)$$

$$l = A_l . Y_n \quad (5)$$

By combining the above relationships, a new relationship is obtained as follows:

$$Y_n = A_n Y_n + X = (I - A_n)^{-1} X = M_a X \quad (6)$$

$$M_a = (I - A_n)^{-1} \quad (7)$$

Relation 6 essentially illustrates the pattern of social accounting matrix in which the income level of endogenous accounts in the social accounting matrix is expressed as a function of the variable level of exogenous X. In this respect, M_a is the accounting multiplier matrix. This matrix is called the accounting multiplier matrix, which only represents the structure formed in the form of the social accounting matrix as it is, and somehow establishes the relationship between certain levels of Y_n and X.

According to the basic equations of SAM table:

$$X = AX + Y \quad (8)$$

X shows the diagonal matrix of the total output, A the matrix of technical coefficients, and Y shows the diagonal matrix of final demand for sectors` production. In this case, usually X is the endogenous, which is calculated in terms of A as the technical coefficients matrix and Y is the exogenous variable.

Table 1- Different types of endogenous and exogenous accounts

Inputs Outputs		Endogenous accouts			Exogenous accouts	
		Productio n	Factors of Production	Innstitutrs (families and companies without govermment	Other accouts govermment, accumulation extemal world	Sum of the Inputs demand and total income)
Endogenous accouts	Production	T_{11}	0	T_{13}	X_1	Y_1
	Factors of Production	T_{21}	0	0	X_2	Y_2
	Innstitutrs (families and companies without govermment)	0	T_{32}	0	X_3	Y_3
Exogenous accouts	Other accouts govermment, accumulation extemal world	l'_1	l'_2	l'_3	T	Y_X
Sum of the outputs		Y'_1	Y'_2	Y'_3	Y'_X	

Source: (Defourney & Thobcke 1984)

$$X = (I - A)^1 \times Y = C \times Y \quad (9)$$

C is a reversal of the Leontief matrix, which shows the effect of the final demand for sectors` production at the level of production of the sectors in question. In other words, the elements of the matrix C are the value of production needed from the manufacturing sectors studied to respond to a final demand unit of the economic sectors.

To calculate the employment rate or labor demand by each sector, the vector of employment coefficients should be multiplied in the inverse of the Leontief matrix so that the total employment generated by the activity of each sector could be calculated. Additionally, if the employment coefficients (employment rate per division for a unit of production) are multiplied by a diagonal matrix in the inverse of the Leontief matrix, employment matrices can be used to distinguish direct employment from indirect employment (Sameti, 2002).

If q_j and e_j are, respectively, production and employment in sector j, the employment coefficient in this sector is considered as such. Thus, the coefficient of employment is derived from the division of the employment of each sector into the total output of that sector. Employment coefficient is the value of work required per unit of production in the i-th unit.

$$a_j = \frac{e_j}{q_j} \qquad \text{i = 1 and 2.... and n} \quad (10)$$

If any of e_is in the original diameter is an n × n matrix and the other elements of this matrix are zero, then the coefficient of employment is created, therefore the following equation is obtained (Tarahomi, 2008).

$$e = \begin{bmatrix} e1 & 0 & 0 \\ 0 & e2 & 0 \\ 0 & 0 & en \end{bmatrix} \quad (11)$$

In this case, the employment matrix L is the product of the diagonal matrix of the employment coefficients e and the inverse of the Leontief matrix.

$$L = \hat{e}(I-A)^{-1} \quad (12)$$

In this case, the inverse matrix of employment coefficient is obtained. Using this employment matrix, which is calculated by multiplying the inverse of the Leontief matrix and the coefficient of employment matrix, one can calculate the employment effect of each sector according to the final demand and its components. For instance, if L matrix is multiplied by governmental expenditures, the employment effect of this component of the final demand can be measured for each sector, and if we multiply the final demand of the whole economy, the priority of the industry would be different from the employment perspective. In other words, to calculate the potential power of different sectors of the economy, the inverse employment matrix (L) is multiplied by the final demand:

$$P = L.Y \quad (13)$$

The total column of the reciprocal matrix

elements of employment shows an increasing employment rate. This index shows th volume of increased employment in the economy if one million riyals increase in the final demand of section j.

$$L=\begin{bmatrix} e_1 & \cdots & 0 \\ \vdots & & \vdots \\ 0 & \cdots & e_n \end{bmatrix} * \begin{bmatrix} 1-a_{11} & \cdots & -a_{1n} \\ \vdots & & \vdots \\ -a_{n1} & \cdots & 1-a_{nn} \end{bmatrix}^{-1} = \begin{bmatrix} l_{11} & \cdots & l_{1n} \\ \vdots & & \vdots \\ l_{n1} & \cdots & l_{nn} \end{bmatrix} \quad (14)$$

As is seen in Equation 7, matrix L is obtained from the product of the multiplication of the diagonal matrix of the direct coefficients of employment (e) and Leontief inverse matrix (c). Thus, the elements of this matrix showed the direct and indirect employment of different sectors of the economy when the final demand or its components changed. In other words, the main diameter of this matrix was the direct employment generated by each unit of the final product produced in the studied section. Other elements of the matrix row showed the indirect employment generated by each unit of final product produced in other sectors of the economy in the studied sector.

Employment multiplier E: It is the row vector (1 * n) obtained from the column sum of the elements of the employment matrix. This vector showed the amount of units that could be added to the total employment if the final demand was increased by one percent (one unit) (Javaheri and Hadi Zonuz, 2008).

$$E = i'.L \quad (15)$$

i': unit row vector

By replacing 10 in 9, a new relationship is obtained that shows the relationship between final demand, production structure, and employment creation capacity (people-job of created direct and indirect) by different economic sectors.

$$L = e(1-A)^{-1}Y = KF \quad (16)$$

And $K = e(1-A)^{-1} = K_{ij}$

MatrixK_{ij} represents the matrix of employment multiplier, and the sum of each of its columns reveals the direct and indirect jobs created by injecting a specific unit of exogenous accounts of economic sectors by those sectors throughout the economy. This matrix is called the incomplete closed-loop effects of employment. If we want to calculate the indirect jobs created by each department, it is enough to subtract the direct employment coefficients from the matrix of employment multipliers. The following relation expresses the indirect job created by the additional injection of a specific unit of exogenous accounts.

$$IL = (K-e)F = QF \quad (17)$$

Where in $Q = (K-e) = q_{ij}$

In relation 17, q_{ij} is the matrix of indirect employment multiplier. The sum of each of those columns reveals the indirect jobs created by the additional injection of a specific unit of exogenous accounts of productive activities by sectors throughout the economy (Banoui and Mahmoudi, 2001).

Statistical resources

The information used in this study was derived from the input-output table and SAM of the country in 2011. In doing so, 71-item table of 2011 IPRC was used. Employment statistics were derived from the statistics of the employed by the major groups based on the Population and Housing Census in 2011. By integrating sub-sections and reaching the main sections, the table was obtained as 13 activities. Finally, the employment statistics of 2011 were converted into 13 economic sectors with activities in the table.

Results and Discussion

The social accounting matrix was used to determine the share of manufacturing activities in direct and indirect employment in the whole economy and the share of each production for use in the creation of employment.

Table 2 showed the employment status of the country in 2011. Of the 20546874 people employed in various economic sectors, service sector (public, social, personal, household, real estate, professional and specialized services, and financial and monetary services) by generating 24.99% employment was in the first rank followed by agriculture and horticulture, animal husbandry, forestry and fishing with 19% of employment in the second place. Construction, industry, commerce, and transportation sectors ranked third to sixth, accounting for 82.4% of all employees in these six sectors. In contrast, oil and gas sectors, mines and water were between tenth and thirteenth, with the lowest number of employees in the stated year. The Table also showed the direct and indirect employment of the sectors separately.

Employment generated in different sectors of the economy depends on various factors. One of these factors is the coefficient of correlation of direct job creation of different economic sectors, as shown in Table 2. According to the calculations,

the coefficient of correlation of direct job creation rates of different sectors of the economy with the employment generated in them was 0.113. Although a part of the employment creation of the sectors was due to the difference in the coefficients of direct employment, the low coefficient showed the low importance of this factor. Thus, factors other than user or capital-based sectors were involved in their employment.

Also, according to results of Sharifi *et al.* (2012), the agriculture, horticulture and forestry sectors were ranked first to third in employment creation in 1385, respectively, and among these, only the agriculture, horticulture and forestry sector is the only sector that is also in terms of creation. Value added and in terms of employment was among the top 5 sectors of the Iranian economy in 1385.

Table 2- Total, direct and indirect employment in different sectors of the economy

Economic sectors	Total employment (people)	Direct employment (people)	Indirect employment (people)	Percent L	Rank L
Agriculture and horticulture	2629352	2208602	42755	12.8	5
Animal husbandry	1104897	977989	126908	5.38	7
Forestry	39481	-276369	315850	0.19	12
Fishing	128668	-107131	235799	0.63	10
Oil and Gas	150878	66015	84863	0.73	9
Mines	92401	-22034	113435	0.44	11
Industry	3062534	3017827	44707	14.91	3
Electricity	253814	131561	122253	1.24	8
Water	9696	-8634	18330	0.05	13
Construction	3112017	2971508	140509	15.15	2
Commerce	2994715	2776620	218095	14.58	4
Transportation	1833745	1586089	2465	8.92	6
Services	5135671	4888009	247662	24.99	1
Total	20547869	18210052	2337817	100	

Source: Research findings

The results of Table 3 showed the effects and consequences of reducing 10% of the water in reducing the employment of the economic sectors in terms of absolute effects and relative effects. In order to avoid increasing the volume of paper, the economic sectors have been covered and presented in the form of 13 parts of the case Trial and analysis.

Table 3- Absolute and relative effects of 10% water reduction on the employment of agricultural sub-sectors and other sectors

Economic sectors	Absolute effects of 10% (person)	Relative Effects (Percent)	Economic sectors	Absolute effects of 10% (person)	Relative Effects (Percent)
Agriculture and horticulture	58989	14.17	Electricity	9210	2.21
Animal husbandry	11626	2.79	Water	24821	5.96
Forestry	761	0.18	Construction	14797	3.55
Fishing	1481	0.36	Commerce	63812	15.33
Oil and Gas	6024	1.45	Transportation	32847	7.89
Mines	2282	0.55	Services	152861	36.72
Industry	58989	8.84	Total	416334	100

Source: Research findings

The results showed that the direct and indirect effects and the consequences of a 10% reduction in water resulted in a decrease of 41,634 people in all sectors with the highest drop in employment being in the service sector with 152,861 people and the lowest reduction in the forestry sector with 761 people. According to SAM, the reduction of water content in agricultural and industrial sectors can be interpreted directly, but the decline in the services` sector cannot be interpreted directly. This is because the mediator need of the water sector to these sectors is low, but the intensity of the dependence of the agricultural sector and services to the water sector is high. Thus, considering Table

3, one can state that agricultural and service sectors were directly affected by the reduction in water.

Relative effects` figures showed the effect of one percentage reduction in water levels on employment units before and after water reduction. For example, agriculture with 17.5% and services with 36.77% reduction in employment had the most effect on job losses. Commerce, industry, transportation, water and construction with 15.33%, 8.84%, 7.89%, 5.96% and 3.55%, respectively, had the next ranks in employment reduction. These results showed that agricultural sectors were among the most important sectors that should be considered by responsible institutions during the drought. Given that the share of employment in the agricultural sector is declining and at the same time labor productivity in this sector is improving. The decrease in the share of agricultural employment in Iran from 56% in 1335 to 23% in 1379 confirms this claim. The unemployment crisis in the last decade has cast doubt on the potential of Iran's agricultural sector to create jobs (Sadeghi and Homayonifar, 2001).

Thus, water reduction in the agricultural sector, besides reducing the product output of these sectors, dramatically reduced employment in this sector and other sectors of the economy. This model could provide a more realistic look at the vulnerability of other economic sectors caused by water reduction (drought) for policy makers and relevant institutions.

According to the results of research Mahmudi and Banouei (2003) and Salami and Ansari (2009), among the producer sectors, agriculture and food industries are important and have priority in terms of job creation, and other producer sectors and some services are in the next categories. Therefore, they can be considered in policies as investment priorities to increase employment. These findings confirm our results.

Table 4- Absolute effects of a 20% water reduction on employment in agricultural sector-sectors and other sectors

Economic sectors	Absolute effects of 20% (person)	Economic sectors	Absolute effects of 20% (person)
Agriculture and horticulture	108002	Electricity	13623
Animal husbandry	21512	Water	55299
Forestry	1417	Construction	28200
Fishing	2583	Commerce	113257
Oil and Gas	11692	Transportation	59862
Mines	4341	Services	282878
Industry	66806	Total	769472

Source: Research findings

In this scenario, it is assumed that if water reduction rate was 20%, according to Table 4, due to the effect of this shock, the reduction in employment of agriculture and horticulture would be 14.17% (equal to 108002 people), and therefore the agricultural sector would reduce by 17.5% (equal to 133514 people). Moreover, service sector with a decrease of 36.72% (equal to 282878 people), commerce 15.33% (equal to 113,257 people) and industries 8.84% (equal to 66,806 people) would be the mostly affected sectors. Therefore, due to the existence of earlier and later links, the effects of this shock can be seen in other sectors in addition to the sub-sector of agriculture and horticulture. One can also state that this shock had the greatest decrease in employment in the agriculture, horticulture and services sectors and forestry had the lowest decrease (0.18%, 1417 people).

Table 5- Absolute effects of 30% water reduction on employment of agricultural sub-sectors and other sectors

Economic sectors	Absolute effects of 30% (person)	Economic sectors	Absolute effects of 30% (person)
Agriculture and horticulture	144623	Electricity	12078
Animal husbandry	29239	Water	92800
Forestry	1942	Construction	39872
Fishing	3215	Commerce	144855
Oil and Gas	16920	Transportation	79634
Mines	6123	Services	384523
Industry	88291	Total	1044114

Source: Research findings

According to the analysis conducted as shown in Table 5 for various sectors separately, 30% reduction in the country's water led to 1044114 people decrease in total employment, with the highest reduction in employment in the service sector and agriculture, respectively, as 384523 and 179019 people. Moreover, water sector with 5.96% employment reduction added 92800 unemployed people directly and indirectly to the unemployed population of the community.

According to Table 6, agriculture and horticulture sector with 20.48 had the highest employment creation coefficient. Hence, for one billion riyals in this sector, 20.48 people-jobs were created. Forestry, services, shipping, fishing, commercial and construction sectors ranked next in terms of employment. On the other hand, water, industry, oil, gas and mining sectors had the lowest employment levels, respectively. Analysis of the data table showed that the agricultural sector had the least investment compared to other economic sectors and could create more employment directly and indirectly, so one of the best ways to increase employment in society could be investment in this sector.

Based on the above results, it seems that the policies for development and expansion of agricultural activities and activities related to agricultural industries can increase the employment creation in the whole economy. On the one hand, there is a great deal of interdependence between the agricultural sector and the agri-industries, and secondly, these activities are users.

Table 6- Correlation coefficients of direct employment creation of economic sectors

Economic sector	L	Rank L	Economic sector	L	Rank L
Agriculture and horticulture	24.48	1	Electricity	5.95	9
Animal husbandry	6.18	8	Water	0.98	13
Forestry	15.37	2	Construction	6.84	7
Fishing	11.48	5	Commerce	10.61	6
Oil and Gas	4.13	11	Transportation	12.05	4
Mines	5.52	10	Services	12.05	3
Industry	2.18	12			

* Correlation coefficient of direct job creation with employment level of the sectors (0.113)
Source: Research findings

The product of the employment matrix and each component of the final demand showed the employment creation effect of that component. Table 7 shows the effect of employment-generation on the components of the final demand, separately for different sectors. As is seen, the highest employment was for the agriculture and horticulture, industries and commerce. Moreover, the effect of government spending on occupations in different sectors was less than the other parts of the final demand.

The positive correlation between the job creation coefficients of the sectors indicates the relative similarity of these sectors in the employment creation. Most of these coefficients are due to the importance of these sectors in employment.

In confirmation of these results, Banoui and Mahmoudi (2001) showed that the total direct and indirect jobs created by the agricultural sector in the whole economy, due to the injection of one billion rials of consumption, investment or export in the model of social accounting matrix is ranked first.

Conclusions and Policy Implications

This study examined the effect of water reduction on the employment of agricultural sub-sectors and other economic sectors using SAM of 2011. The results showed that with 10, 20 and 30% reduction in water, the total employment would decrease by 416334, 769472 and 1044114 people, respectively. This employment reduction was observed in the agricultural sub-sectors separately, with the highest reduction in the agriculture and horticulture sub-sector with an average of 14.17%. Then, the sub-sectors of fishing, animal husbandry and forestry had the highest reduction, respectively. As the results showed, employment reduction in services and commercial sectors was significant, as well.

Table 7- Employment creation according to parts and components of final demand (employment: people)

Economic sector	Private consumption costs	Public consumption costs	Formation of capital	Export	Final demand
Agriculture and horticulture	5535709	90174	3020174	1751890	10391737
Animal husbandry	787866	23138	772069	308374	1891447
Forestry	47754	90109	-45432	39793	132224
Fishing	232123	15930	34924	36351	319329
Oil and Gas	131485	6245	-97537	4196044	4236236
Mines	80150	5033	145133	156215	386532
Industry	2542690	117975	2420333	1424801	6505799
Electricity	1312873	128789	368840	772324	2582826
Water	23004	822	-2857	2035	23004
Construction	289182	122780	4852680	36080	5300721
Commerce	6922376	177276	4770229	827490	12697371
Transportation	2829574	104443	2270452	1097396	6301865

Source: Research findings

In terms of employment creation, the services` sector and agricultural sub-sector ranked first and second, and were far from the other sectors. In other words, these two sectors could potentially account for 52.22% of all Iranian economy employees.

Water reduction in the economy has two consequences: the first is the decline in the employment in the economy and the second is the decline in production in the community. Due to water reduction in the agricultural sector, employment in the economy has decreased by about 17.5%. The results of the estimation of employment creation correlation coefficient showed that among the economic sectors, the agriculture and horticulture sub-sector were not only important in terms of high potential for employment in the agricultural sector, but also it was important in other sectors of the economy. These results clearly indicated the status of the agricultural sector among other sectors of the economy, especially the industrial sectors, in terms of high potential in reducing the unemployment problem and in a shorter period, and again accredited the theory of centrality of the agricultural sector among the production sectors.

Restriction of water resources, rapid population growth and the need for further production have caused a higher demand for this input in the agricultural sector compared to the other water consuming sectors. Thus, the most important challenge in the agricultural sector in status quo is how to produce more food with less water.

It is imperative to consider saving water to help the employment of the economic sectors, especially the agricultural sector. In Iran, given the relative low price of water input compared to other inputs, there is no incentive to invest in water saving technologies. Therefore, simultaneous increase of water prices and subsidies for modern irrigation systems, along with expert methods, observing the agricultural calendar, observing the cultivation pattern appropriate to the climate of each region and preventing over-extraction of groundwater and surface water, timely implementation of sub-networks, development Greenhouse cultivation and education and promotion of optimal water consumption, along with the creation of incentive tariffs for thrifty farmers and the establishment of a fair pricing system can have a significant impact on reducing water consumption and increasing the economic value of water and can reduce water in Eliminate the years of water shortage can have a significant effect on reducing water consumption and increasing the economic value of water and can eliminate the effect of reducing water in the years of water scarcity (Kalaei 2014).

As the results indicated, unemployment and economic downturn would rule the country as a result of water scarcity. Therefore, to help economic units such as the agricultural sector, it is necessary to pay attention to the final demand components and to reduce the effect of water reduction on the economic sectors. Hence, the following strategies can be proposed to alleviate this problem:

Since Iran is located in an arid and semi-arid region, one of the strategies for developing technology in the agricultural sector and reducing unemployment is using the methods that increase water productivity.

using pressure irrigation systems, the implementation of a policy of saving and

rationalizing water use in all sectors of the economy are suggested. Given the above, one can generally consider water-saving technology as a positive tool that can be used to reach the major goals of agricultural development, especially in employment.

Finally, it should be noted that given the drought in recent years and the vulnerability of the agricultural sector in terms of production and employment, one has to consider the infrastructure to reduce these problems of mechanization as soon as possible and also, to eliminate unemployment, the sectors that have a higher employment potential should be given priority in development.

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مقاله پژوهشی

جلد ۳۶، شماره ۲، تابستان ۱۴۰۱، ص ۱۴۱-۱۲۹

تاثیر کاهش آب بر اشتغال بخش کشاورزی و سایر بخش‌های اقتصادی بر اساس جدول ماتریس حسابداری- اجتماعی

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چکیده

آب یکی از منابع مهم پایه‌ای برای توسعه کشور و مهمترین عامل تولید در کشاورزی ایران است. بخش کشاورزی نقش مهمی در تولید، اشتغال، کسب و تحصیل ارز داشته و بر روی سایر بخش‌های اقتصادی تاثیر زیادی می‌گذارد. هدف از انجام این تحقیق، ارزیابی تاثیر کاهش منابع آب بر اشتغال زیر بخش‌های کشاورزی و دیگر بخش‌ها می‌باشد. سهم هر یک از این بخش ها در ایجاد اشتغال مورد بررسی قرار گرفت. بخش خدمات، با ایجاد ۲۴/۹۹ درصد اشتغال در رتبه اول و بخش کشاورزی با ۱۹ درصد اشتغال در رتبه دوم قرار دارند. نتایج نشان داد که در اثر کاهش آب به میزان ۱۰، ۲۰ و۳۰ درصد، اشتغال کل به ترتیب به میزان ۴۱۶۳۳۴، ۷۶۹۴۷۲ و ۱۰۴۴۱۱۴ نفر کاهش پیدا می‌کند. در زیربخش‌های کشاورزی، بیشترین کاهش در زیربخش زراعت و باغداری با میانگین ۱۴/۱۷ درصد دیده می‌شود. با توجه به نتایج حاصل، فناوری آب اندوز راهکاری مناسب برای دستیابی به هدف‌های کلان توسعهٔ کشاورزی به ویژه در زمینه اشتغال می‌باشد.

واژه‌های کلیدی: اشتغال، بخش کشاورزی، ماتریس حسابداری- اجتماعی

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Identification of the Leading Knowledge of the Agricultural Sector Using Key Technology Techniques and AHP in Kermanshah Province, Iran

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Abstract

The pattern of knowledge-based production has recently changed economic and social relations. If one wants to use the benefits of this pattern, they have to pay serious attention to the production, distribution, and dissemination of knowledge; in this regard, Leading Knowledge (LK) plays a vital role in developing areas. However, since government budgets have to be spent for public, especially for science and technology which are too expensive, it is impossible to experience the simultaneous advancement in all branches of knowledge. This qualitative and descriptive analysis adopts an applied approach, and tries to identify the LK of the agricultural sector in Kermanshah province, Iran. First, the initial list of LK and Analytic Hierarchy Process (AHP) method based on key technology techniques were prepared through reviewing documents and surveys, i.e. interviews and a panel of experts. In-depth and purposeful interviews were also adopted to extract experts' opinions. Finally, data were analyzed by a panel of experts using the Analytic Hierarchy Process in Expert Choice (EC) software. The results showed that water engineering (0.223), horticultural Science (0.196), and biotechnology (0.138) were listed in order of priority in Kermanshah province. The results can be helpful in revising the educational policies of universities and research centers at the province level, allocating limited resources to the relevant government organziations, Agriculture Jihad and related research centers, and determining the policy of science and technology park and agricultural research centers at the national level.

Keywords: Agricultural sector, Kermanshah province, Key technology, Knowledge-based economy, Leading knowledge

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Introduction

Over the past few decades, a new economic revolution as the knowledge-based economy, has emerged in the world. According to the reports released by the World Bank and the Organization for Economic Co-operation and Development (OECD), knowledge has taken a leading role in economic growth and improvement of people's quality of life (World Bank, 1998; OECD, 1999). OECD defined a knowledge-based economy as an economy that is directly based on the production, distribution, and use of knowledge and information (OECD, 1996). Accordingly, knowledge innovation is strongly focused in the 21st century (Kao, 2004).

One of the basic prerequisites for the development of societies is the correct choice of Leading Knowledge (LK) (Rahmani *et al.*, 2019). Friedrich List emphasized the need for a leading industry in his book entitled "National System of Political Economy" (List, 1904). It is also highlighted in the US National Security Strategy (NSS) in the 21st Century (The United States Commission on National Security, 2001). As it is acceptable, investment in all sciences is not possible while a limited number of them in developed and leading countries, including the United States, Britain, Germany, Ireland, Chile, and Finland (Rahmani, 2015) are acknowledged.

LK refers to the knowledge that every country or region should follow based on its current conditions and capacities to achieve growth and development (Rahmani *et al.*, 2019). According to the definition, every country must inevitably obtain this knowledge at any stage of development for achieving goals. Targeing all sciences and branches simultaneously could not be possible

Knowledge on the importance of LK is based on the differences in LK by region. This difference can result from different spatial and temporal variations, for instance, climatic and geographical conditions and historical and institutional backgrounds. While traditional planning approaches cannot meet this requirement of society, nowadays, applying regional planning knowledge to identify the LK is necessary (Pourmohammadi *et al.*, 2011; Zali, 2012; Zali, 2013). Therefore, the present study has tried to identify the LK for Kermanshah province using the foresight approach and key technology techniques.

A new concept called "foresight" has emerged in the world over the past few decades. Nowadays, two factors of the awareness of human knowledge and the considerable concern about the acceleration in the rate of unknown events have emphasized the importance of thinking about the future of societies (Amin Nayeri *et al.*, 2017). The term has been widely used to differentiate the concepts in question from other future planning approaches since the 1980s (Amanatidou, 2012). The European Union developed a Practical Guide called Foresight for Regional Development Network (FOREN) concerning foresight and regional development in 2001 to encourage EU's members to use regional foresight. The FOREN project is a practical guide making a better understanding of the nature of foresight. According to the FOREN project, foresight is a systematic and participatory process of understanding the future which builds a medium- and long-term vision to achieving today's decisions mobilizes joint actions, and provides approaches to improve decision-making (Gavigan, 2001). It can also be defined as one's ability and capacity to think systematically about the future properly to inform present-day decision-makers (Conway, 2015). It explains how foresight can provide valuable inputs for strategic planning, regional development policymaking, and the stimulation of strategic collective action. FOREN project has specifically focused on the regional level, especially in the following areas: 1) why and how regional foresight can be used; 2) What different foresight approaches are; 3) when and where regional foresight can be used properly; 4) how regional or local conditions can be addressed in the foresight design process. However, the most appropriate definition for the present study is as follows: foresight is an integrated systematic and multidisciplinary approach that is used to identify technological, economic, and social areas to prioritize investments and research and consequently determine medium- and long-term future strategies using all levels of resources ranging from organizational to international resources (Yuksel, 2017). For example, the United States attempted to use science and technology foresight studies to identify key technologies in the 1990s (Porter, 2010).

In addition, the close relationship between

foresight and science and knowledge was revealed due to the main applications of science and technology foresight. Technology foresight was introduced to achieve several main objectives as follows: 1) providing an approach to select and prioritize science and technology; 2) providing a mechanism for linking research opportunities with economic and social needs; 3) developing a strong relationship between science and technology and innovation and wealth creation resulting in improved quality of life; and 4) developing communication and collaboration between researchers, users, and suppliers for research projects (Martin and Johnston, 1999).

Despite the great potential of the agricultural sector in Kermanshah province for growth and development, there is a consensus about the inefficiency of the current production model in the province, and this model can be improved by transferring from source-based production systems to knowledge-based production systems (Naghavi, 2019). Knowledge-based agriculture has been centered around knowledge and technology. Similar to other economic sectors, the agricultural sector has also highlighted the vital role of knowledge in maintaining and increasing effectiveness (Floriańczyk *et al.*, 2012).

Based on the mentioned issues, the present study tries to find which areas of knowledge should be focused to achieve the knowledge-based production model in the agricultural sector in Kermanshah province.

Theoretical approach

Developed countries have focused on the expansion of high value-added clean industry and transfer of low value-added industries to developing countries. Therefore, their researchers have shown no interest in explaining the logic of science and leading industries nor in publishing scientific documents. List (List, 1904) addressed the necessity and criteria of the leading industry. Although this book is not directly about the LK and cannot be mentioned in the section of the review of literature, its logic of discussions and arguments is often related to the LK. The US National Security Strategy for the 21st Century announced that information and communication technology, biotechnology, and microelectronics are the most significant areas of knowledge (The United States Commission on National Security, 2001). In addition, researchers affiliated with US institutions are more focused on several specific areas, including biotechnology, health, nanotechnology, information, and communication technology, and the environment (OECD, 2013). Rennie introduced biotechnology as a key knowledge of human societies (Rennie, 2000). Paija emphasized information and communication technology and indicated that its role in the third wave of the industrial revolution is the same as the role of water vapor and electricity in the previous waves (Paija, 2001). Also, Karlsson & Rouchy believed that digital technologies are the main knowledge that creates changes in human societies (Karlsson and Rouchy, 2015) and has a high potential for the production, distribution, and application of information.

South Korea and Singapore have prioritized information and communication technology in investing in knowledge. Singapore has mainly worked on the new aspects of semiconductors, aerospace engineering, and medical sciences; however, Finland has mainly worked on digital information and communication technologies (Asian Development Bank, 2014). There are eight great technologies in the UK, including big data and energy-efficient computing, satellites and commercial applications of space, robotics and autonomous systems, biological sciences, genetics, and synthetic biology, regenerative medicine, agri-sciences on industries that reduce carbon dioxide emissions, advanced materials (nanotechnology), energy storage (Department for Business, Innovation & Skills, 2014). China, Japan, and South Korea play a relatively large role in producing nanotechnology and environmental sciences. Germany has focused more on environmental technologies (OECD, 2013). Chile follows some specific areas of knowledge, including biotechnology, environment, information, and financial engineering, forest genetics, and vaccines for aquaculture (World Bank, 2007). Ireland emphasized health and biotechnology greatly (OECD, 2004).

China will have advanced industry through knowledge of digital technology by 2025. In this regard, as its first step, it has launched forty-six smart projects. They also followed ten key areas, including Information and Communications Technology (ICT), robotic, agriculture, aerospace, marine technologies, railway equipment, clean energy, new materials, biological drugs, and

medical devices to support the objectives. Canada has significant relative expertise in biotechnology and information and communication technology. It also made a huge investment in clean energy in 2015. Belgium has international competitive power in different areas of knowledge, including chemicals, biological sciences, and information and communication technology. Australia has retained clear international expertise in biotechnology (OECD, 2016).

According to the reports released by OECD on the perspective of Science, Technology and Innovation in 2016, aging societies, climate change, health challenges and the growth of digitalization may be able to shape research and development program (R&D program) and the scope and scale of innovation demand in the future. The following top ten sciences are identified in this report: The Internet of Things, big data analytics, Artificial intelligence (AI), neurotechnologies, nano/microsatellites, nanomaterials, additive manufacturing (or 3D printing), Advanced energy storage technologies, synthetic biology, and blockchain (OECD, 2016). This organization also accentuated three areas in another report in 2018: 1) Artificial intelligence and machine learning can boost the productivity of science, improve new types of discovery, and increase reproducibility, 2) genetic modification can revolutionize the present-day medical treatment, and 3) nanomaterials and bio-batteries can provide new clean energy solutions (OECD, 2018). With the advent of the coronavirus, synthetic biology or bioengineering has been introduced as basic and fundamental knowledge in a wide range of major economic sectors (OECD, 2021).

Only one article was found on LK and the introduction to its selection criteria in Iran (Rahmani *et al.*, 2019). On the other hand, the most relevant studies are about policymaking in science and technology (Khosravaninezhad *et al.*, 2020; Fatemi and Arasti, 2019; Peivasteh, 2019; Kalantari and Montazer, 2018; Nourmohammadi, 2017), which is beyond the scope of this study. At the national level, some efforts, such as the comprehensive scientific map of the country and document of strategic transformation of science and technology development of Iran have been made to identify the priorities of science and technology. The above-mentioned documents were compiled in 2009 and 2010, respectively. It should be mentioned that these studies and the present study are different in nature. For example, firstly, the present study tries to find LK in one or a few areas of knowledge in the early stages of knowledge development while the comprehensive scientific map of the country and document of strategic transformation of science and technology development of Iran cover a wide range of science and technology priorities in all possible areas. Secondly, the documents have addressed all aspects of the priorities of science and technology; however, this study merely tries to find general areas of knowledge based on the criteria. Thirdly, these documents and the present study are also different in the scope of introduction of priorities. The documents are implemented at the national level; however, the present study determines the LK at the provincial and regional levels.

It may seem that knowledge is ever-shifting in nature and cannot be limited to geographical boundaries, so the regional LK will not be an acceptable issue. Of course, it is true in this respect; however, the LK selection has two other aspects: first, it is necessary to meet the needs of regions with specific climatic, geographical, and institutional conditions. Second, there are some capacities of hardware and software and knowledge development and exploitation in the region, which are tied to the specific conditions, namely geographical and institutional conditions of the region. For example, desert dwellers have higher capabilities in leading the knowledge related to water scarcity control than the residents of waterlogged areas due to their local and indigenous knowledge and previous experiences. In this regard, it seems necessary to focus on regional LK. To put it differently, it is essential to have a scientific definition of the region in various studies of urban and regional development (Zali, 2010; Zali, 2011; Zali, 2013).

The present study is the first innovative study 8which has tried to provide a model for identifying and implementing the LK in the agricultural sector based on the foresight approaches of science and technology in Kermanshah province.

Methods and Materials

This qualitative and descriptive study adopted the key technology which is one of the methods of science and technology foresight and a component

of the prioritization-based approaches (Unido, 2005). Key technology which is confirmed by UNIDO as a valuable approach in the evaluation of different research areas, is mainly applied to identify science and technology priorities, especially the LK in the agricultural sector in several countries, such as the Czech Republic, France, and the United States. It has four main stages, including a selection of experts, the preparation of the preliminary list of technologies, the prioritization of technologies, and the extraction of the final list (Unido, 2005).

In this research, data collection was carried out through library and documentary methods and a survey of experts' opinions. In this regard, articles, books, the document of strategic transformation of science and technology development of Iran, and document of strategic spatial planning in Kermanshah province as the most relevant upstream documents were examined to extract the preliminary list of science and knowledge priorities in agriculture and general criteria of evaluation.

Semi-structured in-depth interviews based on chain sampling, which is one of the types of purposive sampling, were used to seek out expert opinions. At this stage, data analysis and identification of the criteria of evaluation were carried out based on Strauss & Corbin's grounded theory (Strauss and Corbin, 1990). The statistical population included experts in the agricultural sector of Kermanshah province, including faculty members of Razi University and Islamic Azad University, owners of agricultural knowledge-based companies, employees of the department of department of agriculture-jihad, and the Agricultural and natural resources research and education in Kermanshah. Theoretical saturation was obtained in the fourteenth interview; however, the fifteenth to twentieth interviews were also conducted to confirm the findings. In qualitative research, data collection will be completed if no more new information is obtained (Strauss and Corbin, 1990).

There are several methods to validate the findings of qualitative research. Contrary to the reliability and validity in quantitative research, trustworthiness is common in the validation of qualitative research which Guba and Lincoln believe should contain four criteria, including credibility, transferability, dependability, and confirmability (Sharifzadeh *et al.*, 2013). In this regard, in this research, all interviews were recorded while notes were being taken to ensure that all details were recorded. The transcript of the interviews was then provided and a copy was given to the interviewees to verify the accuracy of the contents. The researcher maintained contact with all interviewees until the end of the research and provided them with a hierarchical model of the criteria of evaluation and a list of identified knowledge to review and modify at each stage. Some interviews were coded several times at regular intervals to confirm the similarity of the codes. Moreover, each interviewee had enough time to talk in detail about their experiences and knowledge. In the end, other experts' opinions who did not participate in the study were sought out to verify the findings. Three experts who were specialized in both agriculture and knowledge-based activities and the research team reviewed and confirmed the final findings.

Finally, the key technology was formed based on group brainstorming sessions or a panel of experts. It means that fifteen experts participated in the study to analyze the obtained data and to prioritize the LK through multiple criteria decision making (MCDM). These models are used when it is important to make a decision with multiple criteria and in this respect, the Analytic Hierarchy Process (AHP) which is one of the most efficient and comprehensive techniques is really helpful (Ghodsipour, 2005). Many outstanding studies such as planning and choice of the best option have used the analytic hierarchy process (Vaidya and Kumar, 2006). This technique has also been used in urban planning studies (Zali *et al.*, 2014).

There are four main steps to make decision in the Analytic Hierarchy Process (AHP), including, problem statement, decision mapping, pairwise comparison matrices, and determination of the Weights of criteria and general prioritization framework (Saaty, 2008). Saaty's 9-point scale was used for pairwise comparisons (Ghodsipour, 2005). the complex Analytic Hierarchy Process (AHP) was performed in the software package Expert Choice. Figure 1 illustrates the steps of the research.

We applied employed approach in this study for the Kermanshah province of Iran. Due to the climate and ecology of Kermanshah province, it usually has average annual precipitation and annual relative humidity which has generally

covered the mountain slopes, valleys, and plains with forests and pastures. Climate diversity, large agricultural lands, and agricultural research centers, in general, have unleashed Kermanshah province's considerable potential in the agricultural sector.

A large number of people living in Kermanshah province have been working in the agricultural sector (Management and Planning Organization of Kermanshah, 2018). Although productive sectors (i.e. agriculture and industry) have held the same rank in terms of share of total employment at the provincial and national levels; however, they reflect a significant difference in the absolute values of shares. The mean ratio of agricultural to industrial employees in Kermanshah province has been about three to one during the last two decades. However, it is worth mentioning that the numbers of employees are almost equal in both sectors of the country. In other words, a significant part of the province's labor force has been involved in agricultural activities (Statistical Center of Iran, 2019). Since Kermanshah province has been struggling with widespread unemployment for a long time and its rate of unemployment was twice as high as the mean national rate in 2016 (Statistical Center of Iran, 2019), it can be claimed that the institutions, climate, and tacit knowledge in Kermanshah province are more adaptable to the agricultural sector.

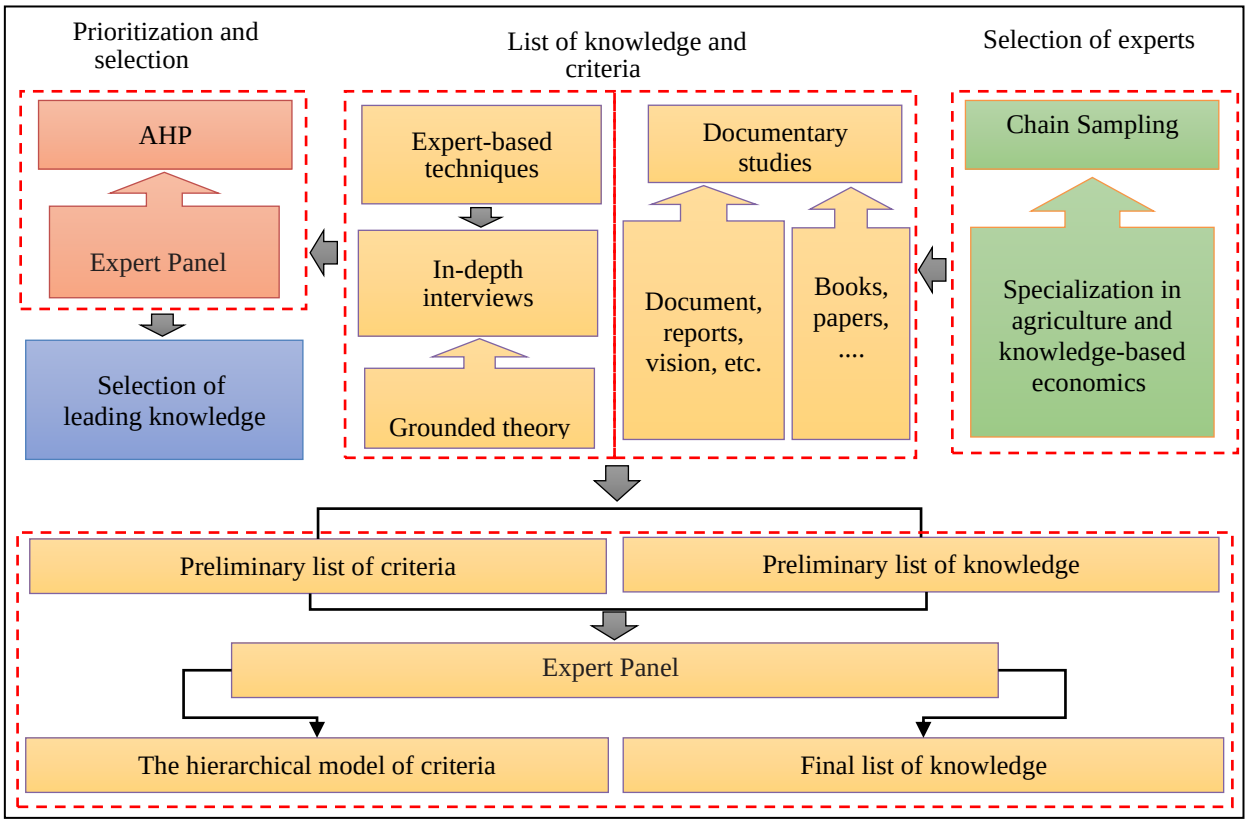

Figure 1- Steps of the research

Discussion and Results

Criteria for selecting Leading Knowledge

Similar to any other selections, it is necessary to find some criteria to identify LK that helps to make the right decision. Figure 2 illustrates the general criteria for selecting LK. These are level 1 criteria which are prepared based on the document of strategic transformation of science and technology development of Iran. The innovation of this research can be indicated by the fact that level 2 and 3 criteria were designed for the agricultural sector of Kermanshah province based on the document of strategic spatial planning in Kermanshah province and the survey of experts' opinions. at the end, all the criteria of the panel of experts were discussed and refined (see Figure 3).

Adaptation to existing capacities (current situation)

In the early stages of development, the existing capacities and capabilities of a region should be regarded as the most important and first criterion for selecting LK. List examines the actions of different countries in the first wave of the industrial revolution and realized that the winners of the Industrial Revolution, such as the factory owners, the nation states, colonial owners, and the people who were rich already have focused on one or more specific industries, concerning their current capacities and potentials and their historical and natural features (List, 1904). List's study is a historical study of the first industrial revolution which does not deal with knowledge as it is presented in the knowledge-based revolution. However, their logic and basis of arguments are similar, and their rules are still valid.

The selection of LK is tied to the path taken. To select LK in the early stages of development, the first and most important criterion, one must refer to natural capacities and capabilities. The integration of geography and historical and institutional backgrounds in a region has given vital importance to this criterion because economic activities have been mainly formed based on the historical and geographical features of a region, resulting in a kind of individuals' tacit knowledge. Stiglitz believed that organizations and individuals' tacit knowledge of years of experience is the source of existence and continuity of competitive advantage (Stiglitz, 1999).

Infrastructure is one of the criteria for evaluating existing capacities to determine LK (Rahmani *et al.*, 2019). These infrastructures, such as trained workforce, laboratory and equipment, and organizations and institutions are needed to enhance knowledge-based development (Management and Planning Organization of Kermanshah, 2018). Natural capacities are also used to examine the adaptation to the current situations. Other relevant sub-criteria were derived from a survey of experts' opinions.

Global trends (future)

Demand and the knowledge supply are both important for future developments and global trends in science and technology. However, all specialized sub-branches of knowledge are beyond the scope of the present study; therefore, only general areas of market growth (two general criteria) are enough for the supply to examine the general trend and demand for knowledge.

Regional needs (strategic issues)

Document of strategic spatial planning in Kermanshah province is the most relevant upstream documents which are used to extract the strategic issues. It referred to the knowledge-based economy and diverse and productive employment as one of its main objectives (Management and Planning Organization of Kermanshah, 2018). Furthermore, level 3 criteria also include the ability to create added value, sustainable employment, and the power of clustering (Rahmani *et al.*, 2019). Sustainable development is one of the strategic issues in the province. Other important issues which are also mentioned in the document of strategic spatial planning in Kermanshah province are Protection from the environment and Sustainability of basic resources (Management and Planning Organization of Kermanshah, 2018). A survey of agricultural experts' and stakeholders' opinions showed that the production of healthy products is regarded as one of the important criteria for sustainable development. Kermanshah province also faced other challenges, such as flood control, drought adaptation, and destruction of pastures which are provided in the section of regional hazards (Management and Planning Organization of Kermanshah, 2018).

Preliminary list of Leading knowledge

Based on key technology, a preliminary list of science and technology was prepared through group brainstorming sessions, the panel of experts, reference research, expert studies, interviews with industry experts, and environmental scanning (Unido, 2005). This study prepared the preliminary list of LK according to upstream documents (i.e. the comprehensive scientific map of the country and document of strategic transformation of science and technology development of Iran) and a survey of experts' opinions.

First, the agricultural science and technology priorities were extracted from the above-mentioned documents. Then, agricultural experts and stakeholders of the province were asked to complete the preliminary list based on the general criteria in selecting the LK (i.e., existing capacities of the province, strategic issues, and regional needs, and global trends). Finally, the priorities

were adapted to the academic fields of studies and therefore a wide range of different specialized sciences was adapted. Since the present study tries not to identify all specialized sub-branches of knowledge and only considers general areas of knowledge, the extracted sciences were categorized into the eight main groups including biotechnology, water engineering, plant pathology, mechanical engineering of biosystems, horticultural sciences, natural resources, soil sciences, and modification of legal relations. The sub-groups are listed as follows:

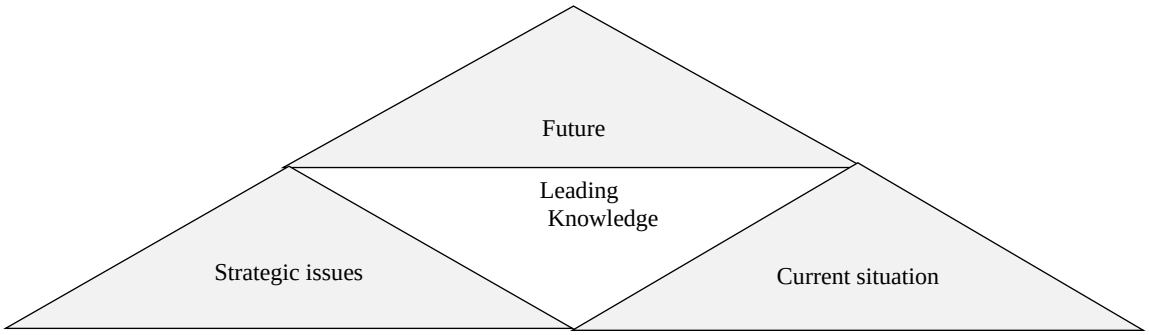

Figure 2- The general pattern of identifying Leading knowledge

1. Biotechnology: precision agriculture, agroecology, agrotechnology (i.e., seed technology, weed science, crop ecology), plant breeding (i.e., molecular genetics and genetic engineering), Animal Husbandry Engineering (i.e., pastoral farming and animal physiology), genetic resources conservation and management, biosafety, genetics, biological and non-Biological stresses, biological products, food security, identification, registration, preservation and restoration of genetic resources, the positive use of biodiversity in production of suitable cultivars and species and Reduction of Air Pollution, Optimization of Regional cropping Pattern
2. Water Engineering: irrigation and drainage water, structures of water, use of modern technologies and management practices in optimizing water distribution and consumption, exploitation of unconventional water resources for sustainable development, development of new irrigation and drainage methods
3. Plant pathology: agricultural entomology
4. Mechanical engineering of biosystem: design and construction, post-harvest technology, new energy, and renewable energies
5. Horticultural sciences: greenhouse products, medicinal plants, fruit farming (Growing fruit plants and trees)
6. Natural resources sciences: Rangeland and Watershed Management, restoration and exploitation of forests and rangelands
7. Soil Science: improving soil fertility
8. Modification of legal relations: modifying and improving operating systems

Selection of leading knowledge

Prioritization of knowledge through the Analytic Hierarchy Process (AHP) requires drawing a hierarchical decision tree consisting of the initial goal and different levels of criteria and options (see Table 1). Therefore, the pairwise comparison matrices of the main criteria and sub-criteria were designed to determine the final weights. Then, pairwise comparison matrices of 8 main groups of knowledge were formed. Paired comparisons were performed at the last level of the criteria resulting in the completion of 17 matrices. The panel of experts performed the completion and scoring of matrices in both stages. Finally, 8 knowledge groups were prioritized through pairwise comparison matrices in the software package Expert Choice (see Figure 4). The results showed that water engineering, horticultural sciences, and biotechnology were ranked first to third, respectively. In other words, the province's macro-policies should be adjusted to develop water engineering, horticultural sciences, and biotechnology sciences to realize the knowledge-based economy in Kermanshah province and benefit from its unique benefits.

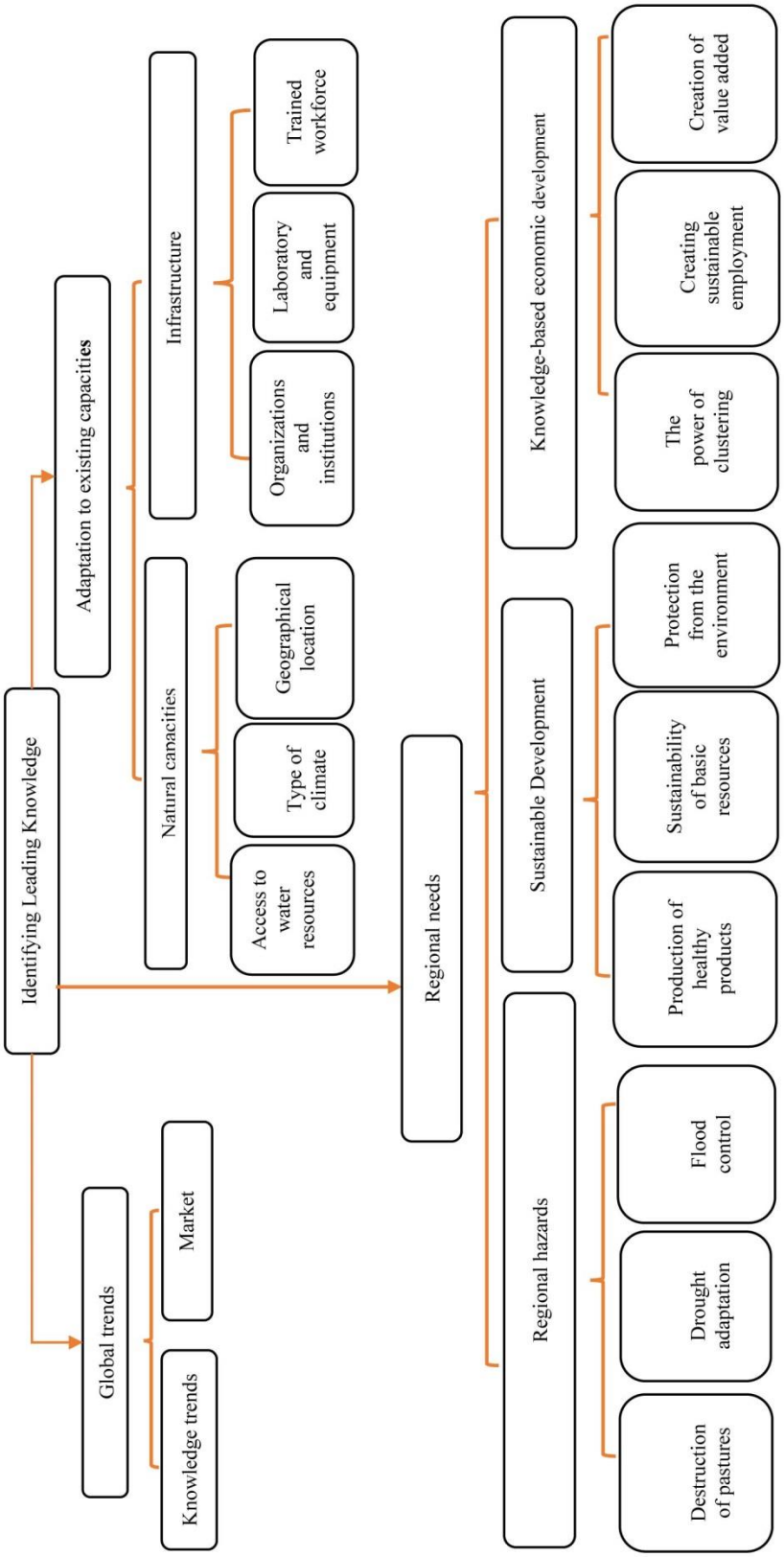

Figure 3- The hierarchical model of criteria for selecting Leading knowledge

Table 1- The final weight of criteria and sub-criteria in the decision-making hierarchy

Level 1 criteria	Weight	Level 2 criteria	Weight	Level 3 criteria	Weight
Adaptation to existing capacities	0.49	Infrastructure	0.125	Trained workforce	0.178
				Laboratory and equipment	0.07
				Organizations and institutions	0.751
		Natural capacities	0.875	geographical location	0.091
				Type of climate	0.455
				Access to water resources	0.455
Regional needs	0.451	Knowledge-based economic development	0.077	Creation of added value	0.156
				Creating sustainable employment	0.659
				The power of clustering	0.185
		Sustainable Development	0.692	Protection from the environment	0.455
				Sustainability of basic resources	0.455
				Production of healthy products	0.091
		Regional hazards	0.231	Flood control	0.057
				Drought adaptation	0.597
				Destruction of pastures	0.346
Global trends	0.059	Market	0.25		
		Knowledge trends	0.75		

Source: Research findings

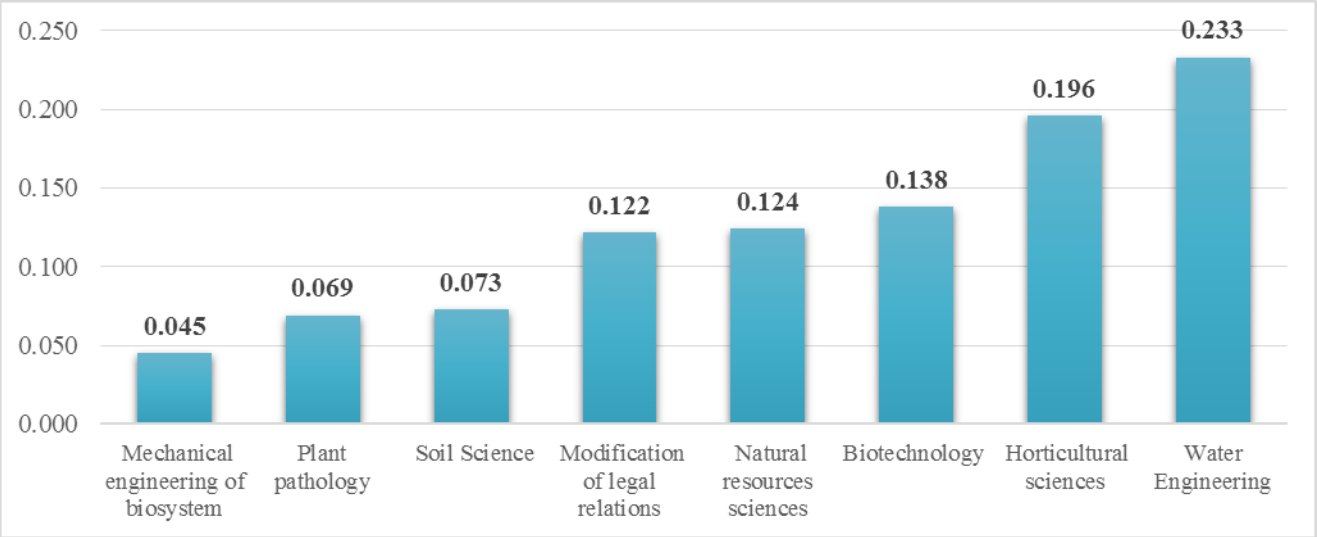

Figure 4- Prioritization of agricultural Leading Knowledge in Kermanshah province

The inconsistency rate was used to evaluate the validity of the research findings. All pairwise comparisons of decision criteria and knowledge groups had an inconsistency rate of less than 0.1. In addition, biotechnology is highly emphasized in US national documents. The U.S. Commission on National Security considers the most significant innovations in the first quarter of the 21st century stems from three categories, including information technology, biotechnology, and Micro-electromechanical systems (MEMS). It also believes that fundamental developments in biotechnology will be even more surprising than innovations in information technology, and there will be more investments in biotechnology than IT leading to more innovation and economic growth (The United States Commission on National Security, 2001).

Since Iran is located in the arid and semi-arid region and there has been a severe water crisis in Kermanshah province in recent years, the first rank of knowledge of water engineering is meaningful. On the one hand, it will not be possible to achieve the survival of agricultural activities in the province and sustainable development without investing in agricultural activities adaptable to drought. On the other hand, horticultural science, as a second priority, has unparalleled potential in dealing with drought, conserving water resources, and creating sustainable employment.

Biotechnology is the second-largest science and technology priority in the United States, Russia, and China (Kalantari and Montazer, 2018). The U.S. Commission on National Security has also emphasized the importance of this area (The United States Commission on National Security, 2001).

It should be noted that the present study emphasizes the agricultural sector; however, it never neglects industrial activities. It is necessary to invest in knowledge-based industries related to selected sciences and the LK of the province's industrial sector should be discussed in a separate study. However, it should be noted that Kermanshah province has favorable conditions for the development of agricultural activities due to its special climatic characteristics. About 30% of the province's workforce is active in agriculture. In other words, most of the tacit knowledge formed in this province is related to agricultural activities and also the institutions in the province have been the basis for the development of such activities. All mentioned conditions confirm that the LK at the early stage in Kermanshah province should be selected from the agricultural sector. On the other hand, the document of strategic spatial planning in Kermanshah province introduced advanced and sustainable agriculture as one of the leading developments of Eslamabad-e-Gharb, Qasr-e-Shirin, Sonqor, Sahneh, and Oramanat (Management and Planning Organization of Kermanshah, 2018).

According to the above-mentioned issues, the following points should be emphasized in development plans:

- Identifying and achieving consensus on the LK in each region and province of the country
- Optimal reallocation of resources to support the LK of the province, especially concerning knowledge and technology-based enterprises under the auspices of Kermanshah science and technology park
- Avoiding the concentration of the research budgets of universities and government agencies in charge on unnecessary and non-practical cases in the province
- The objectives of universities and research centers of the province should be the development of disciplines related to the three sciences of water engineering, horticultural sciences, and biotechnology.

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مقاله پژوهشی

جلد ۳۶، شماره ۲، تابستان ۱۴۰۱، ص ۱۵۶-۱۴۳

شناسایی دانش‌های پیشران با کمک تکنیک فناوری کلیدی و تحلیل سلسله‌مراتبی در استان کرمانشاه

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تاریخ دریافت: ۱۴۰۰/۰۱/۲۱

تاریخ پذیرش: ۱۴۰۰/۰۶/۲۳

چکیده

الگوی تولید دانش‌بنیان طی چند دهۀ اخیر تمام مناسبات اقتصادی و اجتماعی را دگرگون نموده است. دستیابی به مزایای این الگو، در گرو توجه جدی به تولید، توزیع و انتشار دانش است. یکی از اساسی‌ترین و مهم‌ترین پیشنیازهای تحقق الگوی تولید دانش‌بنیان به ویژه در مناطق در حال توسعه، انتخاب دانش پیشران است. ضرورت این انتخاب به محدودیت‌های پیش روی جوامع برمی‌گردد. از سویی بودجه‌های دولتی با فشار فزایندۀ مخارج عمومی روبرو هستند و علم و فناوری هم به این بودجه‌ها وابسته است و از سوی دیگر، هزینه‌های سرمایه‌گذاری در حوزه‌های مختلف دانش به طرز سرسام‌آوری در حال افزایش است. بنابراین، پیشبرد همزمان تمام شاخه‌های دانش برای هیچ کشوری حتی جوامع پیشگام و توسعه‌یافته نیز، امکان‌پذیر نیست. مقاله حاضر با هدف شناسایی دانش پیشران بخش کشاورزی استان کرمانشاه انجام شده است. این پژوهش، از منظر روش پاسخ به سوال محوری تحقیق، کیفی و از منظر هدف، کاربردی است. در گام نخست، احصاء فهرست اولیۀ دانش‌های پیشران و مدل سلسله‌مراتبی معیارهای ارزیابی مبتنی بر تکنیک فناوری کلیدی با کمک دو روش اسنادی و نظرسنجی از خبرگان انجام شد. برای استخراج نظر خبرگان، از مصاحبه‌های عمیق و هدفمند، استفاده شد. در نهایت، تجزیه و تحلیل اطلاعات از طریق تکنیک تحلیل سلسله‌مراتبی با کمک نرم‌افزار اکسپرت چویس، انجام شد. این مرحله به وسیلۀ پنل خبرگان اجرا شد. یافته‌های پژوهش نشان می‌دهد رشته مهندسی آب با ضریب ۰/۲۳۳ اولویت نخست دانش پیشران استان کرمانشاه است. علوم باغبانی (۰/۱۹۶) و علوم مربوط به بیوتکنولوژی (۰/۱۳۸) نیز، در اولویت دوم و سوم، جای گرفتند. نتایج تحقیق برای بازنگری در سیاست‌گذاری‌های آموزشی دانشگاه‌ها و مراکز تحقیقاتی استان، تخصیص بهینه منابع محدود موجود در دستگاه‌های دولتی ذیربط (جهادکشاورزی و مراکز تحقیقاتی مربوطه) و همچنین تعیین خط‌مشی پارک علم و فناوری و مراکز رشد کشاورزی استان، می‌تواند مفید واقع شود.

واژه‌های کلیدی: استان کرمانشاه، اقتصاد دانش‌بنیان، بخش کشاورزی، دانش پیشران، فناوری کلیدی

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Meat Price Bubble in Iran: An Empirical Evidence from State-Space Model

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Abstract

Price bubbles and price fluctuations of agricultural products are important issues that can significantly affect the welfare of consumers and producers. Therefore, in this study, the price bubbles in three main protein products, i.e. lamb, beef, and chicken meats, were investigated by the state-space model based on the Kalman filter using monthly time series data on the price of selected protein products from June 2001 to November 2020. We considered barley, concentrate feed prices, broiler chicken, and corn prices as the main important inputs used for producing lamb, beef, and chicken meat production, respectively. Also, real exchange rate and real oil price were used in the model. The results showed the differences in structures making positive and negative price bubbles, period and number of occurrences and the collapse of the bubble during the sample period. Also, in contrast to chicken prices, we concluded the price bubble of lamb and beef, is not significant compared to the real prices. For chicken meat, the main cause of price bubbles was due to the disruption of the marketing process of agricultural products, the lack of transparency of information, and contradictory government interventions in the market. To deal with the problem, the implementation of aggregated market information through merging technologies in Information and Communication Technology could be considered an efficient tool as suggested. In addition, government intervention should be prioritized on reforming the market structure instead of controlling prices.

Keywords: Beef, Chicken meat, Kalman filter, Lamb
Classification JEL: D84, G14, Q4

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Introduction

Most commodity price fluctuations rooted in market principles contain supply and demand forces, which are not a concern and are essential for market equilibrium. If commodity price fluctuations that occur in the market are due to speculative activities and, in other words, have a significant deviation from the predicted fluctuations, the hypothesis of price bubble occurrence is raised (Garber, 1989). A price bubble is created when price fluctuations are not justified by common market principles, and its source is a factor beyond market principles (Arshanapalli and Nelson, 2016). Usually, the price bubble includes explosive price patterns followed by rapid price declines (Li *et al*., 2017).

Meanwhile, one of the problems faced by most consumers and producers is agricultural market instability, commodity price fluctuations, and price bubbles (Umar *et al*., 2021; Mohammadi *et al*., 2016). In economic literature, rising prices over a long period and a sudden drop in prices are called price bubbles (Li *et al*., 2017). In addition, the deviation of commodity prices from the long-run equilibrium price could be a price bubble. Yildirim (2020) described price bubbles as unexplained price movements in commodity prices and reason is that they are expected to sell at higher prices in the future (Garber 2001).

The occurrence of price bubbles in agricultural products has also exacerbated this issue. These fluctuations at the micro-level lead to numerous problems, such as increasing production risk and income risk, and reducing consumer welfare and food security disruption in production planning. At the macro level, it also poses several problems, especially in developing countries such as Iran. These problems include negative effects on the balance of payments, foreign exchange reserves, agricultural sector growth, and the implementation of social security programs (Gutierrez, 2011).

To deal with the price bubbles of agricultural commodities, it's essential to identify the factors affecting changes in prices of agricultural products. The major factor causing rising food price volatility is exogenous shock due to demand side, supply side, and macroeconomics policies (Tadasse *et al*., 2014) where investigated in this study.

Lamb, beef, and poultry meat are the most important commodities in the Iranian household bundle. However, the trend of changes in red meat (lamb and beef) and chicken meat consumption in Iran are different. A study of the per capita time series of meat consumption in Iran showed that the consumption of red meat decreased from 8.7 kg in 2011 to about 6 kg in 2017. Currently, the per capita consumption of red meat is about 6 kg. On the other hand, the consumption of chicken meat as substitute meat for red meat increased from 17.6 kg in 2011 to about 21 kg in 2017. However, due to the Covid-19 pandemic, the per capita consumption of poultry meat has dropped dramatically over the past two years (CBI, 2021). Figure 1 shows the trends of nominal lamb, beef and chicken meat prices from June 2001 to November 2020.

As can be seen in Figure 1, the trends of lamb and chicken meat prices are upward with many fluctuations while this situation can be devastating to consumers especially in developing countries (Etienne, 2014). Given the importance of meat in providing protein to households and creating food security and trying to control its price by the government, investigating the role of non-fundamental factors in the movement of meat prices can help policymakers to adopt appropriate policies.

Hence, the main objective of this study was to detect price bubbles of the three protein sources, chicken meat, lamb, and beef. In addition, the links between chicken meat, lamb, and beef price and fundamental factors include supply, demand, and macroeconomic variables. Although, in recent years, several studies have detected price bubbles in stock and capital markets. However, few studies have been conducted to detect price bubbles in agricultural commodity markets.

For instance, Gillbert (2010) focused on future price bubbles in corn, wheat, and soybean from 2006 to 2008. The empirical results detected price bubbles only in soybean. Gutierrez (2011) detected explosive processes and collapsing bubbles in the prices of wheat and paddy crops using the bootstrap method over the sample period from 1985 to 2010. In addition, Liao-Etienne *et al.* (2012) detected price bubbles in corn and wheat markets by employing the sup-ADF test. Liu *et al.* (2013) detected speculative bubbles in daily futures prices for six agricultural commodities using a regime-switching approach. Adämmer and Bohl (2015) studied the price bubbles of corn, soybean, and wheat in the market US market by using the momentum threshold autoregressive (MTAR) approach. Areal *et al.* (2016) examined

the explosive price bubble in the market of 28 selected agricultural products by employing the generalized supremum augmented Dickey-Fuller (GSADF) test between 1980 and 2012. Mohammadi *et al*. (2016), examined the existence of multiple bubbles by applying the GSADF test in the chicken and beef meat market of Iran during 2002 -2013. The results showed that food commodities exhibited short-lived bubble behavior during the studied period. Li *et al.* (2017) detect commodity price bubbles in China's agricultural commodity market by applying the GSADF test. They also examined the relationship between commodity price bubbles and macroeconomic factors using a zero-inflated Poisson model. The empirical results show that speculative bubbles occur in most Chinese agricultural commodity futures markets. In addition, economic growth, money supply, and inflation have positive effects on the agricultural future price bubble, while interest rates have a negative effect. In addition, economic growth and money supply have the greatest impact on future agricultural price bubbles.

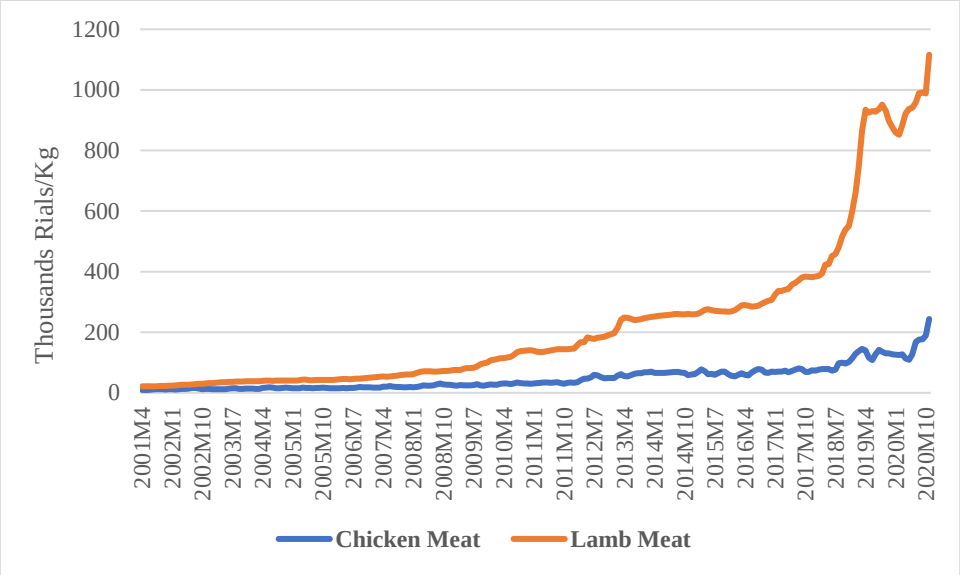

Figure 1- The nominal price of lamb and chicken meat

Maddah *et al*. (2018), studied the existence of commodity price bubbles in the Iranian imported market of some strategic imported commodities from 1976 to 2012. Also, the Right-Tailed Unit Root test is used. The empirical results detected the price bubble in barely. On the other hand, the price bubble did not detect the price of edible oil, wheat, and tea.

Wang *et al.* (2018) examined the existence of multiple explosive bubbles in the international food market between1990 and 2017. The GSADF test was used to detect multiple bubbles. The empirical results illustrate four explosive bubbles in the international food market. Also, Afrasiyabei and Tarazkar (2020) studied the existence of multiple explosive bubbles in domestic production and imported corn and barely by applying the GSADF test in Iran. The results of the research detected at least two or three bubbles from January 2014 to December 2018.

The literature review illustrated that most studies used the GSADF test, MTAR approach, and the Right-Tailed Unit Root test for detecting multiple price bubbles in the agricultural commodity market. Unlike most previous studies, in the present study, the state-space model based on the Kalman filter was used. To the author's knowledge, this study the first research in detecting price bubbles in the agricultural commodity market by using the state-space model. A dynamic system in the state-space form has two main advantages. First, we allow the model with both observed and latent variables to be estimated. Second, the Kalman filter is a powerful recursive algorithm that can be applied to analyze state-space models (Harvey, 1989; Hamilton, 1994; Koopman *et al.*, 1999).The present study is a new attempt to answer these main research questions by a state-space method: Do price bubbles have a significant effect on the price formation and variation of lamb, beef, and chicken meat? What is the intensity of the bubbles and how does it affect the price of the

studied products? Is the formation of the price bubble in the three studied products similar in intensity and duration?

Materials and Methods

According to the bubble model, the prices of meat can be represented as follows (Zhang *et al.*, 2019):

$$P_t = P_t^f + b_t \quad (1)$$

where, P_t^f is the fundamental monthly time series price of the lamb, beef and chicken. b_t represents the bubble. According to equation (1), in the case of b_t inexistence, the basic part P_t^f affects the Pt entirely. However, by considering the price bubble component, the lamb, beef and chicken meat prices are higher or lower than their essential values.

The linear state-space of the dynamic of the z_t is represented by the following equations (Harvey, 1989; Hamilton, 1994; Koopman *et al.*, 1999):

$$z_t = c_t + Y_t\beta_t + \epsilon_t \quad (2)$$

$$\beta_{t+1} = d_t + T_t\beta_t + \vartheta_t \quad (3)$$

where, β_t is a vector of the unobserved state variables. c_t, Y_t, d_t, and T_t are matrices and estimated parameters, where ϵ_t and ϑ_t are vectors of mean zero with serially independent, contemporaneous variance structure (σ_t), and Gaussian disturbances, respectively.

$$\sigma_t = var\begin{bmatrix}\epsilon_t \\ \vartheta_t\end{bmatrix} = \begin{bmatrix}H_t & R_t \\ R_t' & M_t\end{bmatrix} \quad (4)$$

where H_t and M_t are symmetric variance matrices, and R_t is a matrix of covariances. In addition, the unobserved state vector is assumed to be a first-order vector autoregression.

Note that the mean and variance matrix of the conditional distribution of state vector β_t can be defined by providing information available at times.

$$\beta_{t|s} \equiv E_s(\alpha_t) \quad (5)$$

$$P_{t|s} \equiv E_s\left[(\beta_t - \beta_{t|s})(\beta_t - \beta_{t|s})'\right] \quad (6)$$

By setting $s = t-1$, we can obtain the one-step-ahead mean $\beta_{t|t-1}$ and the one-step-ahead variance $P_{t|t-1}$ of the states β_t. Therefore, the linear Mean Square Error (MSE) one-step-ahead estimate of $z_t$can also be formed by the one-step-ahead state conditional mean as follows:

$$\tilde{z}_t = z_{t|t-1} \equiv E_{t-1}(z_t) = E\left[z_t\middle|\beta_{t|t-1}\right] = c_t + Y_t\beta_{t|t-1} \quad (7)$$

The one-step-ahead prediction error ($\tilde{\epsilon}_t$) is given by,

$$\tilde{\epsilon}_t = \epsilon_{t|t-1} \equiv y_t - \tilde{y}_{t|t-1} \quad (8)$$

In fact, the Kalman filter is a recursive algorithm which can be used to compute one-step ahead estimates of the state and the associated mean square error matrix, $(\beta_{t|t-1}, P_{t|t-1})$, the filtered state mean and variance, (β_t, P_t), and the one-step ahead prediction, prediction error, $(z_{t|t-1}, \epsilon_{t|t-1})$. After applying Kalman filter and replacing the unobserved variables with their estimates, the sample loglikelihood can be evaluated under the assumption that ϵ_t and ϑ_t are Gaussian as a below:

$$Log\ L(\theta) = -\frac{nT}{2}\log 2\pi - \frac{1}{2}\sum_t log\left|\tilde{F}_t(\theta)\right| - \frac{1}{2}\sum_t \tilde{\epsilon}_t'(\theta)\tilde{F}_t(\theta)^{-1}\tilde{\epsilon}_t(\theta) \quad (9)$$

By numeric derivatives, the likelihood can be maximized with respect to unknown parameters θ.

In this study, the price bubbles of lamb, beef and chicken meats were state or unobservable variables. In addition, the fundamental components of their prices were divided into supply, demand, and macroeconomic variables according to Tadasse *et al.* (2013). The main stimulate for meat supply-side is the feed cost. Therefore, in this study, real broiler chicken price (RBH), real corn price (RCO), real barley price (RBR), and real concentrated feed (RCF) were used in chicken meat (RCH), lamb (RMU) and beef (RBF) real price equations. Also, the dummy variable (D1), so that in April and Ramadan is one and otherwise zero, were used as a stimulus to demand for meat. Finally, the real exchange rate (EXG) and real oil prices (OLP) are applied as macroeconomic variables.

As a result, the price equations for chicken, lamb, and beef are rewritten as follows:

$$RCH_t = c_0 + c_1\mathrm{RBH}_t + c_2 RCO_t + c_3\mathrm{D1} + c_4\mathrm{EXG}_t + c_5\mathrm{OLP}_t + b_t + \varepsilon_t \quad (10)$$

$$RMU_t = c_0 + c_1\mathrm{RBR}_t + c_2\mathrm{D1} + c_3\mathrm{EXG}_t + c_4\mathrm{OLP}_t + b_t + \varepsilon_t \quad (11)$$

$$RBF_t = c_0 + c_1\mathrm{RCF}_t + c_2\mathrm{D1} + c_3\mathrm{EXG}_t + c_4\mathrm{OLP}_t + b_t + \varepsilon_t \quad (12)$$

Before estimating the above equations, it is necessary to test the stationary of the variables to avoid spurious regression and ensure the accuracy and validity of the results. Since the data used in

this study are monthly, we apply the HEGY[1] seasonal unit root test with the null hypothesis that there is a unit root at the specified frequency including 0, π, $\pi/2$, $2\pi/3$, $\pi/3$, $5\pi/6$, $\pi/6$. The first of these frequency, which is termed a zero frequency unit root, is non-seasonal and occurring at zero cycles per year. The other unit roots which accruing at 2, 4, 3, 6, 2.4, and 12 cycles per year respectively are all seasonal (Gil-Alana, 2007; Tylor, 1998).

Data sources and descriptive statistics

We used the monthly data from June 2001 to November 2020 which collected from the State Livestock Affairs Logistics Company, Iranian ministry of Agriculture, Central Bank of Iran and Statistical Center of Iran. We used Eviews software (Version 12) to estimate the regression equations (10, 11 & 12).In continue, Table 1 provide the variables name of the data used along with their descriptive statistics.

Table 1 shows that the high standard deviation for real lamb and beef prices, and this shows the volatility of these variables. The minimum and maximum of real chicken price are 505.8 and 1395.9 respectively. Also, real broiler chicken price has the highest mean and variation among input prices while the means of real corn, barley and concentrated feed prices are close to each other.

Results

As described in the previous section, in this study, using the Kalman filter method and state space equations, the price bubbles of chicken, lamb and beef. At first, the results of seasonal unit root test are presented in Table 2.The results show that all variables are stationary in level.

Tables 3, 4, and 5 show the empirical results of the state-space equation model for the price bubble of lamb, beef and chicken, including lamb, respectively.

In equation related to the price of lamb (Table 3), there is a positive significant relationship between barley price, as the most important input to production of lamb, and lamb price. However, the demand shock at the beginning of the Iranian New Year in the April and the Ramadan did not have a significant effect on the price of lamb.

Another result is the positive and significant effect of the real exchange rate on the fundamental lamb price at the 10% level. Rising exchange rates, in addition to making exports more attractive, increase the price of inputs, especially barley. Another macroeconomic variable that has a negative and significant effect on the fundamental price of lamb is the real oil price. Since oil sales account for a large share of Iran's gross domestic product, rising crude oil revenues will increase subsidy support and lower fundamental meat prices.

Table 4 shows the state-space estimation results for the beef meat price equation. Looking at the numbers in the one column of this table, it can be seen that all the studied variables have affected fundamental chicken meat prices, except crude oil and demand dummy variables.

As expected, the price of concentrate feed has a positive and significant effect on the price of beef. However, the negative effect of real exchange rate on real beef price is so small. A review of the studied data shows that during the study period, despite the sharp increase in the real exchange rate, the real price of beef decreased. Therefore, this result shows that the inflationary effects of the rising exchange rate have outpaced the nominal price of beef, and the overall real price has decreased.

The estimation result for the chicken meat price equation is presented in table 5. Similar to the previous two estimates, the real price of corn and broiler chicken has a positive and significant effect on the real price of chicken meat. Also, the occasions of the new year and the month of Ramadan have increased the price of chicken meat. This result shows that, unlike lamb and beef, the demand for chicken is influenced by national and religious occasions and should be seen in the price analysis of this product. However, macroeconomics variables, real exchange rate and oil price, with the positive and negative signs are insignificant.

1- Hylleberg, Engle, Granger, and Yoo

Table 1- Descriptive statistics of the variables (Rials)

Variable name	Mean	Maximum	Minimum	Std. Dev.
Real chicken price (RCH)	860.8475	1395.929	505.8316	157.9406
Real lamb price (RMU)	3219.416	5337.833	2402.477	632.2423
Real beef price (RBF)	3011.825	4856.906	2224.397	520.3006
Real corn price (RCO)	111.3469	163.4674	79.06221	18.39018
Real barley price (RBR)	102.4512	163.0980	70.38961	16.72135
Real concentrated feed price (RCF)	97.02995	144.8841	72.23	16.06
Real broiler chicken price (RBH)	170.7127	345.9459	31.08015	58.18573

Table 2- Robustness checks for HEGY seasonal unit root test results

	Frequency							
variable name	0	2π/12	4π/12	6π/12	8π/12	10π/12	π	All frequency
Real chicken price (RCH)	-3.09*	12.70**	15.04**	5.86*	12.87**	9.19**	-2.60***	12.70**
Real lamb price (RMU)	-3.07*	11.89**	7.61**	10.3**	9.52**	5.86*	-2.96***	10.36**
Real beef price (RBF)	-3.33**	33.95**	24.94**	35.15***	35.60***	39.79***	-6.19***	39.63***
Real corn price (RCO)	-2.08**	20.21**	19.15**	17.41**	16.57**	25.25**	-3.90***	18.73**
Real barley price (RBR)	-2.06**	17.27**	19.26**	15.96**	16.37**	23.82***	-3.84**	17.90**
Real concentrated feed price (RCF)	-4.13***	41.23**	15.91**	45.45***	14.25**	43.90***	-3.76***	45.58***
Real broiler chicken price (RBH)	-2.43***	23.30**	19.88**	17.78**	17.03**	26.45***	-3.89**	20.39**
Real exchange rate (EXG)	-6.89***	9.32**	3.9*	4.89*	11.48**	50.00***	-7.86***	61.41***
Real oil price (OLP)	-7.26***	3.91*	16.07**	3.86*	10.41**	13.98**	-9.10***	37.06***

Notes: Single, double, and triple asterisks (*, **, ***) indicate (statistical) significance at the 10%, 5%, and 1% level, respectively.

Table 3- State Space Estimation Results for Lamb Price Equation

Variable name	Coefficient	z-Statistics	Std. Error
Constant	438.46	1.22	357.00
Real Barley Price	2.612**	2.10	1.24
Demand Dummy	10.06	0.76	13.16
Real Exchange Rate	0.0012*	2.05	0.0005
Real Oil Price	-3.23E-05**	-2.36	1.37E-05
State variable	Final State	z-Statistics	Prob.
Sv1	116.08	1.78	0.07
Log-likelihood: -1307.00		Akaike info criterion:11.79	

Table 4- State–space estimation results for beef meat price equation

Variable name	Coefficient	z-Statistics	Std. Error
Constant	3029.81***	6.53	463.91
Real concentrate feed Price	5.06***	4.24	1.19
Demand Dummy	-3.19	-0.5	6.35
Real Exchange Rate	-0.002***	-5.60	0.004
Real Oil Price	4.23E-06	0.69	6.13E-06
State variable	Final State	z-Statistics	Prob.
Sv1	1171.86	1.99	0.000
Log likelihood: -1267.44		Akaike info criterion: 11.44	

Table 5- State–space estimation results for chicken meat price equation

Variable name	Coefficient	z-Statistics	Std. Error
Constant	279.32***	3.11	89.64
Real Corn Price	1.02**	2.20	0.464
Real Broiler chicken	1.00***	10.41	0.095
Demand Dummy	32.20***	5.11	6.30
Real Exchange Rate	0.0002	0.39	0.0005
Real Oil Price	-6.06E-06	-0.58	1.04E-05
State variable	Final State	z-Statistics	Prob.
Sv1	132.02	2.66	0.007
Log-likelihood: -1187.24		Akaike info criterion: 10.72	

So far, the results of the factors affecting the fundamental changes in the price of lamb, beef, and chicken have been presented. However, the question remains whether there is a price bubble for these three products. Figures 2, 3 and 4 are provided to answer this question.

In Figure 2, the estimated bubble price share from the real lamb price is presented. As shown, on average, during the study period, the price bubble accounted for 3.7% of the real lamb price, and the formation of bubbles and their burst in this product is gradual.

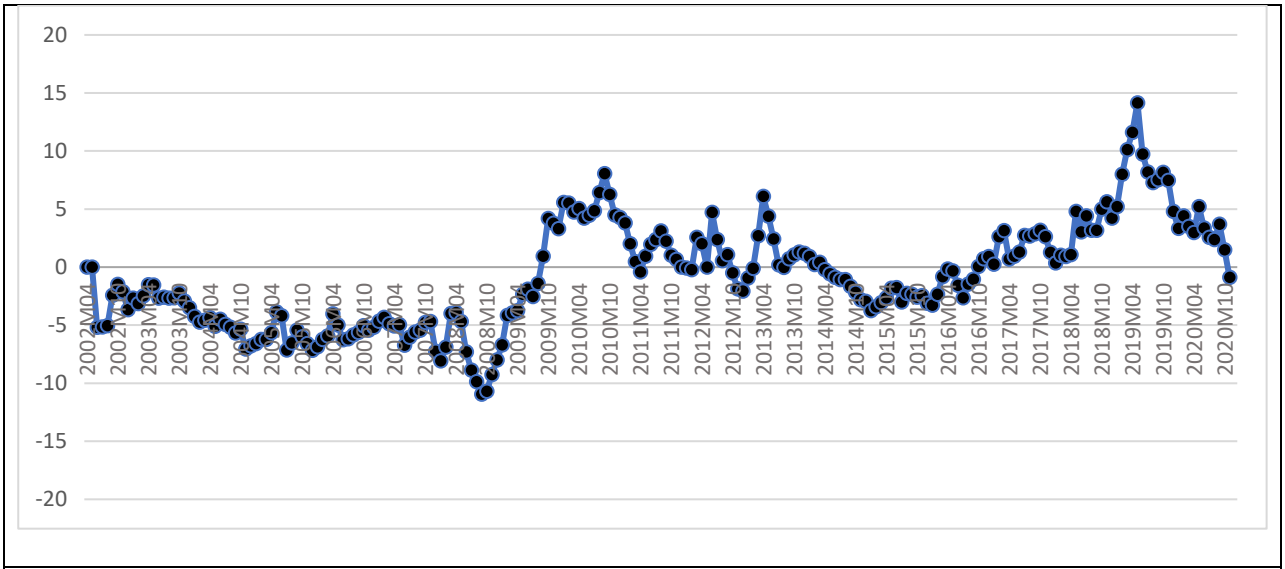

Figure 2- Estimated price bubble share from real lamb price between 1380 to 1399 (percentage)

As mentioned in the previous section, one of the positive features of using the Kalman filter method is the detection of negative bubbles or when the price is lower than the fundamental price. The results showed that real lamb prices before the middle of 1388 were less than the fundamental level. However, the largest bubbles were positive in value and formed in 1398 M02. During this period, the market was faced with the shock of the increasing exchange rate, beyond the expected amount.

In addition, the frequency distribution of the estimated price bubble share from real lamb price show less than 2.5% of the bubbles were formed above 10%, and more than 70% of the bubbles were less than 5%. Therefore, it can be concluded that the price of lamb is influenced by fundamental factors such as feed prices and macroeconomic variables such as exchange rates and the share of price bubbles in it is very small.

Real beef price babbles were different in size and pattern compared with lamb. As can be seen in Figure 3, the average share of babbles from real beef price was less than 1.2%. In addition, Figure 3 shows that the bubbles formed are not long-lived and have collapsed after two or three periods, and the real beef price is close to the fundamental level.

Most of the peaks from 2008 onwards are related to the beginning of the year (March and April) and the middle of the year (September and October) while the biggest bubble similar to real lamb price bubbles was formed in May 2017.

In Figure 4, the estimated price bubble share for chicken meat is presented. As can be seen, the size and range of bubble changes are larger than red meat. In real chicken meat price, averagely, the share of bubbles was about 7%, more than twice as much lamb. Also, many of the created couriers belong to the months of August and September and the highest bubbles, with an approximate amount of 20%, were occurred in September 2002.

Figure 4 also shows that, unlike the real lamb price, the formation of bubbles and their burst in this product is fast. The average bubble burst period for chicken meat during the study period was 7 months while the formation period until reaching the peak was less than 3 months. However, similar to the lamb and beef, real chicken meat prices experienced big positive bubbles at the beginning of 1391 and 1398, coinciding with the implementation of the targeted subsidy scheme and the sharp increase in the

exchange rate. In addition, in the study period, more than 18% of the months had experienced price bubbles above 10%, which is worth considering. Therefore, in general, it can be concluded that the price bubble in chicken meat, in terms of quantity, has a significant share of the price. The reason can be due to the high sensitivity of consumers to price changes and extensive government interventions in controlling it, which sometimes has contradictory effects on the market of this product.

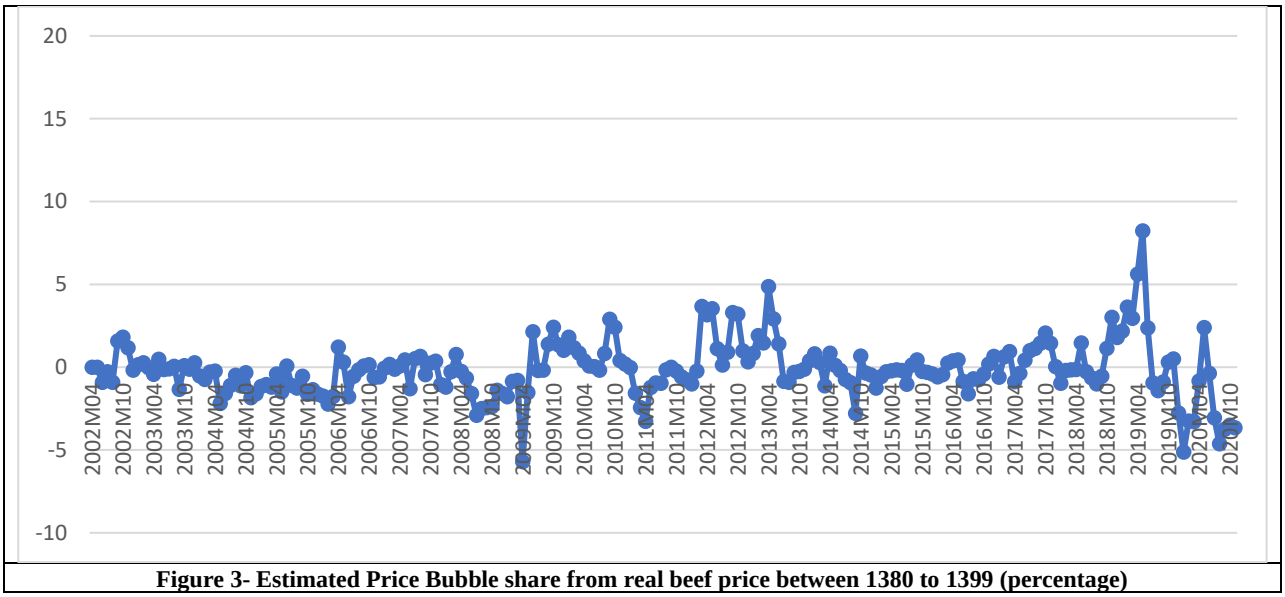

Figure 3- Estimated Price Bubble share from real beef price between 1380 to 1399 (percentage)

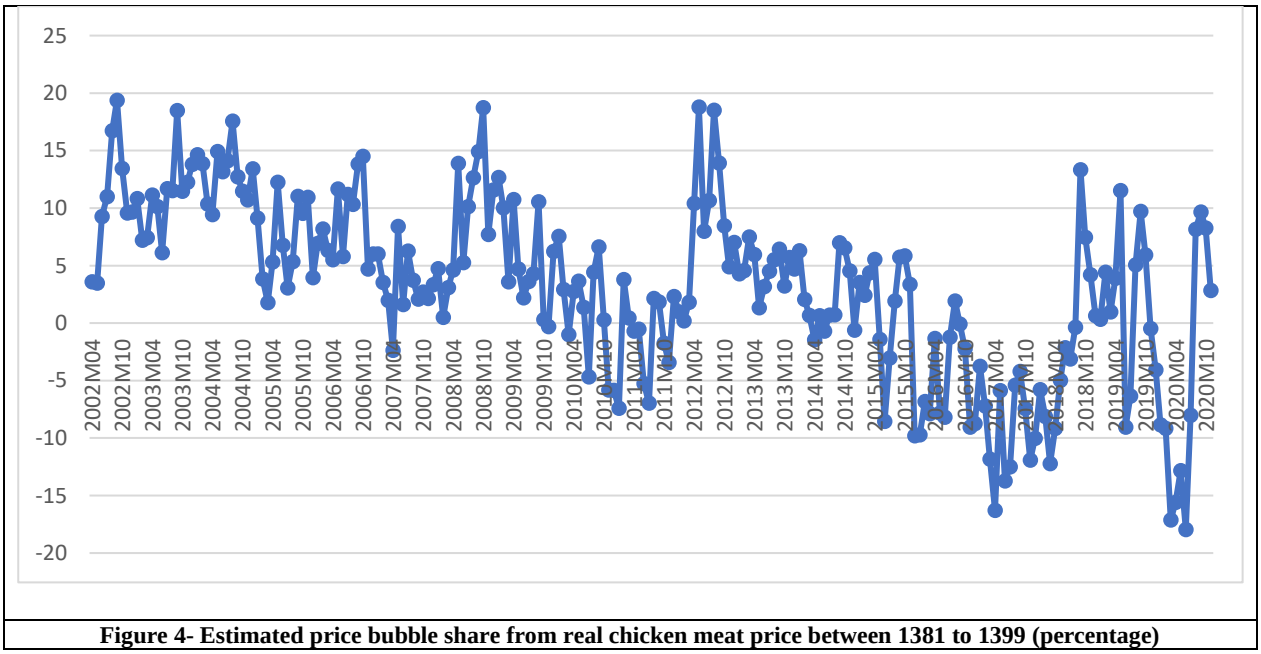

Figure 4- Estimated price bubble share from real chicken meat price between 1381 to 1399 (percentage)

Conclusion and policy implication

One of the problems that can be seen at the microeconomics and macroeconomics levels is the triggering of bubbles and fluctuations in the price of agricultural products. Therefore, in the present study, the price bubbles in three protein products, chicken, lamb, and beef meat, were investigated.

The results of the state-space model based on the Kalman filter showed that there is a significant positive relationship between the real price of feed and the real price of lamb and beef. This is due to the large share of barley and concentrated feed

used as an input in the production process of red meat. Therefore, one strategy to reduce the price of red meat is to control and monitor the price of livestock feed and prevent an excessive increase in the price of livestock inputs. The results of the study also showed a significant positive relationship between the real exchange rate and the real price of lamb. This relationship showed that with the increase in the real exchange rate and as a result of the increase in the price of imported livestock inputs, the price of lamb also increases. Accordingly, one of the other proposed policies to control the price of lamb is to control the exchange rate and subsequently reduce the price of livestock imported inputs.

The empirical results also show that the dummy variables of April and Ramadan months do not have a significant effect on the price of red meat. This result indicates that Iranian consumers do not have more demand for these two months compared to other months. This result confirmed the high proportion cost of red meat in the household bundle, and consumers are not able to spend more on red meat in April and Ramadan compared to other months.

The results of the Kalman filter on chicken meat showed that the price of chicken meat has a significant positive correlation with the price of corn and chicken broiler. Considering the contribution of these two inputs in chicken meat production, monitoring and controlling the price of these two inputs can be suggested as a solution to control chicken meat. The dummy variable also has a positive and significant relationship with the real price of chicken meat. Accordingly, in April and Ramadan, chicken meat prices will also increase with an increase in it demand. Therefore, increasing the supply of chicken meat to the market in these two months can play a key role in controlling the price of chicken meat.

Studying the price bubble of meat showed that the structure of the triggering price bubbles of these three products in terms of positive and negative bubbles, period and number of occurrences, and the collapse of the bubbles are completely different during the sample period. Also, the nature and formation of bubbles for these three products are completely different. Bubbles occurrence and collapse in the real price of lamb are gradual. However, in the case of chicken meat, price bubbles occur, and collapse are faster. The results showed that, on average, the price bubble in chicken meat reached its maximum after approximately seven months, and returned to its original value after approximately three months. In addition, the average share of bubbles in the real price of lamb and beef is less than 3.7% and 1.1% respectively, which indicates that the price bubbles in red meat are not significant compared to the real price. However, in the case of chicken meat, the average share of bubbles at the price is more than7%. The results also showed that more than 80% of the price bubbles in red meat were less than 5% of the real price. However, less than 40 percent of the price bubbles in chicken meat were less than 5 percent of the real price. On the other hand, approximately 60% of the bubbles in chicken meat were more than 5% of the real price. Based on the above results, it can be suggested that the government should pay more attention to fluctuations in the price of chicken meat compared to red meat. For chicken meat, a unified market information release platform should be established. Government intervention should also be done to reform the market structure, not just price control, to avoid the negative effect of stockpiling policy.

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بررسی حباب قیمتی گوشت در ایران: کاربرد مدل فضا–حالت

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چکیده

حباب‌های قیمتی و نوسانات قیمت محصولات کشاورزی از چالش‌های مهمی است که می‌تواند رفاه مصرف‌کنندگان و تولیدکنندگان را به طور قابل توجهی تحت تاثیر قرار دهد. بنابراین، در این مطالعه، حباب‌های قیمت در سه محصول پروتئینی اصلی، یعنی گوشت گوسفند، گوشت گاو و مرغ، با استفاده از مدل فضا–حالت بر اساس فیلتر کالمن با استفاده از داده‌های ماهانه از سال ۱۳۸۰ تا ۱۳۹۹ مورد بررسی قرار گرفت. در این راستا، به ترتیب قیمت جو، قیمت کنسانتره، جوجه یکروزه و ذرت را به عنوان نهاده‌های مهم مورد استفاده برای تولید گوشت گوسفند، گاو و مرغ در نظر گرفته شد. همچنین از نرخ واقعی ارز و قیمت واقعی نفت در مدل استفاده شده است. نتایج نشان دهنده تفاوت ساختارهای در حباب‌های قیمتی مثبت و منفی، دوره و تعداد وقوع و فروپاشی حباب در موراد مورد مطالعه بود. همچنین بر خلاف قیمت مرغ، به این نتیجه رسیدیم که حباب قیمت گوشت گوسفند و گوساله نسبت به سطح قیمت قابل توجه نیست. در بازار گوشت مرغ علت اصلی حباب‌های قیمتی را می‌توان به دلیل اختلال در روند بازاریابی این محصولات، عدم شفافیت اطلاعات و دخالت‌های متناقض دولت در بازار دانست. برای مقابله با این مشکل، پیاده‌سازی اطلاعات بازار بصورت تجمیع شده از طریق فناوری اطلاعات و ارتباطات می‌تواند ابزاری کارآمد در جهت حل چالش مذکور در نظر گرفته شود. علاوه بر این، مداخله دولت باید به جای کنترل قیمت‌ها، اصلاح ساختار بازار باشد.

واژه‌های کلیدی: گوشت گوسفند، گوشت مرغ، گوشت گاو، کالمن فیلتر

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Ranking of Important Indicators of Blockchain Technology for the Vegetable Oil Supply Chain

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Abstract

There are four interconnected markets, i.e. oilseeds, crude oil, meal and edible oil, in the vegetable oil supply chain. Nowadays, emerging tools in context of information and communication technologies (ICTs) have critical role to develop the supply chain. The purpose of this study is to identify and prioritize actors' preferences for using blockchain technology in the vegetable oil supply chain. For this purpose, we applied the Analytical Hierarchy Process (AHP) method. We interviewed 15 experts, including scientific specialists from adjacent fields and actors in the vegetable oil supply chain, in 2021, to determine the weight of the pairwise comparison matrix. This study evaluated the leading indicators of management improvement, performance improvement, data security, transparency, traceability and visibility, as well as their sub-indicators. The calculation of final weight revealed the most relevance of sub-indices, i.e. increasing inter-organizational trust, compatibility and secure data compatibility, with value of 0.467, 0.043 and 0.043, respectively. The rest of the indicators were also ranked as data immutability, close relationship with suppliers, degree of privacy, forecasting, strategic planning capabilities, reduction of lead time and doing the order on time, respectively. The lack of trust between circles and actors is thus the most crucial obstacle and the largest potential for the new chain in the current supply chain. More training and knowledge of supply chain players on emerging technologies should be put on the agenda to achieve optimal supply chain management. Our results also suggested solutions for advocating for the planning and development of the required infrastructure for the implementation of blockchain technology in Iran.

Keywords: Multi-criteria decision making, Transparency, Traceability, Visibility.

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Introduction

In recent years, Iran's food industry has grown to become one of the country's most important industries, with a unique position in the country's development and progress. This industry has a better competitive position compared to other industries in the country (Hosseini and Shekhi, 2012). Meanwhile, the food processing industry uses vegetable oil and incorporates it into other food businesses, contributing significantly to Iranian household consumption (OECD, 2017). Oilseeds, crude oil, meal, and edible oil are all interconnected markets in the vegetable oil supply chain. Oilseeds are the first link in the chain, providing the raw materials for the loops that follow. Soybean, rapeseed, and sunflower products are the most major sources of oil among the available oilseeds (Amjadi *et al.*, 2012; Dehshiri and Yavari, 2007; Fehrestisani, 2015). Consequently, oil seed production in the country has expanded from around 342 thousand tons in 2001 to over 500 thousand tons in 2020 (Iranian oilseed extraction industry association, 2021).The oil mill, which extracts crude oil from oilseeds, is the second link in the chain. The chain's main output is crude oil, whereas meals are considered a by-product. Because of its usage in animal, poultry, and marine nutrition, as well as plant protein, meal is absolutely critical. Vegetable oil factories are the next link in the chain. In general, the amount of vegetable oil production in the country by oil mills in 2019 was about 1.5 million tons, which in 2020 has been reduced. According to the latest numbers issued by the Ministry of Industry, Mines and Trade, vegetable oil production in the first seven months of this year was over 800 thousand tons, a 20% decline from the same period last year.

It should be mentioned that a considerable portion of oilseeds and crude oil is imported each year to supply the huge demand for vegetable oil. According to import and domestic production statistics, imports account for more than 80% of domestic oil demand (Iran Customs statistics, 2014). In 2019, crude oil imports are expected to be around 2 million tons. In addition, 2.5 million tons of oilseeds were imported this year (Iranian oilseed extraction industry association, 2021). The investigation of the vegetable oil supply chain reveals that, like other agricultural supply chains, it contains multiple loops and stakeholders, as well as complicated conditions. It may be claimed that the supply chain has transformed from a traditional network of manufacturers and suppliers to a complex system of products handled by multiple departments, and coordination among actors is critical (Aste *et al*., 2017). As a result, validating various critical criteria, such as product development phases, quality standards compliance, and monitoring the efficiency of the vegetable oil supply chain, is difficult (Salah *et al*., 2019).

Industries are looking for innovative solutions that promote efficient communication and coordination inside and between different organizations to optimize supply chain management and address existing problems (Farooq and O'Brien, 2012; Williamson *et al*., 2004). Incorporating current technologies into the vegetable oil supply chain can help organizations gain a better understanding of their operations and hence gain more control. Any company's primary goal is to maximize customers' satisfaction and retention. This can only be accomplished if they have a supply chain that is efficient, dependable, and transparent. As a result, it's critical to identify and select the right technology with these qualities (Awwad *et al*., 2018). Blockchain technology has recently been examined in several parts of supply chain and operations management, among the various digital technologies (Ivanov *et al*., 2019; Kshetri, 2018; Oliveira and Handfield, 2019). The supply chain can benefit from blockchain because it allows for more transparent, accuracy, and reliability in transactions across the process (Pilkington, 2016). Bitcoin, a digital cryptocurrency that works without the use of a trusted intermediate, was created by Satoshi Nakamoto (2008), who developed the basic concepts of Blockchain. A blockchain is a database that is created and maintained by a network of peer-to-peer (P2P) members (Wu *et al*., 2019; Yu and He, 2019). In essence, it is a one-of-a-kind database system that is produced, duplicated, synced, and maintained by all decentralized network participants (Zhang, 2019).

A blockchain is a data structure that encrypts each transaction, records it in a data block, and links them together in a chain structure using sophisticated cryptographic methods. Multiple distribution points are also used to register and update data blocks, as well as unique encryption methods to assure data block security (Xie and Li, 2021). According to observations, the most common application of Blockchain has been in the financial sector (Attaran and Gunasekaran, 2019;

Feng *et al.*, 2019). However, we may point to broader applications in other areas, including the supply chain, due to the measurements, immutability, and comprehensiveness of this technology and the financial field. Supply chain transactions are highly problematic. Tracking items from raw sources to consumers is one of these issues. It is critical to be able to track customer service and plan and forecast business operations. Furthermore, in supply chain management, stakeholder trust is vital, and an effective supply chain network should be established on it (Tyndall *et al.*, 1998). However, supply chain distrust has led network stakeholders to use intermediaries to conduct transactions, which significantly increases operating costs and reduces process efficiency (Poirier, 1999). The lack of transparency in the traditional supply chain is another issue. The extent to which participants have a common understanding and access to correct and sufficient information about products is referred to as supply chain transparency (Deimel *et al.*, 2008; Pant *et al.*, 2015). However, discrete data in current supply chain networks provide the least transparency. By moving products and data from one agent to another, most of the valuable information is lost. Lack of transparency can also be due to inconsistent data sharing, reliance on paper documents, and inadequate interoperability. In addition to the challenges mentioned, it can be stated that today's supply chain cannot manage risk, reduce costs or meet market needs with rapid change (Chang *et al.*, 2020). Blockchain can solve many problems and issues in the supply chain. This system is an innovative technology that improves customer service and increases operational productivity (Agarwal, 2018). In addition, it allows distrustful or unfamiliar stakeholders to review shared information. The nature of blockchain technology relies on three basic principles: decentralization, cryptography, and consensus. A combination of these principles makes it possible to create an editable database. This technology acts as a book for fast transactions and provides trust in a system of unknown users (Friedlmaier *et al.*, 2018). In short, blockchain technology speeds up transactions, simplifies the process, increases transparency, reduces waste, and ultimately reduces costs (Wasserman, 2016; Williamson, 1979). Despite the potential role of blockchain technology integrated ICTs in the agri-food supply chain, its use in Iran faces many challenges, an important part of which goes back to the required infrastructure. Items such as internet coverage and speed, crypto currency, and the spread of e-banking are in this group. The next challenge is the laws and policies that need to be developed by the legislature and the executive. The third challenge is its acceptance by current supply chain actors. The first and second challenges can be solved with the help of the experience of leading countries, so-called exogenously. But the third challenge is endogenous. This study was conducted to analyze the third challenge. There is a significant knowledge gap between the blockchain technology adoption and emerging ICTs available. It is yet unknown how actors assess the relative importance of various criteria for technology adoption or how such factors influence their adoption-intention decision processes (Saurabh and Dey, 2020). The existing research, in particular, clarifies the possible design and mechanisms of blockchain technology architecture in agri-food supply chain management. Despite this, it has paid little attention to the preferences of supply chain actors for blockchain adoption. It is necessary to determine the important features of the agri-based supply chain, as well as the ideal mix of this restricted number of attributes that are most authoritative on supply chain users' choice or decision-making.

Review of Literature

Among the studies related to Blockchain, we can mention Esmaeili and Rjabzadeghotermi's study (2019), which identified some of the challenges of adopting blockchain technology in supply chain management and divided them into four groups: organizational, inter-organizational, external, and classification technology. Their study emphasized the need to pay attention to the relationships between supply chain partners when adopting this technology. In another study, Abdullahi and Zoghi (2019) examined the strengths of Blockchain and its role in reducing supply chain management challenges. The results of their research showed that Blockchain improves supply chain traceability and reduces financial and operational risks. Other studies related to the study of blockchain structure include the study of Shahbazi *et al.* (2020), which, while introducing consensus algorithms, expressed their characteristics and compared them. Consensus algorithms specify the rules and protocols by which network members agree on how to add an information block to an information chain. Jouybar and Ebadi (2020) also examined the possibility of

using Blockchain in the insurance industry. The study of blockchain capabilities showed that this system could play a significant role by increasing accuracy and speed in the process of acceptance, issuance, and damages and promoting public confidence in the industry.Also, considering the importance of the vegetable oil supply chain, studies examined the issues raised in different links of this chain. Fehrestisani *et al.* (2015) evaluated the capabilities of oil-producing provinces, crude oil extraction units, and edible crude oil refining units. They used the data envelopment analysis method. Based on the results, there is a potential to increase production in the first and second levels of the vegetable oil supply chain. Feyzi (2018) also created a mathematical model for edible crude oil transportation and storage in order to reduce crude oil distribution and storage expenses. Zamani *et al.* (2021) used the multi-market partial equilibrium approach to investigate the import tariff policy along the vegetable oil supply chain. Dehghan *et al*. (2021) designed a closed-loop supply chain network in the edible oil industry using a robust possibilistic-random programming model. Nayak and Dhaigude (2019), who proposed a conceptual model of sustainable supply chain management (SSCM) in small and medium companies (SME) using blockchain technology, are among the foreign research connected to the identification of blockchain features in the supply chain .The conceptual model was developed using multiple-criteria decision-making (MCDM). Various administrative and theoretical implications have been examined, as well as the scope for further research. Competitive dynamics, culture, and financial restrictions, they claim, drive a long-term supply chain employing blockchain technology. Kamble *et al.* (2020) used the Interpretative Structural Modeling (ISM) and Decision-making Trial and Evaluation Laboratory to identify and evaluate thirteen effective variables, including traceability, retrievability, and immutability (DEMATEL). Traceability, auditability, immutability, and provenance were identified as key drivers. These factors are classified according to their driving power and their dependency on power values. Using a rating-based conjoint analysis. Sauraw and Dey (2020) use rank-based symmetric analysis to look at the grape juice supply chain and consider numerous potential drivers for blockchain technology acceptability, including traceability, reduction of intermediaries, transparency, coordination and control factor, adaption factor, and price. Identification and ranking them also proposed a blockchain network structure based on the collected results. To address the issue of information system structure flexibility and reusability, they developed an information system structure with basic supply chain performance requirements in this study. Furthermore, some studies have examined the opportunities and challenges of Blockchain regarding food traceability (Galvez *et al.*, 2018; Kamilaris *et al.*, 2019; Tse *et al*., 2017). Other studies examined the reliability of the tracking system (Mao *et al*., 2018; Wang, 2019). Despite the importance of the topic and the high capability of blockchain technology in the agricultural supply chain, very few studies have been conducted, according to a review of the studies. As a result, the current study identifies the key features of blockchain technology that are taken into account by the actors in the vegetable oil supply chain when configuring it.

Materials and Methods

Multi-criteria decision-making techniques (MCDM)

Decision-making can be considered as one of the most critical challenges for experts and analysts for solving various problems. Thus, different methods and algorithms have been proposed in recent decades to support decision-making (Rajabi *et al.*, 2011). Evaluating important quantitative and qualitative indicators of Blockchain is also a strategic decision which such indicators affect directly the decision-making process. Multi-criteria decision-making techniques (MCDM) are the most common methods for dealing with such problems (Çifçi and Büyüközkan, 2011). There are several methods applied in MCDM such as Analytic Hierarchy Process (AHP), Network Analysis Process (ANP), Vikor and TOPSIS. AHP introduced by Saaty (1977) is one of the most popular multi-criteria decision-making methods. This method is applicable when the decision-making action is faced with several competing options (Khaleghi and Mohammadpourzarandi, 2021). The ability to consider quality of criteria, weighting algorithm of standards and simplicity are the main advantages of this method (Dianti Deilami *et al.*, 2011).

Decision-making based on pairwise comparisons is the basis of the AHP approach as a multi-criteria decision-making method (Khaleghi and Mohammadpourzarandi, 2021). This means it compares pairwise criteria to rank priorities for different options (Saaty and Vargas, 1991). Experts

should therefore offer numerical values to the prioritization or relative importance of one indicator over another. According to Saaty and Vegas (1991), a range of numerical values from 1 to 9 was provided to compare the criteria representing the degree of importance of each criterion. For more details, the number of 1 implies equal importance, whereas a value of 9 shows that one indicator is more important than another (Saaty and Vargas, 1991). In fact, these scales determine the weight of each factor in terms of competing options (Khaleghi and Mohammadpourzarandi, 2021).

The Analytical Hierarchy Process (AHP)

Therefore, to determine the indicators of blockchain technology for the vegetable oil supply chain and identify the problems, we interviewed faculty members in Industrial Engineering and Food Industry Engineering and actors who were familiar in the vegetable oil market. In the next step, the weight of each criteria and sub-criteria is calculated. By reviewing the studies performed on this technology, we determined six main criteria and associated sub-criteria of the blockchain structure that can be used to configure the vegetable oil supply chain. Figure 1 shows the specified criteria and sub-criteria. The explanation and logic of the main features are as follows:

Criterion 1: Improving supply chain management

Supply chain management is recognized as a fundamental principle for creating a sustainable competitive advantage in the market (Feyzi, 2018). In addition to improving the quality of products and services, it seeks ways to reduce the product production cycle and provides services for reaching the prodict by customer (Zamani *et al*., 2021). Here the latest advances in science and technology can be utilized. Blockchain technology can create close relationships with suppliers and customers, just-in-time, strategic planning capabilities, coverage of multiple suppliers, outsourcing capabilities, e-commerce capabilities and the ability to integrate chain activities (Saberi *et al*., 2019; Saurabh and Dey, 2020; Tönnissen and Teuteberg, 2020; Zhang, 2019).

Criterion 2: Improving supply chain performance

Proper supply chain performance plays a key role in the success of an organization and the sustainable achievement of its goals, especially its profitability (Manavizade, 2006). Features of blockchain technology are: to improve performance, reduce lead time, compatibility, forecast, cost savings, resource inventory planning and reduce inventory levels (Hong *et al*., 2018; Saurabh and Dey, 2020).

Criterion 3: Data Security in the supply chain

Blockchain technology uses asymmetric encryption and digital signature algorithms to ensure data security and individual identity (Zhang, 2019). Once a block with a set of transactions is approved and stored by consensus, the enclosed data can no longer be modified. Therefore, blockchain technology provides a platform for secure data compatibility, data immutability, level of privacy and increased inter-organizational trust (Kamble *et al*., 2020; Xie and Li, 2021; Zhang, 2019).

Criterion 4: Supply chain transparency

Supply chain transparency is a socio-technical factor that can be enhanced or ensured through the immutability of transactions onto the distributed architecture of Blockchain (Pant *et al*., 2015). The blockchain consensus algorithm allows supply chain actors to identify process risks and improve supply chain performance and transaction reliability (Saurabh and Dey, 2020; Zhang, 2019).

Criterion 5: Supply chain traceability

Supply chain traceability is a critical quality factor that can be augmented by applying Blockchain and other existing technologies, such as Internet of Things (IoT). The choice or adoption of integrated blockchain technologies is attributed to an electronic traceability system that has gained salience as a risk management tool to ensure food safety, food quality, and chain integrity (Pappa *et al*., 2018, Saurabh and Dey, 2020).

Criterion 6: Supply Chain visibility

Blockchain-based supply chain transactions provide a reliable mechanism for managing identity (Alam, 2016), allowing access to time, location, and other data in any action on the product in the supply chain. All data is synchronized with all stakeholders in real-time, which increases the trust of actors in the supply chain network (Zhang, 2019).

For this purpose, there are different methods,

including the least-squares method, logarithmic squared method, Eigen vector method, and approximate methods (Ghodsipour, 2002). In the present study, the arithmetic means method, one of the approximate methods, has been used, which is expressed as Equation (1):

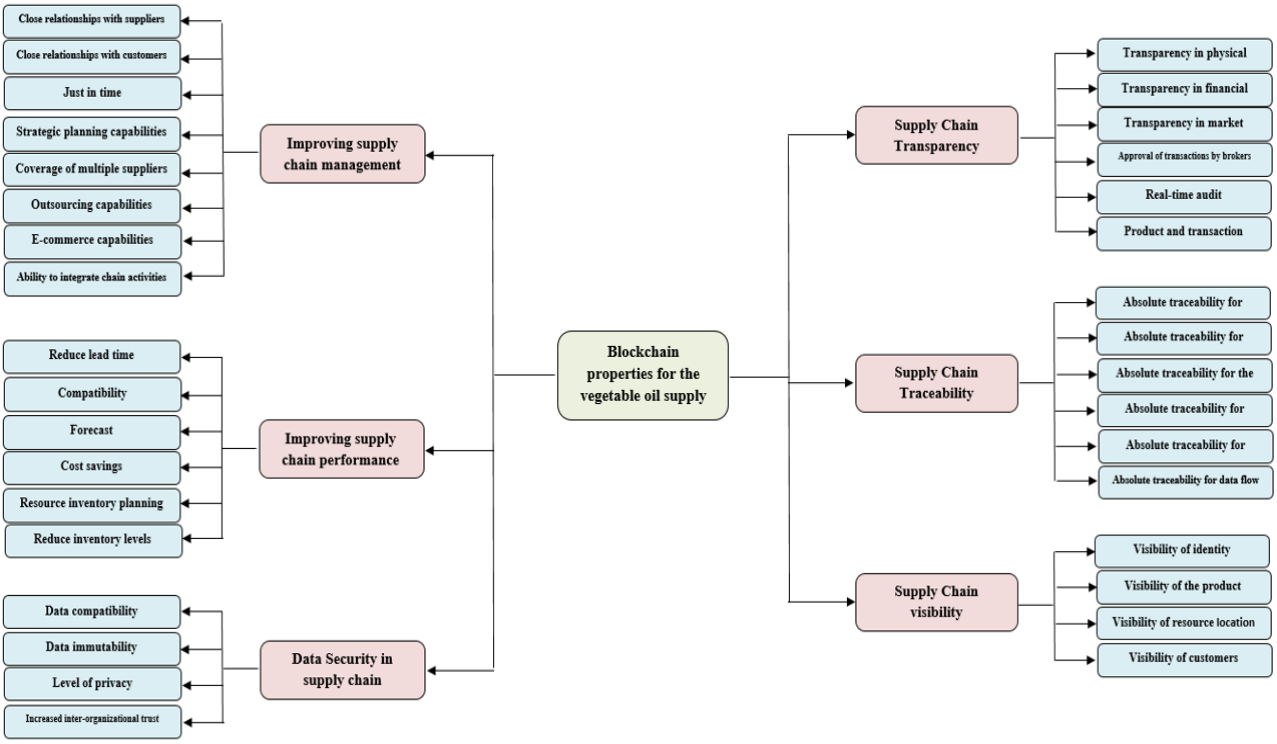

Figure 1- Blockchain technology indicators for configuration of vegetable oil supply chain

$$E_{ij} = \frac{e_{ij}}{Y_j} \quad (1)$$

$$w_i = \frac{\sum_{i=1}^{n} E_{ij}}{n} \quad (2)$$

Where E_{ij} represents the normalized matrix components ande_{ij}, which represents the first pairwise comparisons.Y_j is the sum of the columns of the matrix. In this method, the matrix must first be normalized, for which purpose the matrix elements are divided into their column set. Then, to calculate the weight, the line means of the normalized matrix must be estimated, which is shown in Equation (2)by w_i(Delbari and Davoodi, 2012). But in this method, the validity of the respondents' answers to pairwise comparisons should be examined (Delbari and Davoodi, 2012). The preferences and tastes of different people are contradictory. The dependence of this method on analysts' opinions may cause confusion and deviation in calculations and errors and inconsistencies in comparing and determining the importance of options (Rajabi *et al.*, 2011). Thus, Saaty (1977) introduced the mechanism by which the validity of the even matrix is measured. This method determines the incompatibility rate to check the robustness of the pairwise comparison matrix. Incompatibility rate (CR) The ratio of the incompatibility index (CI) to the random index (RI) is defined, which can be shown as Equation (3):

$$CR = \frac{CI}{RI} \quad (3)$$

Saaty (1977) calculated the random index (RI) as the mean strength of square matrices of different orders, quantified by entirely random values. Therefore, this index is predetermined. The value of the incompatibility index will be prioritized directly from the matrix and will be calculated using Equation (Alam, 2016):

$$CI = \alpha_{max} - \frac{n}{n-1} \quad (4)$$

where, α_max represents the largest eigenvalue of the pairwise comparison matrix and n is the order of the matrix. According to the Saaty and Vargas (1991) study, if the degree of incompatibility of the matrices is less than or equal to 0.1, the judgments are stable, and the comparison matrix does not need to be revised (Saaty and Vargas, 1991). Finally, AHP logic combines matrices from pairwise comparisons to calculate the final weight (Khaleghi and

Mohammadpourzarandi, 2021). In a hierarchical process, the final weight of the sub-criteria is determined by the sum of the product of the importance of the criteria in the weight of the sub-criteria (Delbari and Davoodi, 2021).

Data gathering

Accordingly, in the present study, to determine the weight of the pairwise comparison matrix, 15 experts who specialized in the fields of industrial engineering, food industry engineering and agricultural economics were interviewed through completing a questionnaire.

Results and Discussion

The goal of this research was to identify and prioritize the most important blockchain indicators for configuring the vegetable oil supply chain. For this purpose, the AHP method was used. According to the method, after determining the criteria and sub-criteria and creating a hierarchical structure, the matrix of pairwise comparisons was formed and completed by experts. The relative weight of each criteria and sub-criteria was computed using the arithmetic mean approach after completing the questionnaire and identifying the priorities (Abdipour and Alavian, 2017). Table 1 summarizes the findings.

Table 1- Relative weight of blockchain technology indicators for configuration of vegetable oil supply chain

	Code	Management	Code	Performance	Code	Security	Code	Transparency	Code	Traceability	Code	Visible
1	w_{11}	0.172	w_{21}	0.179	w_{31}	0.252	w_{41}	0.224	w_{51}	0.193	w_{61}	0.224
2	w_{12}	0.136	w_{22}	0.216	w_{32}	0.24	w_{42}	0.192	w_{52}	0.15	w_{62}	0.304
3	w_{13}	0.145	w_{23}	0.196	w_{33}	0.232	w_{43}	0.149	w_{53}	0.165	w_{63}	0.3
4	w_{14}	0.16	w_{24}	0.129	w_{34}	0.275	w_{44}	0.12	w_{54}	0.185	w_{64}	0.171
5	w_{15}	0.082	w_{25}	0.169			w_{45}	0.14	w_{55}	0.149		
6	w_{16}	0.068	w_{26}	0.109			w_{46}	0.173	w_{56}	0.156		
7	w_{17}	0.138										
8	w_{18}	0.095										

Source: Research Findings

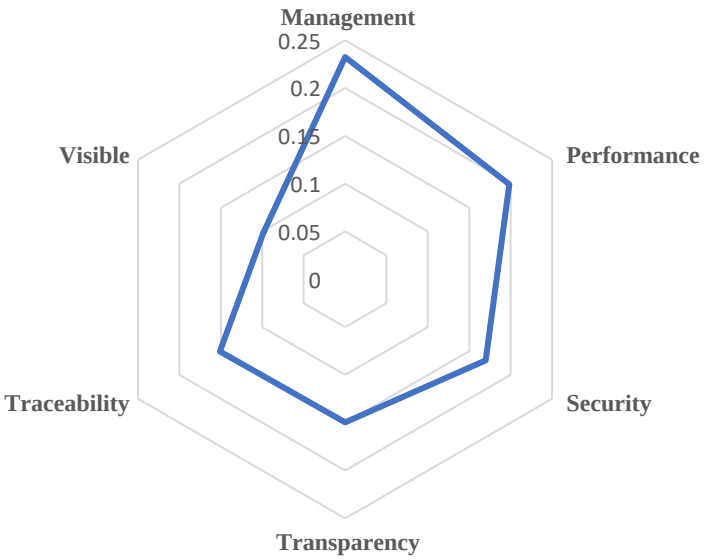

Figure 2- Weight of the main criteria

According to the findings, the criteria of improving management and improving the performance of the vegetable oil supply chain are respectively the most important among the main criteria, as shown in Figure 2. In addition, supply chain visibility was ranked lower than other criteria. The incompatibility rate is calculated in this method to determine the validity of the responses. Equations (3) and (4) were used to calculate the incompatibility rate for each paired comparison matrix in each questionnaire sample in this study. The incompatibility rate for all matrices is less than 0.1, according to the results (Table 2).

Finally, as shown in Table 2, the final weight of

each sub-criteria was calculated. The sub-criteria can also be classified in Figure 2 based on the estimated final weight.

The sub-criteria of "increasing inter-organizational trust" with a weight of 0.068 had the most importance among the 34 sub-criteria, according to the results shown in Table 3 and Figure 3. Organizational performance and shaping and improving organizational efficiency are intimately connected. There is no way to achieve strategic goals without trust. Lack of confidence between supply chain brokers will lead to an instability in the supply chain (1, 25). Mohammadjafari *et al*. (2015) also stated that trust is one of the determining factors in the relationship between industrial buyers and suppliers (Mohammadjafari *et al*., 2015).Therefore, considering that the main features of blockchain technology are transparency, high security, and traceability, it can be said that such features will increase inter-organizational trust. Also, the sub-criteria of "compatibility", "secure data compatibility", "data immutability" and "close relationship with suppliers" were in the second to fifth ranks with, respectively. Compatibility means adapting chain activities to market needs. Supply chain management seeks to increase adaptability and flexibility to respond quickly and effectively to market changes. Therefore, adapting chain activities to market needs can improve performance of the supply chain. Secure data compatibility and data immutability are sub-criteria of data security in the supply chain. Data security is the rapid and constant updating of data and the verification of data by various offices in terms of secure data compatibility. To data immutability, i.e. hacking or forgery, as mentioned, each block contains its hash function, i.e. a unique fingerprint, and the hash of the previous block, which must be recalculated with each change in the block. This feature results in very high data security in blockchain technology. Validation is managed by a central authority in traditional data management systems, which is often hacked and manipulated. Nevertheless, there is no need for the central authority to confirm the user's authorizations in blockchain technology, and all users and members of the P2P network, by adding an agreement, approve new items added to the blockchain, making data manipulation very difficult. A blockchain ensures that each user recovers data correctly and unchanged as the information is recorded.

Table 2- Consistency test of the pairwise comparison matrix

Code	α_{max}	n	CI	RI	CR	Consistency
$\mathbf{m_1}$	8.139	8	0.019	1.41	0.1<0.014	Yes
$\mathbf{m_2}$	6.059	6	0.01	1.24	0.1<0.008	Yes
$\mathbf{m_3}$	4.008	4	0.002	0.9	0.1<0.003	Yes
$\mathbf{m_4}$	6.053	6	0.01	1.24	0.1<0.008	Yes
$\mathbf{m_5}$	6.036	6	0.007	1.24	0.1<0.005	Yes
$\mathbf{m_6}$	4.018	4	0.006	0.9	0.1<0.006	Yes

Source: Research Findings

Table 3- Final weight of blockchain technology indicators for configuration of vegetable oil supply chain

Code	Management	Code	Performance	Code	Security	Code	Transparency	Code	Traceability	Code	Visible
$w_{f_{11}}$	0.04	$w_{f_{21}}$	0.035	$w_{f_{31}}$	0.042	$w_{f_{41}}$	0.033	$w_{f_{51}}$	0.029	$w_{f_{61}}$	0.022
$w_{f_{12}}$	0.031	$w_{f_{22}}$	0.042	$w_{f_{32}}$	0.04	$w_{f_{42}}$	0.028	$w_{f_{52}}$	0.022	$w_{f_{62}}$	0.030
$w_{f_{13}}$	0.033	$w_{f_{23}}$	0.039	$w_{f_{33}}$	0.039	$w_{f_{43}}$	0.022	$w_{f_{53}}$	0.024	$w_{f_{63}}$	0.029
$w_{f_{14}}$	0.037	$w_{f_{24}}$	0.025	$w_{f_{34}}$	0.046	$w_{f_{44}}$	0.017	$w_{f_{54}}$	0.028	$w_{f_{64}}$	0.016
$w_{f_{15}}$	0.019	$w_{f_{25}}$	0.033			$w_{f_{45}}$	0.021	$w_{f_{55}}$	0.022		
$w_{f_{16}}$	0.015	$w_{f_{26}}$	0.021			$w_{f_{46}}$	0.025	$w_{f_{56}}$	0.023		
$w_{f_{17}}$	0.032										
$w_{f_{18}}$	0.022										

Source: Research Findings

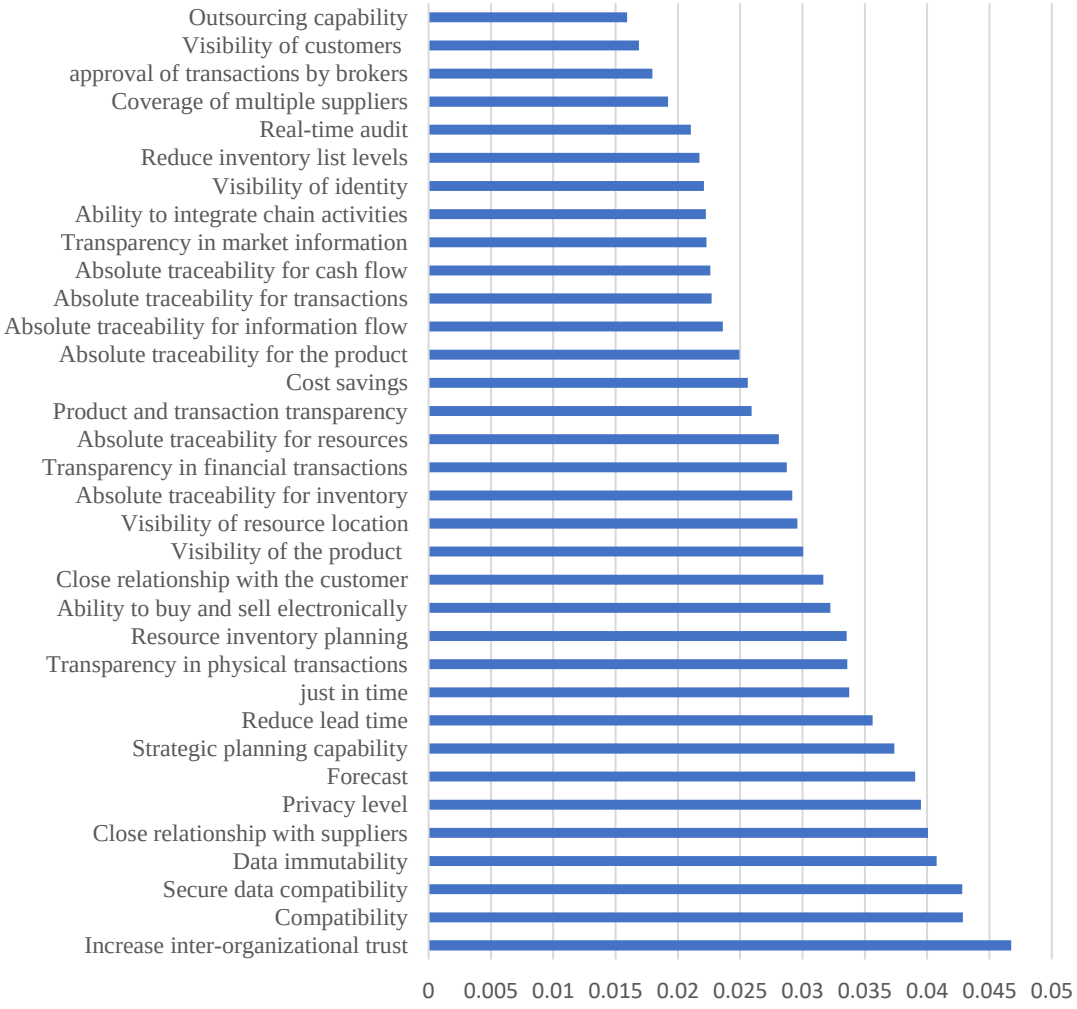

Figure 3- Ranking of blockchain technology indicators for configuration for vegetable oil supply chain

Then, the new transaction is validated and the transaction is written. A transaction alters the information contained in the block, which occurs due to the transfer of assets between a seller and a buyer. Inputting a set of new data to the blockchain does not make a distortion in pervious data. After validation, miners broadcast the new, unchangeable block to the entire P2P network. In the last stage, actual information about the contractual status and transaction tracing using internet capacity is done. The integration of different organizations that can interact with each other and share digital assets with each other continuously is facilitated. Fundamentally, interoperability is improved by this module and assists in building more partnerships among various organizations and driving better business value with common blockchain solutions (Ghode *et al.*, 2020). Another important indicator is the close relationship with suppliers. This index allows each link to connect with its previous links in the supply chain. Suppliers can have a huge impact on the performance of companies in terms of price, quality, technology and delivery. Ghafaritouran (2007) stated in his study that new and important approaches that have been proposed in supply chain management could lead to strengthening and expanding relationships with suppliers in the organization in the form of a supplier relationship management system (Ghafaritouran, 2007). Supplier Relationship Management, which considers the entire supply chain from the supply of raw materials to the final consumer to increase customer satisfaction and reduce costs. Other important indicators include level of privacy protection of individuals' identity through encryption, forecasting, strategic planning capability or long-term planning to attract

investment, Financing, providing input and selling the product, reducing lead time "and"just-in-time".

Conclusions

The current study aims to identify and rank Blockchain technology indicators that performed to configure the vegetable oil supply chain, taking into account the potential role of blockchain technology as well as integrated information and communication technology in the food supply chain, as well as the need to identify the preferences of vegetable oil supply chain actors in order to design a blockchain structure for this chain. The AHP approach, which is one of the MCDM methods, was employed for this. This strategy aids in the simultaneous identification of the best solution among a variety of decision criteria. The proposed framework has been done using survey data collected from two sources, including scientific experts from various academic disciplines and vegetable oil supply chain actors. The results of calculating the weight of each of the sub-criteria showed that "increase in inter-organizational trust", "compatibility", "compatibility of secure data", "data invariance", "close relationship with suppliers"," The level of privacy", "forecast", "strategic planning capability", " reduce lead time " and " just-in-time" have the highest weight and importance, respectively. The present study can help existing research on Blockchain, especially concerning supply chains, by providing a helpful evaluation model and a quantitative framework to implement blockchain technology. Also, this research has taken a step toward improving the existing conditions in this chain by identifying the current problems in the vegetable oil supply chain, providing a suitable solution, and introducing innovative technology. Furthermore, by designing the structure of this technology according to the preferences of the actors in the supply chain of vegetable oil and the cooperation of the policymakers of this sector, the conditions of this chain can be improved. According to the findings, the supply chain management criteria was critical. To do this, increased training and familiarity of supply chain actors with new technologies and their features should be prioritized in order to move the supply chain away from its existing traditional configuration. It is also recommended that infrastructure be planned and prepared in connection with legal and governance frameworks, building on the experience of other countries to identify infrastructure and executive concerns.

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رتبه‌بندی شاخص‌های مهم فنآوری بلاکچین برای زنجیره تأمین روغن نباتی

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چکیده

زنجیره تأمین روغن نباتی مشتمل بر چهار بازار به هم پیوسته می باشد. این بازارها شامل دانه‌های روغنی، روغن خام، کنجاله و روغن خوراکی می‌باشد. امروزه فناوری اطلاعات و ارتباطات یکپارچه در بهبود زنجیره تأمین نقش انکارناپذیری دارد. پذیرش هر فنآوری جدید بخش مهمی از توسعه آن می‌باشد. هدف از این مطالعه شناسایی و رتبه‌بندی ترجیحات بازیگران زنجیره تأمین روغن نباتی کشور نسبت به ویژگی‌های فنآوری بلاکچین است. به این منظور از روش فرآیند تحلیل سلسله مراتبی (AHP) استفاده شد. برای تعیین وزن ماتریس مقایسات زوجی، با ۱۵ کارشناس متشکل از کارشناسان علمی از رشته‌های مرتبط و همچنین کارگزاران زنجیره تأمین روغن نباتی در سال ۱۴۰۰ مصاحبه انجام گرفت. در این پژوهش، شاخص‌های اصلی بهبود مدیریت، بهبود عملکرد، امنیت داده، شفافیت، ردگیری و پدیداری و زیرشاخص‌های آنها مورد ارزیابی قرار گرفتند. نتایج حاصل از محاسبه وزن نهایی نشان داد که زیرشاخص‌های "افزایش اعتماد بین سازمانی"،"سازگاری"، "سازگاری داده‌های ایمن" به‌ترتیب با وزنی معادل ۰/۴۶۷۰، ۰/۰۴۲۸ و ۰/۰۴۲۸۲ بالاترین اهمیت را داشتند. همچنین شاخص‌های "تغییرناپذیری داده‌ها"، "ارتباط نزدیک با تأمین‌کنندگان"، "سطح حریم خصوصی"، "پیش‌بینی"، "قابلیت برنامه‌ریزی استراتژیک"، "کاهش زمان بازپرسازی" و "انجام به موقع سفارش" به‌ترتیب در رده‌های بعدی قرار گرفتند. به این ترتیب مهمترین چالش در زنجیره عرضه فعلی و بهترین فرصت برای زنجیره جدید عدم اعتماد بین حلقه‌ها و فعالان می‌باشد. به‌منظور دستیابی به مدیریت بهینه زنجیره تأمین، پیشنهاد می‌شود آموزش و آشنایی بیشتر بازیگران زنجیره تأمین با تکنولوژی‌های جدید و ویژگی‌های آنها در دستور کار قرار گیرد. همچنین برنامه‌ریزی و آماده‌سازی زیرساخت‌های لازم جهت پیاده‌سازی فناوری بلاکچین در کشور پیشنهاد می‌شود.

واژه‌های کلیدی: تصمیم‌گیری چندمعیاره، فنآوری بلاکچین، زنجیره تأمین، روغن نباتی

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Comparison of Single and Multiple Hypotheses Test of Aggregation the "Pulses" and "Sugar and Sugar Cubes" in Urban Areas of Iran

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Abstract

The main purpose of this study was to investigate the possibility of aggregation different types of pulses as well as sugar, using the single and multiple hypotheses test. The former hypothesis tests include Composite Commodity Theorem (Leontief and Hicks) and Generalized Composite Commodity Theorem (GCCT) and the latter hypothesis tests include the Bonferroni, Simes, Holm, and Hochberg procedures and the results of mentioned methods were compared. Data of the period 2006-2018 for this study were obtained from the Statistics Center of Iran..The results of multiple tests of Bonferroni, Simes and Hochberg for different types of pulses showed that with the exception of "mixed pea and bean", other products can be aggregated into the group of Pulses. Also, based on the results of Bonferroni, Simes, Holm and Hochberg, different types of sugar can be aggregated into the group of Sugar. The results of the individual hypothesis test are not the same for different types of pulses and different types of sugar. In other words, according to Leontief method, the hypothesis of aggregate the different types of beans together was not confirmed, while according to Hicks method, this hypothesis was confirmed. Similarly, according to the Leontief method, the hypothesis of aggregate the different types of sugar together was rejected, while according to the Hicks method, this hypothesis was confirmed. The result of the GCCT showed that all types of pulses (except "other beans") can be aggregated into the Pulses group. The types of sugar can also be aggregated into the Sugar group according to the generalized composite method. Based on the results, when the number of observations is low, the use of single tests and specifically the GCCT will not show the exactly same results, which confirms Davis (2003) finding that the GCCT does not guarantee proper aggregation of goods. In these cases, multiple tests would be recommended.

Keywords: Aggregation, Multiple hypotheses test, Pulses, Single hypothesis test, Sugar
Classification JEL: C43 ،D11

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Introduction

Lack of adequate information about individual behavior of consumers makes analysis of their behavior challenging. Under such circumstances, data aggregation proves to be an effective solution for this challenge (Shokoohi *et al*., 2016). In this regard, there are many cases in which the sum of the production of several products is used instead of a specific product in order to estimate a production or cost function (Salami and Kianirad, 2001). In general, aggregation and using composite goods have been considered by the researchers as an effective solution for addressing issues such as unavailability of detailed information about individual goods, higher cost of data gathering process, losing observations and data, multicollinearity problem and restrictions of degree of freedom (Shabanzadeh and Mahmoodi, 2015). As a result, data aggregation in research process is inevitable. Knowledge on optimization method for integrating individual data in consistency with the fundamental theories of microeconomics is also important (Shokoohi *et al*., 2016). In this process, proper and correct grouping of goods is extraordinary important, because incorrect grouping of goods leads to specification error and biased estimations. Additionally, incorrect grouping of goods makes an error in tests of hypotheses and consequently makes an incorrect patern of consumers' behavior as well as policy making process (Davis, 1997).

The first theory called Composite Commodity Theorem (CCT) which are introduced by Hicks (1936) and Leontief (1936). Based on this theory, if the prices of a group of goods change in the same proportion so that their ratio remains constant over time and this group of goods can be integrated together.

Assuming the separability of utility function, Leontief (1947) and Sono (1961) proposed restricting structure of consumer's preference behavior as one of the means for minimizing the number of parameters. Lewbel (1996) proposed Generalized Composite Commodity Theorem (GCCT) which imposes fewer but more acceptable constraints on goods price trend than the Hicks-Leontief Composite Commodity Theorem. According to Davis *et al*. (2000), GCCT is more important than Composite Commodity Theorem (CCT) because it facilitates establishment of connection between goods prices which is required for a consistent and compatible integration. In spite of vast application of GCCT, Davis (2003) believe under low number of observations the methods proposed by Lewbel does not necessarily guarantee the proper integration of goods. Therefore, to elevate the capability of the theorem test, Davis proposed other methods such as Bonferroni, Simes, Holm and Hochberg (Shokoohi *et al*., 2016). During the past years, numerous Iranian scholars such as Kiani Rad and Salami (2000), Salami and Kiani Rad (2001), Faryadras and Chizari (2005), Falsafian *et al*. (2006), Kiani Rad and Salami (2007), Izadimehr and Javanbakht (2013), Shabanzadeh and Mahmoodi (2015) and Shokoohi *et al.* (2016) used GCCT for goods grouping in their research. Studies by Ash *et al*. (2010) on aggregation of Swordfish imports, Frank et al. (2010) on US import demand for Swordfish, Xie and Myrland (2011) on aggregation of Salmon demand, Schulz *et al.* (2011) on aggregation of different brands of ground beef, Schulz *et al*. (2012) composite demand for ground beef in the US, Lee *et al.* (2012) on composite demand of ground beef in the US, Peterson and Myrland (2016) on aggregation of seven different fishes, and Hang *et al.* (2018) applied GCCT to test for on analyzing drinks composited demand systems such as other studies carried out test for valid aggregations using the generalized composite commodity theorem.

The review of various studies showed that the main focus of these studies was on the use of GCCT theory. While less research was on using different methods such as Leontief Theorem, Hicks Theorem, Bonferroni, Simes, Holm and Hochberg. However, it is important to compare different methods to study the aggregation of goods, which is one of the advantages of the present study over previous studies.

Indeed, aggregation test without selecting the proper method can affect the consumers' behavior analysis (Shokoohi *et al.*, 2016). The main aim of this study is its comprehensive and integrity of the use of the test of single and multiple addition hypotheses.

Pulses are one of the main sources of protein as the most important source of food which conserve a special grain food in urban and rural household basket; after cereals, these products are considered (Khofi and Anvieh Tekiyeh, 2009). According to the Food and Agriculture Organization (FAO) statistics, the per capita supply of energy from pulses consumption in 2019 in Iran was equal to 49.97 kcal per day, which is lower than the world

(66.86 kcal per day) (Iranian Sugar Factories Association, 2015). Sugar and sugar cube are other important goods that have significant roles in Iranian household basket of goods. Investigating the aggregation of different types of sugar is very important for analyzing behavior of the consumers. By a 50% decrease, the annual sugar consumption of a Iranian household with four members decreases from 20 kg in 2005 to 10 kg in 2014 (Reference(s)). Also, the annual sugar cube consumption of the household decreased from 32 kg in 2005 to 21 kg in 2014 which shows 35% decrease (Iranian Sugar Factories Association, 2015). According to the FAO statistics, the per capita supply of energy from the consumption of various sugars in Iran in 2019 was equal to 280.68 kcal per day that was higher than the world by amount of 231.04 kcal per day.

Therefore, due to the importance of pulses as source of plant proteins and types of sugar in the consumer basket of Iranian households, in this study, we examined the possibility of aggregation the products including pea, split pea, pinto bean, kidney bean, other beans, soybean, mixed pea and bean, lintels, mung bean, broad bean, split bean, sprouts and other pulses in the group of "Pulses" and sugar cube, sugar granules, artificial or diet sugar, powdered sugar and types of sugar in the "Sugar" group. According to the authors' information , the aggregation tests in order to the possibility of aggregating foods or goods using different theories, has been done very rarely in Iran.

Therefore, the main objective of this study is to investigate the possibility of aggregation of different pulses, sugar and sugar cubes in groups entitled “Pulses” and “Sugar”, respectively, using single test, i.e. Leontief’s CCT& Hicks’s CCT & GCCT, and multiple test, i.e. Bonferroni, Simes, Holm procedure and Hochberg procedures.,

Materials and Methods

The following methods are common for testing the goods aggregation (Shabanzadeh and Mahmoodi, 2015):

Hicks’s Composite Commodity Theorem

Based on Hicks’s Composite Commodity Theorem, if the prices of a group of goods change in the same proportion, that group of goods behaves just as if it were a single commodity. Indeed, the relative price of the goods must remain constant during a specific period.

Leontief’s Composite Commodity Theorem

Aggregation condition of this theorem is same as the Hick’s, but the relative amounts must remain fixed during specific period. In other words, goods can be in one group whose relative value remains constant over time.

Generalized Composite Commodity Theorem (GCCT)

Lewbel (1996) provides a generalization of the CCT that is empirically useful. In this theory, goods will be aggregated into the same group if the ratio of price of each good to the group’s price index remains independent from group’s price index. In this method, assuming that there are *n* individual goods or commodities i=1,2,...,n if the objective is to aggregate them under N groups and price of individual goods and group’s price index are demonstrated respective as P_i (i=1, 2, 3 … n) and P_I (I=1, 2, . . . , N) and N<n. Then the relative price (ρ_i) and index group of interest (R_I) will be shown as follows:

$$\rho_i = \ln\left(\frac{P_i}{P_I}\right) \quad (1)$$

$$R_I = \ln(P_I) \quad (2)$$

The aggregation criterion in GCCT is the independence of ρ_i index from ρ_i index. For nonstationary prices this is equivalent to find that ρ_i and R_I is not cointegrated.

Davis’s Approach

Many of the previous empirical studies, including Lewbel’s (1996), used single testing to address the issue of small sample. In GCCT, the cointegration test is carried out between relative price of each individual good (ρ_i) and price index of the respective group (R_I). If the calculated probability values are less than the 10%, the GCCT theory is rejected.

It should be noted that the rejection of aggregation between the relative price of each commodity (ρi) and the price index of its own group (Ri) provides only the necessary condition for GCCT. A sufficient condition in this regard is to examine the hypothesis of independence between ρi and all price indices of other commodity groups. The important point in this regard is the method of testing the sufficient condition for the aggregation of goods in the conditions of low data. Davis (2003) proposed the multiple hypotheses test for this purpose. In other

words, following the critique of this method (lack of cointegration between commodities of the same groups does not guarantee the lack of integration between commodities of different groups), Davis found that the GCCT could not guarantee proper aggregation of goods for a small number of observations and Therefore, suggested the use of multiple comparison testing procedures (Bonferroni, Holm, Hochberg and Simes methods). In this approach, the null hypothesis is that the price ratio of each product to the price index of the group is not correlated or co-integrated with any of the price indices.

Suppose there are N individual hypotheses H_1, H_2,…H_N each being tested at the α_I level with corresponding p-values p_1, p_2, p_N. Let H:{H_1,H_2,...,H_N} and define the family hypothesis H0 to be the intersection of all hypotheses in H (Hochberg and Tamhane, 1987; Device, 2003; Shokoohi *et al*., 2016):$H_0=\bigcap_{j=1}^{N} H_J$. The family wise error rate (FWER) is the probability of a type I error for a family hypothesis. Calculation process of family-wise error rate (FWER) will be explained bellow. As Dufour and Torres (1998) point out, multiple comparison procedures are especially useful when standard asymptotic methods are either not applicable or unreliable, which is certainly the case in this research here which we are faced with data size limitations.

Bonferroni Procedure

In this procedure, p-values are initially calculated for single hypotheses (H_0: no correlation or cointegration between ρ_i and R_I); then, critical values for the null hypothesis (H_0), which is called family-wise error rate or FWER is calculated using the following formula:

$$FWER=\alpha/N \quad (3)$$

In this procedure, α is significance level (10% for smaller samples) and N is the number of single hypotheses under N groups. If any individual p-values are less than α/N, the null hypothesis (H_0) is rejected, otherwise, it is retained (Davis, 2003; Shokoohi *et al.*, 2016).

Simes Procedure

In this procedure, p-values are calculated for single hypotheses, but FWER is calculated by the following formula:

$$FWER= i\alpha/N \quad (4)$$

where *i* is order of FWER-values, α and N are defined above. In this procedure, if each of the computational p-values is less than $i\alpha/N$, H_0 is rejected, otherwise, it is retained. Since significance degrees are adjusted with the ordering of the p-values, Simes procedure is more powerful than the regular Bonferroni procedure (Davis, 2003 and Shokoohi et al., 2016).

Hochberg Procedure

Hochberg (1988) developed a step-up procedure based on the Simes (1986) equality. Let order the p values $P_{(1)}$..., $P_{(m)}$ (smallest to largest) and the corresponding hypotheses $H_{(1)}$,. .. , $H_{(m)}$. Let $\alpha'_{(1)}$, … , $\alpha'_{(m)}$ be the adjusted significance levels (or FWER**)**. If $p_{(m)} \leq \alpha'_{(m)}$, then all hypotheses are rejected; otherwise $H_{(m)}$ is retained, and $p_{(m-1)}$ is compared with $\alpha'_{(m-1)}$. If $p_{(m-1)}$ is smaller than $\alpha'_{(m-1)}$, then all the remaining hypotheses are rejected; otherwise $H_{(m\_1)}$ is retained, and P(m - 2) is compared with $\alpha'_{(m-2)}$, and so on (Davis, 2003; Shokoohi *et al.*, 2016).

Holm Procedure

In this procedure, the individual p-values are first arranged in increasing order $p_{(1)} \leq p_{(2)} \ldots \leq p_{(N)}$ along with their corresponding hypotheses $H_{(1)}$,$H_{(2)}$,...,$H_{(N)}$ before the testing commences. FWER is calculated using the following procedure:

$$FWER= \alpha/(N-i+1) \quad (5)$$

Decision rule: if H_0 is accepted or rejected, the following steps are taken:

1) First, it is assumed that i=j and it is checked if the smallest p value is less than FWER. If the answer is negative, it can be resulted that none of the single hypotheses are statistically significant. Indeed, null hypothesis is retained and testing is complete.

2) If the smallest p value is less than FWER, then the comparison is statistically significant and the test proceeds. In the next step, it is assumed that i=j-1 and again, it is checked if the smallest p value is less than FWER. The decision is made same as before and the procedure continues until reaching the point that the H_0 is not statistically significant; at this point, Holm procedure is stopped and the test is not conducted on other i values (Holm, 1979; Davis, 2003; Shokoohi *et al.*, 2016).

Steps of Aggregation Testing Using GCCT through Different Procedures

The followings are steps of aggregation testing

using GCCT, through different procedures (Shabanzadeh and Mahmoodi, 2015):

Performing the variables unit root test (price ratio of each commodity to group's price index (ρ_i) and product group price index (R_I)): price index of each group can be calculated using Törnqvist-Theil price index.

To determine proper testing method, variables independence should be evaluated using stationary test according to Table 1.

Table 1- Type of test for determination of correlation

Row	Result		Type of Test
	ρ_i	R_I	
1	Stationary	Stationary	Correlation
2	Nonstationary	Nonstationary	Cointegration
3	Stationary	Undetermined	Correlation
4	Undetermined	Stationary	Correlation
5	Nonstationary	Undetermined	Cointegration
6	Undetermined	Nonstationary	Cointegration
7	Undetermined	Undetermined	Both of cointegration and correlation
8	Stationary	Nonstationary	None
9	Nonstationary	Stationary	None

Davis *et al.*, (2000) ; Shaabanzadeh and Mahmoodi (2015)

Data Source

Required data and information of the present study, including consumption expenditures and amount of each of pulses (pea, split pea, pinto bean, kidney bean, other beans, soybean, mixed pea and bean, lintels, mung bean, broad bean, split bean, sprouts and other pulses) and Sugar group's items include of sugar cube products (sugar cube, sugar granules, artificial or diet sugar, powdered sugar) are gathered from Statistical Center of Iran, covering the period of 2006-2018.

Results and Discussion

As mentioned before, the purpose of the present study is to investigate the possibility of aggregation of different types of pulses and sugar products under respective groups, using Composite Commodity Theorem (CCT) through single aggregation Theorem (Leontief's CCT, Hicks's CCT and GCCT) and multiple aggregation Theorem (Bonferroni, Simes, Holm and Hochberg procedures). In this regard, first the results of Leontief's CCT, Hicks's CCT and GCCT for different types of pulses and sugar are presented and then the results of Bonferroni, Simes, Holm and Hochberg procedures are presented. Finally, comparison of single and multiple testing results is presented.

Results of Leontief and Hicks's CCT for Pulses

Correlation matrix and consumption ratio parity tests were used for testing the aggregation of pulses using Leontief's CCT.The results of Leontief's CCT using correlation matrix (Table 2) show that pea, split pea, kidney bean and lintels can be aggregated under the same group and pinto bean, soybean, mixed pea and bean, other beans, mung bean, broad bean, split broad bean, spouts and other pulses cannot be integrated to the mentioned group. As can be seen, a large number of products cannot be aggregated into the group of Pulses.

Correlation matrix and price ratio parity tests are also used for testing the aggregation of pulses using Hicks'CCT. The results driven from Hick's CCT using correlation matrix (Table 3) shows that except for pinto bean, kidney bean and other beans, the remaining crops can be aggregated under pulses group. Therefore, using the correlation matrix, a large number of products can be aggregated into the group of Pulses.

The results of the Leontief and Hicks's CCT test using the parity test of the consumption quantities ratio and price of different types of pulses are presented in Table 4.

Table 2- Correlation matrix of pulses consumption amount

Item	Pea	Split pea	Pinto bean	Kidney bean	Other types of beans	Soybean	Mix pea & beans	Lentils	Mung bean & the rest*
Pea	1	0.960	0.799	0.948	0.900	-0.343	0.743	0.921	0.891
Split pea	0.960	1	0.854	0.977	0.958	-0.354	0.728	0.968	0.828
Pinto bean	0.799	0.854	1	0.856	0.819	-0.291	0.465	0.797	0.671
Kidney bean	0.948	0.977	0.856	1	0.916	-0.486	0.734	0.940	0.837
Other beans	0.900	0.958	0.819	0.916	1	-0.285	0.638	0.919	0.764
Soybean	-0.343	-0.354	-0.291	-0.486	-0.285	1	-0.607	-0.291	-0.582
Mixed pea and bean	0.743	0.728	0.465	0.734	0.638	-0.607	1	0.718	0.861
Lentils	0.921	0.968	0.797	0.940	0.919	-0.291	0.718	1	0.768
Mung bean & the rest*	0.891	0.828	0.671	0.837	0.764	-0.582	0.861	0.768	1

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Table 3- Correlation matrix of pulses price

Item	Pea	Split pea	Pinto bean	Kidney bean	other types of beans	Soybean	Mix pea & beans	Lentils	Mung bean & the rest*
Pea	1	0.991	0.942	0.943	0.955	0.962	0.963	0.977	0.968
Split pea	0.991	1	0.976	0.979	0.985	0.984	0.989	0.993	0.989
Pinto bean	0.942	0.976	1	0.996	0.994	0.967	0.995	0.969	0.973
Kidney bean	0.943	0.979	0.996	1	0.998	0.981	0.997	0.981	0.986
Other beans	0.955	0.985	0.994	0.998	1	0.984	0.998	0.986	0.987
Soybean	0.962	0.984	0.967	0.981	0.984	1	0.984	0.994	0.995
Mixed pea and bean	0.963	0.989	0.995	0.997	0.998	0.984	1	0.987	0.990
Lentils	0.977	0.993	0.969	0.981	0.986	0.994	0.987	1	0.997
Mung bean & the rest*	0.968	0.989	0.973	0.986	0.987	0.995	0.990	0.997	1

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Table 4- Results of Leontief and Hicks's CCT test using parity test of pulses consumption ratio and prices

	Leontief's Composite Commodity Theorem			Hicks's Composite Commodity Theorem		
Method	df	Value	Pro.	df	Value	Pro.
Bartlett	8	89.25	0.000	8	6.75	0.56
Levene	(8, 99)	13.3	0.000	(8, 99)	2.32	0.02
Brown-Forsythe	(8, 99)	8.24	0.000	(8, 99)	1.17	0.33

References: Research findings.

As demonstrated above, significance level of the pulses consumption parity test is less than 0.05 and the H_0 hypothesis (variance parity) is rejected and pulses cannot be aggregated under the same group. In other words, pulses are not grouped according to the Leontief Theorem because the consumption of each pulses does not change in the same proportion over time. On the other hand, significance level of results of price ratio parity test is more than 0.05 and the H_0 of variance equivalency is retained; therefore, the null hypothesis (variance is equal) cannot be rejected and different type of pulses can be aggregated under the same group. In general, comparing the results of Leontief and Hicks Theorem using the methods of correlation matrix and equality of ratios indicates that there is a major difference in the grouping of pulses based on these two theories, which is mainly due to the nature of these two theories (Hicks's Composite Commodity Theorem focuses on prices and Leontief's Composite Commodity Theorem focuses on quantities). It should be noted that the results of grouping the products using the methods of correlation matrix and equality of ratios in the form of Leontief and Hicks Theorem are almost similar.

Lewbel's GCCT Test

As mentioned before, the first step for aggregation test using GCCT is to conduct stationary test on price ratio of each goods to group's price index of goods and product group price index. Price index of each group (R_I) can be calculated using Törnqvist-Theil price index. Then, independency between R and ρ must be tested

based on the results of stationary test and through the proper procedure selected based on Table 1.

Results of stationary test on R and ρ variables for studying their independence are provided in Table 5.

As shown in Table 6 and by considering stationary level of R and ρ variables, co-integration test proves to be appropriate for studying independence between "split pea relative price", "kidney bean relative price", "other beans relative price", "soybean relative price", and "mixed pea and bean relative price" with the price index of pulses group. However, there is no need for conducting any test for evaluating independence of "pea relative price", "pinto bean relative price", "lintels relative price" and "mung bean, broad bean, split broad bean, sprouts and other pulses relative price" with the price index of pulses group. Summary of results of Engle–Granger cointegration test in terms of time variables and the aggregation test of pulses in urban areas by GCCT is presented in Table 6.

Based on the results of GCCT test, except for "other brans", different types of pulses can be aggregated under the same group.

Table 5- Results of stationary test on variables of Pulses and Sugar groups

Production	Variable		Generalized Dickey Fuller Statistic			Stationary	Appropriate Test
			t-Statistic	Prob.	Description		
Pulses	Pea relative price	ρ_1	-5.38	0.0023	With intercept	I (0)	None
	Split pea relative price	ρ_2	-2.18	0.2211	With intercept	I (1)	Cointegration
	Pinto bean relative price	ρ_3	-4.02	0.0636	With intercept & trend	I (0)	None
	Kidney bean relative price	ρ_4	-3.39	0.1254	With intercept & trend	I (1)	Cointegration
	Other beans relative price	ρ_5	-2.51	0.1431	With intercept	I (1)	Cointegration
	Soybean relative price	ρ_6	-3.27	0.1427	With intercept & trend	I (1)	Cointegration
	Mixed pea and bean relative price	ρ_7	-1.61	0.4451	With intercept	I (1)	Cointegration
	Lentils relative price	ρ_8	-3.21	0.0505	With intercept	I (0)	None
	Mung bean, &the rest* relative price	ρ_9	-3.08	0.0606	With intercept	I (0)	None
	Price index of group pulses	R_1	-3.05	0.1696	With intercept & trend	I (1)	-
Sugar	Sugar cube products relative price	ρ_1	-2.67	0.0127	Without intercept & trend	I (0)	None
	Sugar relative price	ρ_2	-3.06	0.1678	With intercept & trend	I (1)	Cointegration
	Price index of group sugar	R_2	-1.12	0.8751	With intercept & trend	I (1)	-

References: Research findings. *: broad bean, split broad bean, sprouts of beans and other pulses relative price

Table 6- The result of aggregation test of different types of Pulses in urban areas by GCCT method

Variable		Type of Test	Cointegration Test		GCCT
			t-statistic	Result	
Pulses (R_1)					
Pea relative price	ρ_1	None	-	–	Accept
Split pea relative price	ρ_2	Cointegration	-3.2 (0.2934)	Reject	Accept
Pinto bean relative price	ρ_3	None	-	–	Accept
Kidney bean relative price	ρ_4	Cointegration	-3.7 (0.1754)	Reject	Accept
Other beans relative price	ρ_5	Cointegration	-4.5(0.0656)	Accept	Reject
Soybean relative price	ρ_6	Cointegration	-4.02(0.1211)	Reject	Accept
Mixed pea and bean relative price	ρ_7	Cointegration	-3.5(0.2317)	Reject	Accept
Lentils relative price	ρ_8	None	-	–	Accept
Mung bean & the rest*	ρ_9	None	-	–	Accept

Source: Research findings. The numbers in parentheses indicate significant level.
*: broad bean, split broad bean, sprouts of beans and other pulses relative price

Comparison of the test results of Hicks, Leontief, and GCCT show that there are differences in the grouping of pulses. As Davis (2003) pointed out, one of the reasons for this

could be the number of observations. In other words, the results of the study confirm Davis's finding that the GCCT does not guarantee proper aggregation of products when the number of observations is low. In these cases, Davis has proposed Bonferroni, Simes, Holm, and Hochberg procedures to increase the test capability of this theory.

Results of Single Aggregation Hypothesis Test of Sugar

A) Results of Leontief and Hicks's CCT for Sugar Products

Table 7 shows the results of Leontief and Hicks's CCT sugar products aggregation test using correlation matrix.

Results of Leontief's CCT test show that sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar cannot be aggregated in the same group. However, Hicks' CCT test on price of sugar cube and sugar products using correlation matrix show that sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar can be aggregated in the same group.

The result of the equality test of the ratio of sugar consumption (Table 8) indicates that the significance level is lower than 0.05 and H_0 is rejected; hence, sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar cannot be aggregated in the same group.

Table 7- Correlation matrix of sugar price and consumption amount

Leontief's CCT		
	Sugar cube products	Sugar
Sugar cube products	1	0.9
sugar	0.9	1
Hicks's CCT		
	Sugar cube products	Sugar
Sugar cube products	1	0.99
Sugar	0.99	1

References: Research findings.

Aggregation test of sugar cube products (sugar cube, sugar granule, artificial or diet sugar, powdered sugar) and sugar using Hicks's CCT show that the significance level of the results of price parity test is more than 0.05 and the H_0 of variance equality is retained; therefore, sugar cube products and sugar can be aggregated in the same group.

b) Lewbel's GCCT

Table 5 shows the results of stationary test (Augmented Dicky-Fuller test) on relative price of sugar cube products and relative price of sugar and price index of Sugar group. According to the results, there is no need for conducting any test for studying independence between sugar cube products relative price and price index of Sugar However, co-integration test proves to be appropriate for studying independence of relative price of sugar and price index of Sugar group. Accordingly, Engle–Granger cointegration test is used for studying cointegration of the variables and by taking into account the time variable, the results show the significance level (0.24) is higher than 0.1 (10%) which indicates the variables are not cointegrated and GCCT is accepted. Results of sugar cube products and sugar cointegration test for urban areas of Iran, using GCCT are shown in Table 9. According to the results, sugar cube products and sugar products can be aggregated in the same group.

Based on the results, using the method of equality of ratios or correlation matrix to test the Leontief's CCT or Hicks's CCT has no effect on creating differences as a result of grouping different types of sugar. However, the overall result of commodity grouping varies depending on the theory used, which is probably due to the focus of Hicks's CCT on prices and Leontief's CCT on quantities.

Table 8- Results of sugar consumption and price ratio Parity Test using Leontief and Hicks's CCT

Method	Leontief's CCT			Hicks's CCT		
	df	Value	Pro.	df	Value	Pro.
F-test	(11, 11)	3.47	0.050	(11, 11)	1.25	0.715
Siegel-Tukey		-0.029	0.977		0.32	0.750
Bartlett	1	3.83	0.050	1	0.13	0.715
Levene	(1, 22)	9.55	0.005	(1, 22)	0.28	0.599
Brown-Forsythe	(1, 22)	4.08	0.055	(1, 22)	0.25	0.619

References: Research findings.

Table 9- Results of Cointegration Test on Sugar Cube and Table Sugar products in urban areas of Iran Using GCCT

Variable		Type of Test	Cointegration Test		GCCT
			Tau-Statistic	Result	
Sugar (R_2)					
Sugar cube products	ρ_1	none	–	–	accept
Sugar	ρ_2	cointegration	-3.46 (0.24)	reject	accept

References: Research findings. The number in parenthesis indicate significant level.

Results of Multiple Aggregation Hypothesis Test

The probability value resulting from Engle – Granger co-integration test between relative price of each product and price index of the respective group and price index of other groups is considered in order to using multiple test methods and calculated p values are compared to FWER.

The FWER is chosen to be 0.10 to compensate for the low power of the cointegration tests (Davis, 2003; Shokoohi *et al.*, 2016). The results of Bonferroni, Holm, Hochberg and Simes procedures are presented and compared. Significance levels driven from Engle – Granger cointegration test are presented in Table 10.

Bonferroni Procedure

In this study, FWER values were calculated using Bonferroni procedure based on α=0.1 and N=2 which results shown in Table 12. According to multiple testing results driven from Bonferroni procedure, all calculated p values, ("mixed pea and bean" excluded), are higher than 0.05 and H_0 (indicating independence of relative prices of the products and price indices of two groups) is accepted. Indeed, except for "mixed pea and bean", not only all pulses can be aggregated in "Pulses" group but also all types of sugar can be aggregated under "Sugar" group.

Holm Procedure

Initially, p values (values driven from Engle–Granger cointegration test between relative price of each commodity and price index of the related group and price indices of the other groups) are calculated for each single hypothesis; then, the calculated values are ordered from smallest to larges (Table 11).

Critical values are demonstrated in Table 12. In this procedure, the lowest values are compared to highest critical value (0.1). In the first step of Holm procedure, as shown in the result, except for "mixed pea and bean" & "other beans", all calculated values are higher than 0.1 and hypothesis of independence between relative prices of split pea, kidney bean, soybean and sugar with price index of the groups is accepted. As for "mixed pea and bean" and "other beans", the next step must be taken and their values must be compared to the second critical value; indeed, values of "mixed pea and bean" and "other beans" which are respectively 0.231 and 0.453 must be compared to 0.05. Subsequently, the results show that independence hypothesis between relative price of the products and price index of the groups is accepted.

Hochberg Procedure

The Hochberg procedure uses the same criterion for each hypothesis as does the Holm procedure but tests hypotheses with larger p-values first. If any of the calculated p-values is less than their respective FWER, H_0 is rejected.

By considering significance levels provided in Table 11, it can be concluded that:

For sugar, calculated p-values are higher than the second FWER (0.1), the hypothesis of independence is accepted. Indeed, sugar cube products and sugar can be aggregated in "Sugar" generic group.

For all products except for "mixed pea and bean" which the first calculated value is higher than the first FWER (0.05), the hypothesis of

independence between relative price of products and price indices of the groups is accepted. Therefore, except for "mixed pea and bean", all pulses can be aggregated in "Pulses" generic group.

Comparison of the results shows that findings of Hochberg procedure are same as the findings of Bonferroni procedure.

Table 10- Results of Engle–Granger Cointegration Test (significance level)

ρ_i		Pulses Price Index(R_1)	Sugar Price Index(R_2)
Production	**Stationary**	**Stationary: I (1)**	**Stationary: I (1)**
Pea	I (0)	–	–
Split pea	I (1)	0.293	0.629
Pinto bean	I (0)	–	–
Kidney bean	I (1)	0.175	0.227
Other beans	I (1)	0.065	0.453
Soybean	I (1)	0.121	0.279
Mixed pea and bean	I (1)	0.231	0.039
Lentils	I (0)	–	–
Mung bean, the rest*	I (0)	–	–
Sugar cube products	I (0)	–	–
Sugar	I (1)	0.126	0.24

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Table 11- Significance level of Cointegration test in order from minimum to maximum

Production	**Probability Value**	
	Ordered p-value (R_1)	**Ordered p-value (R_2)**
Pea	No Comparison	No Comparison
Pinto bean	No Comparison	No Comparison
Lentils	No Comparison	No Comparison
Mung bean, the rest*	No Comparison	No Comparison
Sugar cube products	No Comparison	No Comparison
Mixed pea and bean	0.039	0.231
Other beans	0.065	0.453
Soybean	0.121	0.279
Sugar	0.126	0.24
Kidney bean	0.175	0.227
Split pea	0.293	0.629

References: Research findings. *: broad bean, split broad bean, Sprouts of beans and other pulses

Simes Procedure

The decision-making rule of this procedure is same as the Hochberg's and the only difference is in calculation of critical values. According to the results provided in Table 11 and Table 12, except for "mixed pea and bean" which the corresponding calculated p-value in the step one (R_1) is larger than FWER (0.05), the hypothesis of independency between relative price of other products and price indices of the groups is accepted. Therefore, "mixed pea and bean", cannot be aggregated in "Pulses" group. All calculated p values in step two (R_2) are higher than FWER(0.1), so the H_0 is accepted.

Therefore, sugar cube products and sugar can be aggregated under "Sugar" group. As it is evident, the results of Simes procedure are consistent with the results from Bonferroni and Hochberg procedures.

Table 12- Family-Wise Error Rate (FWER) values

Simes	Holm, and Hochberg	Bonferroni	Group Ordered
0.05	0.05	0.05	1
0.1	0.1	0.05	2

References: Research findings.

Conclusion and Recommendations

The general purpose of the this study was to investigate the possibility of aggregating the different types of pulses as well as types of sugar in groups called "Pulses" and "Sugar", respectively, using the single hypothesis test (Leontief Composite Commodity Theorem, Hicks Composite Commodity Theorem, and the Generalized Composite Commodity Theorem) and multiple hypothesis test (Bonferroni, Simes, Holm, and Hochberg methods) and comparing the results of different methods together. The following results were obtained:

Leontief's Composite Commodity Theorem: 1- It is not possible to aggregate the different types of pulses together. 2- It is not possible to aggregate the different types of sugar together.

Hicks's Composite Commodity Theorem: 1- It is possible to aggregate the different types of pulses together. 2- It is possible to aggregate the different types of sugar together.

Generalized Composite Commodity Theorem: 1- All types of pulses except "other beans" can be aggregated in one group called Pulses. 2- All of the types of sugar can be aggregated in a group called Sugar.

Bonferroni method: according to this method, aggregation types of pulses (except "mixed pea and bean") in the group of "Pulses" and types of sugar in the group of "Sugar" is possible.

Holm method: The results of this method showed that the hypothesis of independence between the relative prices of products and the price index of groups is accepted and the aggregation of types of pulses in the group of "pulses" and types of sugar in the group of "Sugar" is possible.

Hochberg method: The aggregation test based on this method indicates that the aggregation of different types of pulses except *for "mixed pea and bean"* in the "Pulses" group is possible and it is also possible to aggregate different types of sugar in the "Sugar" group. The result of this test is similar to the result of Bonferroni test.

Simes method: The study of aggregation of the studied products using the Simes method showed that it is not possible to aggregate "mixed pea and bean" in the group of Pulses. The result obtained in this method confirms the results of Bonferroni and Hochberg methods.

According to the results of the Bonferroni, Simes and Hochberg multiple hypothesis testing for types of pulses & sugar, are the same.

Based on the results of this study, the use of consumption values (according to Leontief's CCT) for grouping the products, offers different results. The use of product price values (according to Hicks's CCT, GCCT, multiple hypothesis testing) provides closer results. Moreover, using the single tests, and specifically the GCCT does not show exactly the same results, which is in line with Davis (2003) finding that the GCCT does not guarantee proper aggregation when the number of observations is low. In this case, the importance and necessity of performing the test of sufficient condition of aggregation using multiple tests (Bonferroni, Simes, Holm, and Hochberg methods) is emphasized. According to the research results, in studies on the consumers behavior of pulses including pea, split pea, pinto bean, kidney bean, other beans, soybean, mixed pea and bean, lintels, mung bean, broad bean, split bean, sprouts and other pulses in Iran's urban communities, considering all pulses except "mixed pea and bean" will provide reliable and compatible results. Among the possible reasons for not including "mixed pea and bean" in the group of Pulses, we can mention the existence of different types of beans (pinto bean, kidney bean, other beans) and pea in the group of Pulses. In other words, the presence of the main groups of these products in the group of Pulses has probably led to the non-inclusion of the mixture of these products in the group of Pulses.

Also, considering the different types of sugars including sugar cube, sugar granules, artificial or diet sugar, powdered sugar with the types of sugar in one group called "Sugar" in studying the behavior of urban consumers in Iran, will provide compatible results.

One of the important cases to provide more accurate results is the expansion of the study period along with increasing the number of studied product groups. In addition, it is suggested that in studding consumer behavior in order to increase

the validity of the results, in the aggregation test, in addition to using the single hypothesis test (Leontief Composite Commodity Theorem, Hicks Composite Commodity Theorem, and the Generalized Composite Commodity Theorem), multiple hypothesis tests (Bonferroni, Simes, Holm, and Hochberg methods) also be considered.

It should be noted that the rejection of aggregation between the relative price of each commodity (ρi) and the price index of its own group (Ri) provides only the necessary condition for GCCT and sufficient condition in this regard is to examine the hypothesis of independence between ρi and all price indices of other commodity groups using multiple hypothesis tests (Bonferroni, Simes, Holm, and Hochberg methods). The important point in this regard is the method of testing the sufficient condition for the aggregation of goods when data is low. Therefore, similar to the results of the study of Shokoohi *et al.* (2016), the results of the present study also emphasize the importance of not paying enough attention to the sufficient condition of goods aggregation and the number of observations can lead to incorrect aggregation of goods.

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مقاله پژوهشی

جلد ۳۶، شماره ۲، تابستان ۱۴۰۱، ص ۱۹۵-۱۸۳

مقایسه آزمون فرضیه انفرادی و چندگانه جمع‌پذیری انواع حبوبات و قند و شکر در مناطق شهری ایران

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چکیده

هدف کلی مطالعه حاضر، بررسی امکان تجمیع انواع حبوبات و همچنین انواع قند و شکر در گروه‌هایی به ترتیب با عنوان "حبوبات" و "قند و شکر" با بهره گیری از آزمون فرضیه انفرادی و چندگانه است. آزمون فرضیه انفرادی شامل قضیه کالای مرکب (لئونتیف و هیکس)، و قضیه کالای مرکب تعمیم یافته و آزمون فرضیه چندگانه شامل روش‌های بن فرونی، سیمز، هولم، و هاچبرگ می‌باشد. همچنین نتایج حاصل از روش‌های مذکور با هم مقایسه شده است. داده‌های مورد نیاز مطالعه از مرکز آمار ایران برای دوره ۱۳۸۵ تا ۱۳۹۷ اخذ گردید. نتایج آزمون‌های چندگانه بن فرونی، سیمز و هاچبرگ برای انواع حبوبات نشان داد که به استثنای " نخود و لوبیا مخلوط"، سایر محصولات در گروه حبوبات قرار می‌گیرند. همچنین بر اساس نتایج روش‌های بن فرونی، سیمز، هولم و هاچبرگ، انواع شکر و انواع قند در گروه قند و شکر قابل تجمیع می‌باشند. نتایج آزمون فرضیه انفرادی درخصوص انواع حبوبات و انواع قند و شکر، یکسان نیستند. به عبارت دیگر، بر اساس روش لئونتیف، فرضیه جمع‌سازی انواع حبوبات با یکدیگر تایید نشد در حالی که بر اساس روش کالای مرکب هیکس، این فرضیه مورد تایید قرار گرفت. به طور مشابه، بر اساس روش لئونتیف، فرضیه جمع‌سازی انواع قند و انواع شکر با یکدیگر رد شد در حالی که بر اساس روش کالای مرکب هیکس، این فرضیه مورد تایید قرار گرفت. نتایج آزمون فرضیه کالای مرکب تعمیم یافته نیز نشان داد که همه انواع حبوبات به جز "سایر انواع لوبیا"، قابل تجمیع در یک گروه تحت عنوان حبوبات می‌باشند. انواع قند و شکر نیز مطابق روش کالای مرکب تعمیم یافته قابل تجمیع در یک گروه تحت عنوان قند و شکر هستند. بر اساس نتایج، هنگامی که شمار مشاهدات کم باشد، استفاده از آزمون‌های انفرادی و به طور مشخص آزمون کالای مرکب تعمیم یافته، نتایج یکسانی را نشان نخواهند داد که این نتیجه تاییدی است بر یافته‌های دیویس (۲۰۰۳) مبنی بر اینکه آزمون کالای مرکب تعمیم یافته تضمین کننده تجمیع مناسب کالاها در زمان کم بودن تعداد مشاهده‌ها نیست. در این شرایط انجام آزمون‌های چندگانه نیز پیشنهاد می‌شود.

واژه‌های کلیدی: حبوبات، قند و شکر، مرکب‌سازی تعمیم یافته

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Investigating the Factors Affecting Fast Food Consumption Level: Case Study, Mashhad, Iran

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Abstract

Due to increase of consumption of fast foods in Iran, the factors affecting the consumption level of sausages, salami and hamburgers have been investigated in this study. For this purpose, we investigated the probability of each household being in groups of non-consumption, low consumption, medium consumption and high consumption using an ordered logit model and data of 396 households of Mashhad, in 2020. The results of the ordered logit model indicated that variables such as price, income, consumption of other meats and education level of consumers do not have a statistically significant effect on the level of consumption of prepared meat products. While variables such as awareness of the existence and effects of nitrite, information about cheating in the product and awareness about the materials used in the ready-made foods have a negative and significant effect on the probability of consuming these kinds of foods. Accessibility of households to the fast foods and households' trust in the producers also have a positive effect on the likelihood of consuming the ready-to-eat meat products under question. Regarding the importance of controlling fast food consumption in society, we concluded that improving awareness of consumers about the properties of fast foods and their consequences effects on health could be considered as an important tool to control fast food consumption

Keywords: Fast food products, Ordered Logit model, Marketing

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Introduction

Today, with development of societies, the life style has changed and this issue has led to the weakening of indigenous traditions and customs and cultures, including nutrition and food customs and behaviors, and in the meantime, people tend to use fast-food products (Bowman and Vinyard, 2004). Fast foods are those that are quick and easy to prepare and include a variety of sandwiches, burgers, cheeseburgers, fried chicken and shrimp, hot dogs, French fries, chicken nuggets, pizzas, sausages and hot dogs. Of course, many nutritionists consider fast food to be harmful to health due to its high calorie and trans fatty acids, and the presence of sodium and potassium nitrate compounds of them (Kamkar *et al*, 2003; Nazari and Sarrafzadega, 2009). Initially, Becker's (1984) theory can be used to analyze the behavior of fast food consumers. According to this theory, the household is considered as an economic unit with two roles of consumer-producer, in the role of the consumer they try to increase their utility, and in the role of the producer, they produce some goods which meet their needs optimally. Becker considers a pattern of household behavior in which the opportunity cost to prepare food at home includes the price of food, energy, the value of time to prepare food, and all activities after eating, such as washing dishes and disposing of garbage. Based on these factors, the family decides whether to pay the opportunity cost or prepare fast food. The decision in this regard depends on various economic, social and demographic factors of households. Prices, incomes, opportunity costs, time constraints and some demographic characteristics such as age, gender, place of residence, race, level of education and household size are the most important factors (Sadeghi *et al*., 2010, Pereira *et al*., 2005, Gould and villareal 2006, and Bai, 2010). Of course, some households consider eating fast food as a kind of entertainment that is directly related to their income level (Long, 1997). Households also spend more time on fast food when their jobs and occupations require them to spend more time outside the home, especially as women's employment rates increase (McCracken and Brandt, 1987). In addition, the number of people in a household can affect these costs, so that the larger the household, the more economical it is to prepare foods at home, which makes single-person or double-family households less likely to have opportunity compared to large households, so these households spend more on fast foods (Long, 1997; Gould and Villareal 2006). In addition, households with younger members are more likely to consume fast foods than households with higher average ages (Sampaio *et al*., 2004).

Experimental studies have confirmed the effect of consumers' level of awareness about fast foods and their ingredients in creating a positive or negative attitude towards the purchase and consumption of these foods. Most studies have shown that fast food consumers have inaccurate or inadequate information about these foods. However, the group that felt sufficient information had a negative attitude toward the consumption of processed foods and their consumption was lower than the group that had insufficient information (Kim *et al*., 2007; Aoki *et al*., 2010).

Sausages, burgers and salami are among the most popular meat products that are consumed by millions of consumers around the world (Sadeghi *et al*., 2010). In Iran, the consumption of these products due to their cost-effectiveness compared to buying white or red meat, ease of cooking and the desirable taste of traditional food has a growing trend. The average per capita consumption of these products in Iran is estimated at one and a half kilograms per year (Prochaska and Schrimper 1973). In one study, it was found that the priority of Iranian households in choosing sausages, burgers and salami, is compliance with health standards and good taste. The results showed that the importance of healthy products for consumers is high, the importance of good taste and fast preparation is relatively high, and the importance of reasonable price is low and relatively low. Also, the main consumers of these products are between 19 and 31 years old, and the most purchases in this group are made by mothers, and the children are the most interested in sausages, burgers and salami in the family, and they have the greatest impact on their purchases (Hassan Gholipour, 2007).

Some studies also showed that the highest age group of fast food consumers were young, single and students, which indicates that young people do not have the necessary experience and knowledge about healthy eating and they have less care about their health and as a result, fast food consumption among them is high. However, as people get older, their experience, awareness and understanding of danger increase and they pay more attention to their health. Of course, in addition to age, advertising and education level have also been effective in consuming fast foods (Fazelpour *et al*.,

2010; Fatehi Panah *et al.*, 2015; Stewart *et al.*, 2006).

In another study, the effect of various factors such as age group, education level, ethnicity, marital status, the level of mother's education, mother's job, participation in a nutrition education class, students' knowledge and attitude on fast food consumption was investigated. Among these factors, students' knowledge, attitude and ethnicity were identified as effective factors in adopting fast food consumption behavior. Also, the existence of an inverse relationship between awareness and behavior was confirmed, so that people with moderate or low awareness were more inclined to consume fast foods (Didarloo, 2018). In this regard, another study identified people's attitudes and beliefs as the strongest predictors of behavioral intention for fast food consumption; so, people with moderate to high attitude scores compared to others, were more inclined to consume these foods (Tehrani, 2019).

Considering the factors affecting the consumption of fast food products is important because by identifying these factors, we can plan and take action to increase or decrease their consumption trend in society according to the concept of social marketing, and also reduce the harm of consumption of these products. On the one hand, consumers can be informed about the consequences of consuming these products, and on the other hand, producers can be encouraged to comply with the main production standards. In this regard, the main purpose of this study is to investigate the factors affecting the consumption of fast foods (sausages, salami, hamburgers) in order to identify the extent and severity of these factors in changing the consumption of these products.

Methodology

This study examines the factors affecting the level of consumption of fast food products by consumers in Mashhad, Iran. For this purpose, we studied consumers of these products in Mashhad across 13 municipal regions. The sampling was a stratified random sampling method. The required data were collected by filling a questionnaire in 2020. In order to determine the number of samples, a pre-study was conducted and the first 50 households were randomly selected and questioned and the information obtained from this sample was used to determine the sample size of the whole sample. The total sample size was 396 households, and the required models were estimated using STATA 16 software.

The dependent variable in this study is the level of consumption of fast food products as a qualitative variable in 4 categories including no consumption, low consumption or monthly consumption less than 0.5 kg, average consumption or monthly consumption between 0.5 to 1 kg and high consumption or monthly consumption more than 1 kg per month. It should be noted that the classification of the dependent variable is done according to the average sample consumption and its standard deviation. Due to the qualitative nature of the dependent variable, ordered logit or ordered probit regression models should be used to investigate the effect of independent variables effect on the probability of dependent variable. The ordered logit model is based on a continuous latent variable (Long, 1997) and its model is defined as equation (1):

$$y_i^* = \beta' x_i + \varepsilon_i \ , \quad -\infty < y_i^* < +\infty \qquad (1)$$

In equation (1), y_i^* is the continuous variable of consumption of the products, β' is the vector of parameters that should be estimated, and x_i is the vector of non-random explanatory variables that measures the $i$is households characteristics.ε_i is also an error term that has a logistic distribution. y_i^* is an invisible variable and therefore we cannot estimate equation (1) by conventional regression methods. But if we assume that it is a discrete and observable variable y_i that represents different levels of household $i$thconsumption, the relationship between the invisible y_i^*variable and the observable y_i variable is obtained from the ordered logit model as follows:

$$\begin{aligned} y_i = 1 \quad if \quad -\infty < y_i^* < \mu_1, \quad & i = 1, \dots, n, \\ y_i = 2 \quad if \quad \mu_1 < y_i^* < \mu_2, \quad & i = 1, \dots, n, \\ y_i = \mathrm{j} \quad if \quad \mu_3 < y_i^* < +\infty, \quad & i = 1, \dots, n, \end{aligned} \qquad (2)$$

n is the size of the sample.

μ's are thresholds that define the observed responses and should be estimated (14). The probability that $y_i = J$ is calculated by the equation (3).

$$pr(y_i = J) = pr\left(y_i \geq \mu_{J-1}\right) = pr(\varepsilon_i \geq \mu_{n-1} - \beta' x_i) = F(\beta' x_i - \mu_{J-1}) \qquad (3)$$

In terms of cumulative probability, the ordered logit model estimates the probability that the household i occupies the level j or lower levels of $(j-1, \dots, 1)$. Unlike the multinomial logit model,

the response groups in the ordered logit model, represent sequential levels among themselves. The ordered logit model is specified as relation (4).

$$\log\left[\frac{\gamma_i(x_i)}{1-\gamma_j(x_i)}\right] = \mu_j - [\beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki}] \quad (4)$$

Here γ_j is the cumulative probability calculated as follows:

$$\gamma_j(x_i) = \gamma(\mu_j - \acute{\beta} x_i) = P((y_i \le j|x_i) \quad (5)$$

β is a vector of the parameters and the x_i is a vector of the explanatory variables.$\mu_j$also depends only on the probability of the prediction class and does not depend on explanatory variables.

The parallel regression test is used to test the null hypothesis on equality of all parameters across groups. The marginal effect of a unit change in the x_k predictor on the probability of class j is calculated as follows (Long, 1997):

$$\frac{\partial P(y_i = j|x_i)}{\partial x_k} = \left[\frac{\partial \gamma(\mu_j - \acute{\beta} x_i)}{\partial x_k} - \frac{\partial \gamma(\mu_{j-1} - \acute{\beta} x_i)}{\partial x_k}\right] = [\lambda(\mu_{j-1} - \acute{\beta} x_i) - \lambda(\mu_j - \acute{\beta} x_i)]\beta_k$$

where:

$$\mu_j = +\infty\,, \mu_o = -\infty\,, \lambda_j(x_i) = \frac{\partial \gamma_i(x_i)}{\partial x_k}$$

Given that the marginal effect depends on the values of all explanatory variables, the decision to use the values of the variables in the estimation is important. Usually the marginal effect is calculated on the mean values of variables. Given that the sum of the probabilities is always equal to one, the sum of the marginal effects for each variable will be zero.

Results and Discussion

Based on the theoretical foundations, the important variables affecting the level of fast food consumption products that were used in this study are: The gender variable that reflects the gender of the head of the household, Education (head of household), income (household), awareness of the existence and properties of nitrate, knowledge of the composition of ready-made meat products, information about fraud and its methods, consumer satisfaction index of these products, consumer confidence index of production and the employment status of the head of the household, each of them is classified into three groups. Table 1 lists the independent variables used in the research and their classes along with their expected sign.

Table 1- Description of the variables

Variable	Description	The expected sign
Gender	(Female=0 , male=1)	−/+
Education	Under diploma=1 , diploma to bachelor=1, master's degree to Ph.D. =3	−/+
Income(in million Rials)	(1:< 50 ; 2: 50-100 ; 3: >100)	+/−
Awareness of nitrate harm	(Low=1 , medium=2 , high=3)	−
Awareness of product compositions	(Low=1 , medium=2 , high=3)	−
Awareness of fraud	(Low=1 , medium=2 , high=3)	−
Consumption of other meats	Consumption per month(kg)	+/−
Consumer satisfaction index	(Low=1 , medium=2 , high=3)	+
Trust index	(Low=1 , medium=2 , high=3)	+
Job	(Governmental=1 , private=2 , other=3)	+/−

into 4 groups, shows that more than 30% of respondents have a high level of consumption of these products (Table 2).

A descriptive study of the questionnaire data on the level of consumption of fast food products (sausages, salami, hamburgers) which aredivided

Table 2- Consumption of fast food products

Consumption of fast food products	Frequency	Percent
No consumption	62	15.6
Low consumption (<0.5kg)	115	29
Medium consumption (0.5-1kg)	98	24.7
High consumption (>1kg)	121	30.7
Total	396	100

Also, the level of consumption of these products by households according to the research variables listed in Table 3, shows that; first, the largest group of fast food consumers were younger than 30 years old, which was indicated in previous studies. Second, people with lower incomes consumed more, which can be attributed to the effect of substitution; Third, the consumption of these products in other occupational groups, which includes students and freelancers, is higher than other groups, which seems to be due to lack of time; Fourth, people with lower education consume more food, which seems to be due to lack of awareness, and Fifth, men consume more fast foods than women; Which can be related to the lack of time and cooking skills.

Table 3- fast food consumption percent according to selected variables of the study

Variable	Category	Consumption(percent)				Total(percent)
		High	Medium	Low	None	
Age	<30	73(33.6)	49(22.6)	61(28.1)	34(15.7)	217(100)
	30-50	42(26)	46(28.4)	48(29.6)	26(16)	162(100)
	>50	6(35.2)	3(17.6)	6(35.2)	2(12)	17(100)
Income	<50 million Rials	70(31.5)	49(22)	66(29.5)	39(17)	(١٠٠)٢٢٤
	50-10 million Rials	47(30)	47(30)	42(27)	20(13)	156(100)
	>100 million Rials	4(25)	2(12)	7(44)	3(19)	16(100)
Job	Governmental	40(25.3)	36(22.8)	60(38)	22(13.9)	158(100)
	Private	38(31.4)	29(24)	28(23.1)	26(21.5)	121(100)
	Other	43(36.7)	33(28.2)	27(23)	14(11.9)	117(100)
Education	Under diploma	15(34.1)	11(25)	11(25)	7(15.9)	44(100)
	Diploma to Bachelor	98(30.2)	81(24.8)	98(30)	49(15)	326(100)
	Master's and Ph.D.	8(31)	6(23)	6(23)	6(23)	26(100)
Gender	Male	94(31.6)	75(25.1)	86(28.9)	43(14.4)	298(100)
	Female	27(27.5)	23(23.5)	29(29.6)	19(19.4)	98(100)

Table 4 presents the estimation results of the ordered logit model. Regarding the nominal nature of the job variable, the method of dummy variables has been used, so that the government job is considered the basic group and other groups (private = 2 and others = 3) are ranked based on it.

As shown in Table 4, the variables of trust, easy access and the type of job have a positive effect on the level of consumption of fast food products. In other words, an increase in these independent variables increases the likelihood that the household will be at higher levels of product consumption. The more consumers' confidence in producers and production methods, the higher their level of consumption of these products, and these results are according to the expectations. Therefore, trying to gain the trust of consumers by moving towards improving the quality of products and production at the level of global standards can be helpful in this regard. Increasing access to food products also has a positive effect on consumption. Therefore, one of the tools to increase or decrease the level of consumption of these products is to increase or decrease the level of consumer access to them. Restricting the supply of fast food products to authorized retailers or protein supply centers can limit consumers' access to these products and thus affect consumption.

In the case of jobs, the results also show that other occupations, including workers, the unemployed, students, and so on, have a higher consumption of fast foods than the basic group (government jobs).

Table 4- Results of ordered logit model estimation

Variable	Coefficient	Std. error	Z statistic	Prob.
Gender	۰.۱۵۵	۰.۲۲۸	0.68	0.496
Education	۰.۰۱۸	۰.۲۴۴	0.08	0.938
Income	0.195	0.186	1.05	0.293
Awareness of nitrate harm	-0.291**	0.142	-2.04	0.041
Awareness of product compositions	-0.010*	0.006	-1.62	0.10
Awareness of fraud	-0.274**	0.129	-2.13	0.034
Consumption of other meats	0.016	0.075	0.22	0.826
Accessibility	0.265**	0.103	2.55	0.01
Price	-0.006	0.971	-0.06	0.949
Trust index	0.023***	0.007	3.28	0.001
Job:				
Private=2	0.061	0.232	0.27	0.790
Other jobs=3	0.474**	0.251	1.89	0.05
Age	-0.065	0.175	-0.38	0.707
Cut1	0.35	0.161		
Cut2	1.9	0.85		
Cut3	3.07	1.26		
Pseudo R-Square				
Cox-Snell/ML		0.11		
Nagel-Kerke		0.12		
McFadden(adjusted)		0.04		

*** represents significant level at 1%.
** represents significant level at 5% .
* represents significant level at 10%.

Higher living standards for public and private employees and their preference for home-cooked meals can be one of the reasons for this result. Also, based on the results of Table 4, the variables of awareness of the existence and effects of nitrate, information about the existence of fraud and its methods, as well as knowledge of the composition of prepared meat products, affect the probability of consumption of these products in the opposite direction. In other words, increasing the levels of these independent variables reduces the likelihood of consuming fast food products in the household. Consumption of other types of meat, prices of fast food products, education of the head of the household and household income did not have a significant effect on the probability of consuming fast food products.

Based on the R^2_{Pseudo} statistics calculated in Table (4), it can be said that the estimated ordered logit model has a good level of fit. In addition, as mentioned earlier, parallel regressions evaluate the parameter equality hypothesis for all groups. The results of the mentioned test are presented in Table 5, which indicates that the hypothesis of equality of parameters for all groups in the estimated model is logical. Considering the significance level of the χ^2 statistic of the parallel regression test, it can be assumed that the value of the status parameters is the same for all response groups, and therefore in this respect the estimation of the logit model is correct.

The results of the Pearson and Deviance tests with the null hypothesis of a good fit of the data by the present model are also reported in Table 6, so the computational chi-square statistic indicates the accuracy of the null hypothesis.

Table 5- Results of parallel regression test

Model	2Log Likelihood	Chi- square statistic	Prob.
Null hypothesis(present model)	۱۰۲۵/۸۳۱	۳۰/۴۷۳	0.25
Alternative hypothesis	۹۹۵/۳۵۷		

Table 6- Fits of goodness indicators

Statistic	StatisticChi- Square	Prob.
Pearson	1195.012	0.3
Deviance	1025.831	1.000

Due to the significant level of computational chi-square of this test, the data in this model are properly fitted, so according to the test results, the estimated model is sufficiently reliable and the results of this model are assured.

Since the signs of the estimated coefficients can only be used in relation to the probability of low or high consumption of households, so in order to make more use of the results of the estimated model, the marginal effects for each consumption group should be calculated. In this regard, the marginal effects for each of the consumer groups have been calculated and the results are presented in Table 7. Based on the results of this table, it can be said that the probability of households being less aware of the presence of nitrate and its effect on health is increased in the groups of non-consumption and low consumption, and on the other hand, the probability of being inmedium consumption and high consumption groups are reduced.

Table 7- Calculation of marginal effects for different groups of fast food products

Variable	Marginal effect model(1) Consumption: none	Marginal effect model(2) Consumption: <0.5kg	Marginal effect model(3) Consumption: 0.5-1 kg	Marginal effect model(4) Consumption: >1 kg
Gender	-0.0191	-0.0192	0.0070	0.0313
Education	-0.0022	-0.0024	0.0007	0.0039
Income	-0.0233	-0.0248	0.0080	0.0401
Awareness of nitrate	0.0349	0.0370	-0.0119	0.0600
Awareness of product compositions	0.0012	0.0012	-0.0004	-0.0020
Awareness of fraud	0.0328	0.0348	-0.0112	-0.0564
Consumption of other meats	-0.0019	-0.0021	0.0006	0.0034
Accessibility	-0.0317	-0.0337	0.0109	0.0545
Price	0.0007	0.0008	-0.0003	-0.0012
Trust index	-0.0028	-0.0029	0.0009	0.0048
Job	-0.0073	-0.0079	0.0025	0.0127
	-0.0530	-0.0619	0.0138	0.1011
Age	0.0078	0.0083	-0.0026	-0.0135

These results also show that households whose jobs are free (other) are less likely to be in the non-consumption and low-consumption groups than in government jobs, and on the other hand, they are more likely to be in the middle-consumption and high-consumption groups.Freelancers are often forced to eat ready-made meals due to their job position and the lack of a clear daily schedule.

In addition, it can be said that with the increase of households' awareness of the existence of fraud and its methods, the probability of these households being in the low consumption or non-consumption group has increased and on the other hand, the probability of being in the high and very high consumption groupis reduced.The same interpretation can be said about the variable of recognizing the compounds of these products.The more households know about the ingredients of ready-to-eat meat products, the more likely they are to be in the low-consumption group.

Other results indicate that the higher the household access to fast food products, the lower the probability of their being in the non-consumption and low consumption groups and the higher the probability of their being in the medium and high consumption groups.In addition, households that have more confidence in ready-to-eat meat products are less likely to be in the non-consumption and low-consumption groups, and on the other hand, this leads to an increase in the probability of households being in the middle consumption and high consumption groups.

Contrary to the expectations, the consumption of other types of meat and also the price of red or white meat has not had a significant effect on the consumption of ready-made meat products, and therefore to change the consumption of these products, changing the price of their substitutes like other types of meat is not appropriate. In addition, household income has not had an effect on the consumption of fast food products, which seems to be the reason that ready-made meat products are available in different grades, different qualities and at different prices in the market, and most households with different incomes can buy and consume a variety of these products, and therefore income does not affect the consumption of these products.

Summaries and Suggestions

Ready-made meat products such as sausages, salami and hamburgers are among the most widely consumed products in the food industry in Iran. High consumption of these products is harmful to health and a number of fundamental improvements should be made in their production and consumption.Therefore, identifying important and effective factors on the level of consumption of fast food products is an important issue in this study, using the logit model, an attempt was made to model the factors affecting the probability of consumption of these products.

The results of fitting the ordered logit model indicate that contrary to the expectations, some important variables such as price, household income and meat prices did not have a significant effect on the level of consumption of ready-made meat products. It seems that the supply of ready-made meat products at various prices and with different qualities (good and bad, depending on the types of compounds added to these products and the percentage and the type of meat) is the main reason for these results, and so the consumer with any level of income can buy and consume a variety of these products.

However, the variables of consumer confidence in the manufacturer and the level of access to these products have a positive effect on the probability of consumption of fast food products. So that the more consumer confidence in the units of production and supply of ready-made meat products, or the more access to these products in the community, the more likely they are to be consumed.In addition, compared to the group of employees, freelancers (others) like workers are more likely to consume ready-to-eat food products.

It is noteworthy that the variables of awareness of the existence and effects of nitrite, knowledge of fraudulent methods in production and recognition of ingredients of ready-made meat products have a negative and significant effect on the level of consumption of these products. Therefore, if the goal of policymakers in the field of health and nutrition in society is to use social marketing tools to control and even reduce the consumption of fast food products, they can act with these tools to reduce consumption. Moreover, they can inform the existence and the properties of nitrite and its harmful effects on the body, as well as the possibility and methods of fraud in production and trying to identify the composition of ready-to-eat meat products for consumers through mass media and by these tools they can control the level of consumption of these foods in society and reduce the potential harm to people in terms of nutrition.

On the other hand, with accurate and targeted information, producers can be led to produce healthier products with high nutritional value. It is also suggested that with more supervision of health officials and relevant institutions, producers are forced to enter complete information about ready-made food products in terms of type and amount of ingredients of these products to control the level of consumption.

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بررسی عوامل موثر بر سطح مصرف فرآورده‌های گوشتی آماده در شهر مشهد

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چکیده

با توجه به افزایش مصرف فرآورده‌های غذایی آماده در کشور، در این مطالعه عوامل موثر بر سطح مصرف فراورده‌های غذایی آماده از جمله سوسیس، کالباس و همبرگر مورد بررسی قرار گرفته است. به منظور بررسی عوامل موثر بر سطح مصرف فرآورده‌های غذایی آماده و هم چنین نحوه تاثیر هر عامل بر احتمال قرار گرفتن هر خانوار در چهار گروه عدم مصرف، مصرف کم، مصرف متوسط و مصرف زیاد، الگوی لاجیت ترتیبی و اطلاعات ۳۹۶ خانوار شهر مشهد در سال ۱۳۹۹ به کار گرفته شد. نتایج مدل لاجیت ترتیبی حاکی از آن است که متغیرهای قیمت، درآمد، مصرف سایر گوشت‌ها و تحصیلات مصرف کننده از لحاظ آماری اثر معناداری روی سطح مصرف فراورده‌های گوشتی آماده مورد بررسی ندارند و متغیرهایی چون آگاهی از وجود و اثرات نیتریت، اطلاع از تقلب و شیوه‌های آن و شناخت ترکیبات فراورده‌های غذایی آماده دارای اثر منفی و معنادار روی احتمال مصرف این فراورده‌ها است. میزان دسترسی خانوارها به فراورده‌های غذایی آماده مورد بررسی و اعتماد خانوارها به تولیدکنندگان نیز روی احتمال مصرف فراورده‌های گوشتی آماده تحت بررسی، اثر مثبت برجای می‌گذارد. از این رو اگر هدف سیاست‌گذاران حوزه تغذیه و بهداشت در جامعه کنترل و تغییر مصرف فراورده‌های گوشتی آماده است، می‌توان از ابزارهایی از جمله تغییر در میزان دسترسی خانوارها به این فراورده‌ها بهره گرفت. همچنین با اطلاع‌رسانی از وجود و خواص نیتریت و اثرات آن و نیز با تلاش برای شناساندن ترکیبات فراورده‌های گوشتی آماده برای مصرف‌کنندگان، می‌توان مصرف این مواد غذایی را در جامعه کنترل کرد و از این مسیر آسیب‌های احتمالی را در حوزه تغذیه کمتر ساخت.

واژه‌های کلیدی: الگوی لاجیت ترتیبی، بازاریابی اجتماعی، فراورده‌های غذایی آماده، مصرف

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