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An Econometric Model-Based Projection of Nigeria's Rice Self-Sufficiency

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Abstract

Motivated by Nigeria's persistent pursuit of rice self-sufficiency, this paper projects the country's future rice self-sufficiency levels. These projections could guide policy decisions in areas of the rice market that show potential for growth, aiding in the achievement of Nigeria's goal through improved planning strategies. Using time series data covering the period from 1980 to 2018, this study adopted an econometric technique to model Nigeria's rice market which was estimated using a dynamic Autoregressive Distributed Lag (ARDL) approach. The results revealed that paddy producer price elasticity was 0.206 and had no influence on paddy area harvested. On the other hand, the national policy of rice credit guarantee scheme variable displayed a positive relationship with paddy area harvested. Lagged yield and lagged area harvested had positive influences on yield and area harvested, respectively. This could mean that paddy producers were motivated by previous year's yield levels and area harvested. The demand own-price elasticity of rice was -0.321 and its cross-price elasticity was 0.193, with wheat revealed to be a substitute. The obtained elasticities were then used to make a ten-year projection. Results suggested that by 2028, increasing rice production relative to dwindling imports will boost rice self-sufficiency level to 71%. However, the average yearly rice self-sufficiency level was 53%, requiring 3.85 million Mt of rice imports. The projections revealed that Nigeria will not achieve rice self-sufficiency by 2028 unless intensive yield enhancing policy-supporting efforts are pursued.

Keywords: Autoregressive distributed lag, Elasticities, Projection, Rice, Self-sufficiency

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Introduction

In Nigeria, annual rice consumption per capita in 2021 was estimated at 33.35 kg (FAOSTAT Online database), making it an important national staple. With a growth rate of 5.3% between 2007 and 2018, the country's regional consumption was estimated to be 20.74% of Sub-Saharan Africa (USDA PSD Online database). Within the same decade, the country's rice supply was estimated at 8735 thousand Mt (USDA PSD Online database). This figure included import volumes of 2133 000 Mt (24%) as the country is incapable of satisfying the demand with domestic supply, which has costed it huge import bills over the years. According to KPMG (2019), Nigeria spends approximately US$5 million daily on rice imports which is expected to increase because the Nigeria's rice outlook for the 2019–2028 period shows rice imports are expected to reach 5274.73 thousand Mt, and world rice prices are expected to increase by 5.15% to US$470 Mt^{-1} by 2028 from 2018 (OECD/FAO, 2019). These unfavorable import dependence and bleak forecast incited a renewed policy directive of pursuing self-sufficiency in rice since 2005 and have been fostered by various government regimes at both federal and state levels. Nevertheless, the self-sufficiency level (SSL) of 64% in 2018 puts the successes of these policies/projects/programs into question. Under the existing circumstances, the inability of the country to achieve its policy goal of self-sufficiency in rice might be related to a lack of information supported by empirical evidence on the capability of the country to reach self-sufficiency in rice in the first place. As supported by Kholikova (2020), such information is considered a key factor in the successful development of an industry (Kholikova, 2020) and this is true for Nigeria's rice industry.

Agricultural policy analysts have benefited from considerable advances in forecasting/projection over the past decades. With particular reference to agricultural commodity markets, forecasting serves to not only provide relevant information on agricultural commodities in advance, which decision-makers rely on but also reduces uncertainties and risks in agricultural markets (Wang, Yue, & Wei, 2017).

The food self-sufficiency (FSS) agenda pursued by many countries has inspired a large collection of studies on the topic, focusing on a variety of different aspects including forecasting. Studies adopting econometric techniques are motivated by interests in predicting self-sufficiency while considering influencing factors like levels of input use, climate change and policies, as can be found in the works of Kurnia and Iskandar (2019), Hudoyo *et al*. (2016) and Seng *et al*. (2017). The gaol of this study was substantiated by the argument that projecting the country's rice self-sufficiency level and its associated parameters serves in understanding the dynamics of the country's rice market which could facilitate national policy formulations. Hence, a key question is whether Nigeria can be self-sufficient in rice given its current market environment. In this regard, this study sought to project Nigeria's rice SSL using an econometric approach.

Methodology

Data Source

The dataset for this study spanned 38 years, from 1980 to 2018. Data on paddy/rice production, consumption and population were obtained from the International Rice Research Institute (IRRI) online database, retail prices of rice and wheat were obtained from FAO'S FPMA online database, various issues of Nigeria's National Bureau of Statistics Annual abstract of statistic and various issues of Central Bank of Nigeria's statistical bulletin, paddy producer price were sourced from FAOSTAT online database, data on Gross National Income per Capita was retrieved from Central Bank of Nigeria database, and Nigeria's currency exchange rate, as well as the world price of rice, were retrieved from UN Comtrade online database.

Conceptual Framework of Nigeria's Rice Model

This study adopts a commodity market approach based on the concepts proposed by Labys (1973). A simple commodity market model for a non-storable product is a multi-equation market equilibrium formulation consisting of three main components - demand, supply, and price (Labys, 2003). As this market model approach relates to a single economic sector (Labys, 2003), it lends itself well to FSS analysis. Therefore, drawing inspiration from the conceptual framework established by Labys (1973) with modifications by Shamsudin (2008), the Nigeria rice market was modelled, based on available data. The model, depicted in Fig. 1 comprised of the demand, the supply and the price components. The rice market price was determined based on the market clearing condition which equates the total supply of rice to its total demand.

The Econometric Model

Following FAO's definition, the country's rice self-sufficiency is calculated as the ratio (in percentage) of domestic rice production to domestic rice demand. The model developed by Abdulsalam *et al*. (2021) consisted of four structural equations and five identities as presented in Table 1.

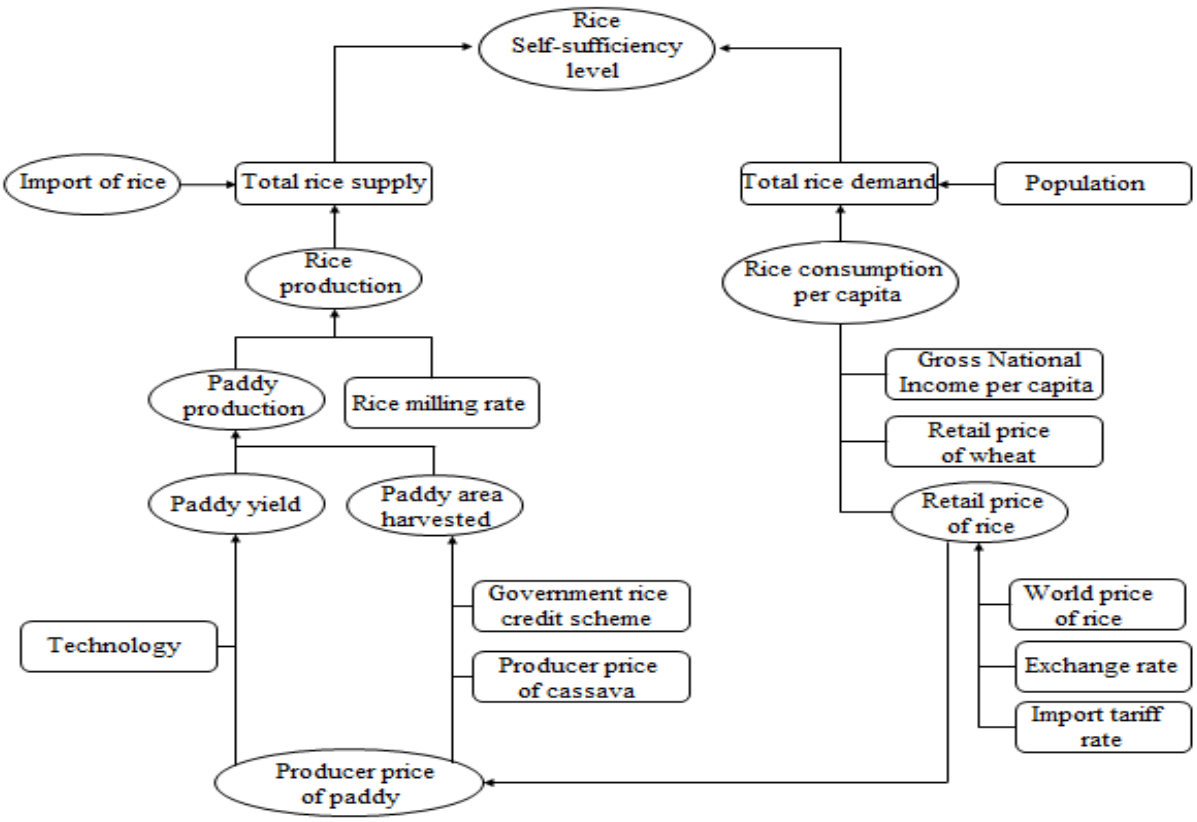

Figure 1- Conceptual framework of Nigeria's rice market

Table 1- The Nigeria's rice market model specification

S/N0	Equation
Supply	
[1]	$PYAH_t = f(PYAH_{t-1}, PYPP_{t-1}, CVPP_{t-1}, CGSF_{t-1})$
[2]	$PYYD_t = f(PYYD_{t-1}, PYPP_{t-1}, TREND_t)$
[3]	$PYPN_t = PYYD_t * PYAH_t$
[4]	$REPN_t = PYPN_t * PYMR_t$
[5]	$REIM_t = NTRD_t - REPN_t$
	Demand
[6]	$REPC_t = f(REPC_{t-1}, RERP_t, WTRP_t, GNIPC_t)$
[7]	$NTRD_t = REPC_t * POP_t$
	Price
[8]	$RERP_t = [REWP_t (1 + REIT)] * EXRT_t$
[9]	$PYPP_t = (PYPP_{t-1}, RERP_t)$
	SSL
[10]	REPN x 100 / (REPN + REIM)

Definitions of Variables
$PYAH_t$: Paddy Area Harvested in Hectares
$PYYD_t$: Paddy Yield in Mt ha^1
$PYPN_t$: Paddy Production in Mt
$REPN_t$:Rice Production in Mt
$PYPP_t$:Paddy Producer Price in ₦ Mt^{-1}
$CVPP_{t-1}$: Cassava Producer Price in ₦ M^{-1}
$GCSF_{t-1}$: Government Rice Credit Guarantee Scheme Fund in '000 ₦
$TREND_t$: Time Trend as a proxy of technology change
$PYMR_t$: Milling Rate of Paddy in %
$REIM_t$: Rice Import in Mt
$NTRD_t$: Total Rice Demand in Mt
$REPC_t$:Per Capita Domestic Demand of Rice in Kg $Capita^{-1}$
$RERP_t$: Retail Price of Rice in ₦ Mt^{-1}
$WTRP_t$:Retail Price of Wheat in ₦ Mt^{-1}
$GNIPC_t$:Gross National Income per Capita in '000 ₦
POP_t : Population in Millions
$REWP_t$: World Price of Rice in US$ Mt^{-1}
REIT : Rice import tariff in percent
$EXRT_t$: Nigerian Currency Exchange Rate in ₦ $US\$^{-1}$

Model Estimation

In the estimation phase of this analysis, an autoregressive distributed lag (ARDL) approach was adopted due to some advantages it possesses such as its applicability to variables of mixed or single order of integration. The ARDL modelling approach had the following structure: -

$$y_t = \alpha + \beta x_t + \delta z_t + e_t \quad (1)$$

the error correction version of the ARDL model is given by: -

$$\Delta y_t = \alpha_0 + \sum_{i-1}^{p} \beta_i \Delta y_t + \sum_{i-1}^{p} \delta_i \Delta x_i + \sum_{i-1}^{p} \varepsilon_i \Delta z_{t-1} + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + \lambda_3 z_{t-1} + \mu_t \quad (2)$$

the first part of the equation with β, δ and ε represents the short-run dynamics of the model. The second part with λs represents the long-run relationship. The null hypothesis in the equation is $\lambda_1 + \lambda_2 + \lambda_3 = 0$, which means the non-existence of long-run relationship.

Model Validation

The basic concept of model reliability is to identify models that effectively explain the past behavior of the time series variable under consideration. Two common approaches are often used: a graphical method, where line graphs of actual data are compared against the model's predicted values, and a statistical approach, which involves conducting a series of tests on the model. In this study, both approaches were adopted using four statistical measures namely Mean Absolute Error (*MAE*), Mean Absolute Percent Error (*MAPE*), Root Mean Square Percent Error and Theil's inequality coefficients (U) (Pindyck &

Rubinfeld, 1998). These quantities measure the differences between the actual values in the time series and the predicted or fitted values generated by the projection technique.

Projection Technique

In the second stage, the estimated model was used to project rice SSL for ten-years from 2018 base year. To obtain the projected values, the elasticities of the estimated model and annual rates of change of the associated variables were used. :

$$lnY = \delta_0 + \delta_1 lnX_1 + \delta_2 lnX_2 + \delta_3 lnX_3 + \cdots + \delta_n lnX_n + \varepsilon \quad (3)$$

where, Y denotes an endogenous variable, X_i is independent variables with $i = 1, 2, 3 \ldots n$, δ_i with $i = 0,1,2,3 \ldots n$ are coefficients to be estimated and ε is error term.

The projections, represented by their rates of change are generated using the following equation:

$$Y_t = Y_{t-1} + Y_{t-1}(\phi Y) \quad (4)$$

Where Y is the variable under consideration, ϕY is the annual growth rate for Y - either exogenously or endogenously determined, and t is the current year.

The annual rates of change for the endogenous variable were given by a generic formula of the form.

$$\phi Y = \delta_1 * \phi X_1 + \delta_2 * \phi X_2 + \delta_3 * \phi X_3 + \cdots + \delta_n * \phi X_n \quad (5)$$

where ϕY is the calculated annual growth rate of the endogenous variable, Y, δ is the elasticity of variable Y with respect to X_i for $i = 1,2,3,\ldots n$, and ϕX_i is the annual percentage rate of change for variable X for $i = 1,2,3 \ldots n$

A base year of 2018 was established where the tariff rate was 70% while growth rates for the exogenous variables were referenced from their last five-year averages.

Results and Discussion

Unit Root and Co-integration Tests

Aligned with the study's objective, it was necessary to test the data series for non-stationarity—a condition where the series exhibits a time-varying mean, time-varying variance, or both, thereby violating classical econometric assumptions. As a result, modeling non-stationary data using traditional econometric techniques can lead to spurious regression results (Granger & Newbold, 1974), undermining its effectiveness for forecasting purposes. To test for stationarity, this study employed the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) Unit Root Tests. The findings (Table 2) showed that the regressors were all of I (1). Additionally, the result of the unit root test validated the adoption of the unrestricted ARDL Bound Test to estimate the model.

Table 2- ADF and PP Unit Root Tests (with intercepts)

Variable	ADF		PP		Conclusion
	Level	First difference	Level	First difference	
	t-statistic	t-statistic	t-statistic	t-statistic	
lnPYAH	-1.792	-8.090***	-1.998	-8.071***	I(1)
lnPYPP	-2.657	-6.801***	-2.616	-6.772***	I(1)
lnCVPP	-0.438	-8.814***	-0.697	-9.428***	I(1)
lnCGSF	-1.877	-4.033***	-1.593	-4.010***	I(1)
lnPYYD	-1.554	-8.142***	-1.669	-8.126***	I(1)
lnREPC	-1.080	-7.504***	-0.655	-7.709***	I(1)
lnRERP	-1.768	-6.559***	-1.767	-6.845***	I(1)
lnWTRP	0.170	-2.742***	-1.213	-8.859***	I(1)
lnGNIPC	0.453	-4.318***	0.113	-4.343***	I(1)

Following the stationarity test was a bounds test of co-integration to determine whether the variables share a long-run association. The bounds test is mainly based on the joint F-statistic in which its asymptotic distribution is non-standard under the null hypothesis of no co-integration. Therefore, the four specified equations were subjected to an F-test for the joint significance of the coefficients of the lagged levels of the variables. As a criterion, the null hypothesis of no co-integration is rejected when the value of the test statistic exceeds the upper critical bounds provided by Narayan (2005), otherwise it is accepted if the F-statistic is lower than the lower bounds value. Accordingly, based on the results in Table 3, the null hypotheses were rejected, thus indicating the existence of long run relationships (co-integration) between the variables of each of the four equations.

Table 3- ARDL bounds test of co-integration

Dependent variable	K	Lag	F-statistic	Narayan (2005) Critical values	
				I(0)	I(1)
lnPYAH	3	2	4.081*	2.933	4.020
lnPYYD	2	2	4.591*	3.373	4.377
lnREPC	3	2	11.023***	5.018	6.610
lnPYPP	1	2	6.497**	5.260	6.160

Note: ***, ** and * denotes significant at 1%, 5% and 10% levels, respectively.

Estimated Long-run Coefficients

A presentation of the ARDL long-run coefficients of the estimated model including results of the necessary diagnostic statistics are provided in Table 4. In general, the estimated equations fitted the data in a manner consistent with economic theory. The statistical properties of the model viz Ramsey's RESET test for functional form misspecification, Breusch Godfrey LM (BG-LM) test for serial correlation, Breusch-Pagan-Godfrey (BP-G) test for heteroskedasticity and Jarque-Bera (JB) test for normality of residuals fell within acceptable statistical thresholds, and all the equations had at least 92% of their historical variations explained.

In the supply sub-model, the paddy area harvested was significantly influenced by the lagged area harvested and the government rice credit guarantee scheme fund. As reflected by the paddy's own price elasticity of 0.206, it was observed that the paddy area harvested was unresponsive to paddy producer price. It makes sense that the slow response could be caused by agricultural commodities' typically long production cycles, which make it challenging for producers to adjust production activities quickly. It follows that farmers' decisions about the size of their farms are only slightly influenced by paddy prices. Similar rice studies in Nigeria found slightly higher own-price elasticities of paddy. They reported 0.633 (Ayinde & Bessler, 2014), 0.23 (Takeshima, 2016) and 0.34 (Okpe, Abu, & Odoemenem, 2018), respectively. The rice credit guarantee scheme variable showed a positive relationship with paddy area harvested with a coefficient of 0.162 and had a statistically significant effect on paddy area harvested at a 5% level. As for paddy yield, the result showed that a 1% rise in the producer price of paddy will cause a yield improvement of 0.220%. This result paralleled Boansi's (2014) who observed a 0.210 elasticity. As expected, lagged yield had a positive effect on yield by about 0.49% because higher volumes of yield may drive producers to increase their investment in yield-enhancing inputs subsequent production seasons.

On the demand sub-model, all the featured variables carried their expected signs, more so, significantly. The own-price elasticity of rice was -0.321 and the cross-price elasticity was 0.193, meaning that a higher retail price of rice suppressed its quantity demanded. The relationship between per capita rice demand

and income was described by the income elasticity of demand value of 0.95. This means that rice is a normal good, more so, a necessity, therefore, consumers' demands for rice are tied to their income levels - more incomes means more quantity demanded. The behaviour of wheat was expected since wheat is also a staple in Nigeria and therefore, a substitute. Other researchers like Makama *et al*. (2017), found a higher own price elasticity (-0.55) for rice. In the paddy producer price equation, rice retail price was positive with an elasticity of 0.168.

Model Validation

As a necessary step in time series forecasting studies, the estimated model's forecasting ability was examined to establish its validity and reliability. This was done via both graphical and statistical methods. A visual examination of the graphical method depicted in Fig. 2 shows that each of the endogenous variables tracked fairly well over its historical data. Although some variations were observed, this is not uncommon (Pindyck & Rubinfeld, 1998).

Table 4- Estimated results of Nigeria's rice market model

Variable	Sub-model			
Regressor	**Paddy harvested area**	**Paddy yield**	**Rice consumption per Capita demand**	**Producer price**
Constant	9.520***	3.272	-8.799	-0.622
	(3.830)	(2.724)	(-4.350)	(-0.807)
$PYAH_{t-1}$	0.260			
	(1.555)			
$PYPP_{t-1}$	0.206	0.220**		0.985***
	(4.170)	(2.569)		(38.915)
$CVPP_{t-1}$	-0.076			
	(-1.433)			
$CGSF_{t-1}$	0.162**			
	(2.252)			
$PYYD_{t-1}$		0.488***		
		(3.557)		
$TREND_t$		0.292**		
		(3.041)		
$REPC_{t-1}$			0.493***	
			(5.646)	
$RERP_{t-1}$			-0.321***	
			(-5.380)	
$WTRP_{t-1}$			0.193***	
			(3.754)	
$GNIPC_{t-1}$			0.951**	
			(2.693)	
$REDP_t$				0.168
				(1.588)
Diagnostic test				
Adjusted R^2	0.951	0.951	0.920	0.987
BG-LM	0.888[0.422]	0.932[0.437]	0.244[0.786]	2.675[0.084]
JB	19.556[0.000]	1.592[0.451]	1.037[0.595]	2.413[0.299]
RESET	0.084[0.774]	0.008[0.929]	2.633[0.116]	3.447[0.072]
BP-G	1.051[0.406]	0.695[0.601]	0.884[0.542]	1.431[0.253]

Note: ***, ** and * denote significant at 1%, 5% and 10% levels, respectively. Figures in parenthesis (…) are t-statistics while figures in brackets […] are p-values.

Results of the validity tests are presented in Table 5 and they allow a satisfactory confirmation of the model's forecasting ability and performance. The value of the MAPE revealed a reasonable forecast accuracy since the simulated values were off by less than 3%. The RMSPE of the yield equation was quite high but this can be explained. According to literature, the RMSPE can be misleading when the variable under consideration has a wide

variability or volatility (as is the case with the historical yield data) which can lead to larger errors when calculating the percentage errors. It can also be due to unpredictability nature of these types of data such as yield. Additionally, if the yield equation has small magnitudes, any minute error of prediction creates a high proportion of error when such error is compared to the small actual value. In such cases, other model validation measure such as Theil statistics would be more convincing. The individual components of U^T showed that the model had a good fit with little to no systematic forecasting error and overall, possessed a good forecasting ability. This was supported by Pindcyk and Rubinfield (1998) who suggested that U^b values above 0.1 or 0.2 would indicate the presence of systemic bias, necessitating a possible re-specification of the model.

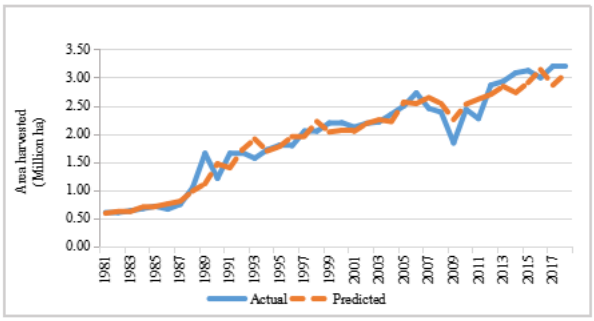

Figure 2. 1: Actual versus projected values for paddy area harvested, 1980 - 2018

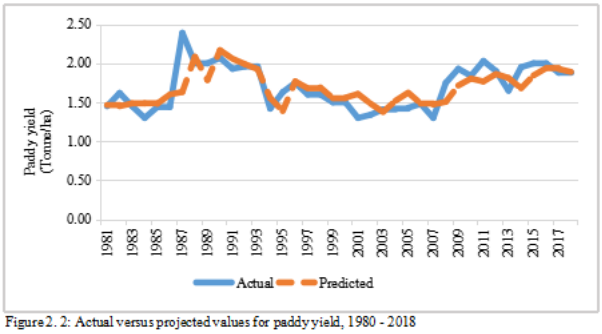

Figure 2. 2: Actual versus projected values for paddy yield, 1980 - 2018

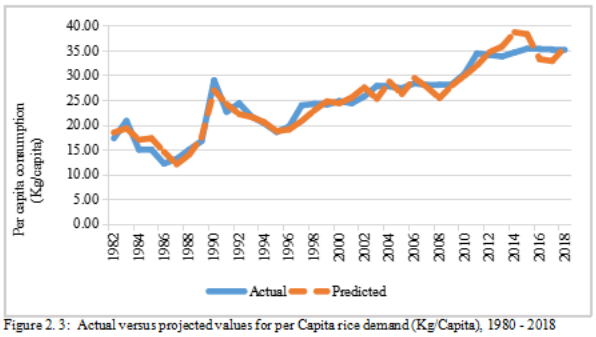

Figure 2. 3: Actual versus projected values for per Capita rice demand (Kg/Capita), 1980 - 2018

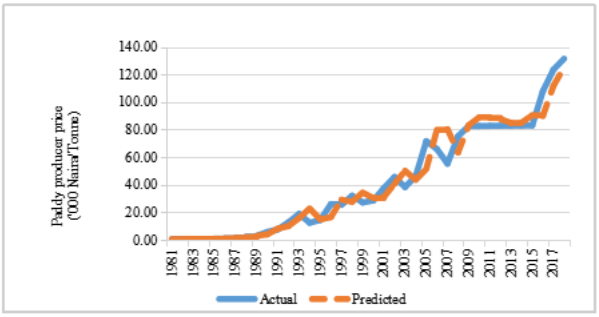

Figure 2. 4:Actual versus projected values for Producer price of paddy ('000 Naira/Tonne), 1980 - 2018

Figure 2- Graphical representation of within-sample validation

Rice Self-sufficiency Level Baseline Projections

The basic idea in this analysis was to replicate and project the market situation using historical data from 1980 to 2018. At a SSL of 67% in 2018, Nigeria was far behind its official goal of reaching SSL by the year 2020, as targeted in the Agricultural Promotion policy of reaching rice self-sufficiency by 2020. In an effort to use the latest available estimate, 2018 was set as the baseline in which official import tariff was 70% while a last five year average growth rates were used for the exogenous variables. A ten years projection reported in Table 6 shows a generally uneven trend. It revealed a sharp drop from the baseline estimate of 67% to 51.34% in 2019. Nonetheless, it gradually increased in 2022 to reach 70.96% in 2028, while maintaining a yearly average of 53%. This outcome was unsurprising for two reasons. First, the projected trend mirrored the erratic nature of the historical data (Fig. 2). Second, it reflected the inherent instability of Nigeria's rice production-consumption dynamic, particularly given the smallholder nature of the country's production systems. Overall, the results indicated the country's inability to meet its population's demand for rice. Additional related variables were examined to understand their influence on SSL.

Rice production will average 4.30 Mt per

year, mainly as a result of an average yield of 2.12 Mt ha^{-1}, equivalent to a 3.06% growth rate. Yield growth (3.06%) appeared to be the primary driver for paddy production relative to the paddy area harvested. Complementing the yield growth is an annual area harvested growth of 1.14% so that projections topped 3.46 hectares in 2028. Together, these variables spiked a 4.25% growth in rice production, which is expected to reach 5.44 million Mt in 2028.

Average annual figures showed demand increasing by 0.65% per year, averaging 8.15 Million Mt. The highest estimates were recorded in 2022 with 8.63 million Mt of rice to be demanded compared to a rice production volume of 3.91 million Mt in the same year. This meant that, despite the growth in rice production by 2028 (5.44 million Mt), it would be insufficient to satisfy a demand of 7.66 million Mt by 2028. As explained earlier, demand for rice is driven by population which has a 2.4% annual growth rate in 2022 (World Bank Online database) and urbanisation, which has a growth rate of 4.1% in 2020 (Index Mundi database). Therefore, imports will be unavoidable with its forecast averaging 3.85 million Mt yearly. At the initial stage, demand increases due to quality differentials in favour of imported rice which urban households usually prefer. However, consistent with the theory of demand, there is a drop in demand from 2023 due to high retail price which may cause affordability concerns resulting in a substitution reaction for wheat in the long run.

As an important factor in total demand, per capita demand started at 36.41 kg $Capita^{-1}$ in 2019, it increased to 40.64 kg $Capita^{-1}$ in 2021 but then declined to 30.87 kg $Capita^{-1}$ in 2028. Two factors could explain this behaviour. First, retail prices gained, owing to increasing exchange rates and higher world market prices. Consequently, consumers will experience higher retail prices of ₦409 thousand Mt^{-1} on average, equivalent to an 11.11% yearly growth rate, causing a reduction in per Capita demand. Secondly, this weakening rice consumption could result from the positive income elasticity. Based on the estimation result, rice was determined to be a normal good. As income increased, consumers respond initially by increasing rice consumption, but in the long run, a continuous rise in income could encourage consumers taste to evolve in favour of other healthier eating habits featuring options like brown rice and basmati rice. Other additional element of uncertainty, such as high exchange rate and high inflation can cause a shift from imported rice for domestically produced rice in the long run. Overall, the projections show that the demand for rice is expected to be shaped by the population growth, price of rice and income. Their individual influences on quantity demanded are considered while keeping other factors constant in line with economic theory. Nonetheless, their aggregate influence results in a declining per capita consumption in the long run projection figures which began in 2023.

The results of this study revealed a bleak outlook for Nigeria's rice self-sufficiency goal. This gloomy future was shared by Van Oort *et al*. (2015) adopted a yield gap assessment technique to determine Nigeria's SSL of 54% for 2025 projection, given a one one Mt ha^{-1} yield increment. An average SSL of 53% for the 10-year projected period means that Nigeria will need to almost double its average production volumes of 4.3 million Mt or increase production by about 47% to be self-sufficient in rice. Decomposing the rice production sub-model from a yield perspective to consider this goal, IRRI estimates the required yield to attain rice self-sufficiency for Nigeria is 5.30 Mt h^{-1} (Gloria-Pelicano & Prandelli, 2013). This means that Nigeria will have to more than double its current average yield of two metric tonnes per hectare. On a positive note, this seems feasible, given the tremendous rice production potential of the country available for intensive exploitation for a productive and sustainable national rice market.

Table 5- Results of Within-Sample Validation

Statistic	Notation	Endogenous variable			
		PYAH	PYYD	REPC	PYPP
Mean Absolute Error	MAE	0.077	0.093	0.065	0.216
Mean Absolute Percent Error	MAPE	0.533	1.271	2.113	2.541
Root Mean Squared Percent Error	RMSPE	0.763	24.53	2.501	3.030
Theil Inequality Coefficient	U^T	0.004	0.008	0.014	0.014
Bias proportion	U^B	0.000	0.001	0.000	0.032
Variance proportion	U^V	0.014	0.015	0.055	0.193
Covariance proportion	U^C	0.986	0.984	0.945	0.775

Table 6- Summary of Nigeria's rice market projection

Variable	Unit	Projection										Average	
		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2019-2028	
Supply													μ	Δ
Harvested area	Million ha	3.20	3.13	3.12	3.12	3.12	3.13	3.17	3.22	3,28	3.36	3.46	3.21	1.14
Paddy yield	Mt h^{-1}	1.88	1.90	1.94	1.96	1.99	2.03	2.09	2.16	2.25	2.36	2.49	2.12	3.06
Paddy production	Million Mt	6.12	5.95	6.05	6.11	6.21	6.37	6.61	6.94	7.38	7.93	8.63	6.82	4.25
Rice production	Million Mt	5.34	3.75	3.81	3.85	3.91	4.01	4.17	4.37	4.65	5.00	5.44	4.30	4.25
Rice import	Million Mt	3.00	3.55	4.36	4.70	4.72	4.55	4.26	3.87	3.41	2.86	2.23	3.85	-4.27
Demand														
Domestic demand	Million Mt	6.90	7.30	8.17	8.55	8.63	8.56	8.42	8.24	8.05	7.86	7.66	8.15	0.64
Per capita demand	Kg $Capita^{-1}$	35.23	36.41	39.79	40.64	40.08	38.83	37.29	35.65	34.01	32.41	30.87	36.60	-1.72
Price														
Retail Price	'000 ₦ Mt	305.04	243.33	270.36	300.39	333.76	370.84	412.03	457.80	508.65	565.16	627.93	409.02	11.11
Producer price	'000 ₦ Mt^{-1}	52.94	53.92	53.06	53.22	54.37	56.54	59.83	64.36	70.37	78.15	88.13	63.19	5.71
Self-sufficiency														
SSL	Per cent	64.00	51.34	46.64	45.06	45.33	46.88	49.46	53.05	57.71	63.60	70.96	53.00	3.87

Note: Mt denotes metric tonnes, μ denotes variable average and Δ denotes average growth rate in percentage.
Note: 306.08 Naira = 1 US dollar

Conclusion

Strengthening rice self-sufficiency has gained priority in Nigeria's staple food policy agenda. Nonetheless, there is a lingering situation of demand-supply imbalance. An important step is to understand the dynamics of the demand for food staples and production potentials in relation to rice SSL. Such analysis serves as a valuable tool for guiding policy design that could help to create efficient agricultural food market systems and promote sustainable economic development. This study empirically projected rice SSL, which will help provide insight into the ability of the country to achieve rice self-sufficiency in the future and thus guide the formulation of future national rice market policies. The analysis adopted a theory-oriented market model for a non-storable commodity to provide a 10-year projection of rice self-sufficiency level for Nigeria based on an econometric approach. The model performance was validated by the results of the statistical tests showing appreciable model forecasting strength. The result of this paper underscored a broader policy message that, given the current policy environment of the country's rice market, achieving self-sufficiency is unfeasible in the future, despite many past intervention projects. Such a situation will push the country towards a continuous dependence on imports at the expense of affordable domestically produced substitutes, consequently creating a risk of a deteriorating rice market as well as threatening food security. One effective way to improve SSL is to design policies towards investing in yield enhancing technology. In this study, the appreciation for adopting the econometric market model approach extends beyond producing the projections of FSS level to highlighting the dynamics of the key variables as they influence the country's rice market system.

Since this article aimed to replicate the Nigerian rice market as a foundation for making projections, several limitations are worth noting. First, the initial model specification included weather-related variables, such as rainfall and temperature, as well as policy variables like fertilizer subsidies, which were theorized to influence paddy production in the national paddy production sub-model. However, the estimated functions had unacceptable results in terms of their signs and their result diagnostic tests, hence the model had to be re-specified with those variables removed for an acceptable result. Secondly, there were issues of few missing data entries for some variables and these issues were resolved by interpolation. Ultimately, the presented results were based on available data and are believed to be the acceptable of the specifications attempted from an economic theory point of view.

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مقاله پژوهشی

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پیش‌بینی مبتنی بر الگوی اقتصادسنجی برای خودکفایی محصول برنج در نیجریه

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چکیده

خودکفایی در محصول برنج از اولویت‌های سیاست کشاورزی کشور نیجریه قلمداد می‌شود و این مقاله درصدد آن است سطح خودکفایی محصول برنج را مورد بررسی قرار دهد. بدین منظور، داده‌های سری زمانی برای دوره ۱۹۸۰ تا ۲۰۱۸ از طریق روش اقتصادسنجی خودرگرسیون پویا با وقفه توزیع شده برای الگوسازی بازار برنج نیجریه مورد استفاده قرار گرفت. نتایج نشان داد کشش قیمتی شلتوک معادل ۰/۲۰۶ و بدون معنی است. همچنین، سیاست ملی تضمین مالی کاشت برنج تأثیر مثبت بر نواحی کاشت برنج داشت. وقفه متغیر عملکرد و وقفه سطح کشت با تأثیر مثبت به افزایش عملکرد و سطح زیرکشت منجر شده است. کشش خود قیمتی تقاضای برنج و کشش قیمتی متقاطع، به‌ترتیب، -۰.۳۲۱ و ۰.۱۹۳ برآورد شد، که کشش قیمتی متقاطع به جایگزینی با گندم اشاره دارد. پیش‌بینی دوره ده ساله با استفاده از کشش‌های به‌دست آمده نشان داد، تا سال ۲۰۲۸، افزایش تولید برنج نسبت به کاهش واردات به خودکفایی تا سطح ۷۱ درصد منجر می‌شود. همچنین، سطح متوسط خودکفایی سالیانه ۵۳ درصد، معادل ۳.۸۵ میلیون تن از وادرات برنج، برآورد شد. با استفاده از این نتایج، انتظار می‌رود خودکفایی برنج در نیجریه تا سال ۲۰۲۸ محقق نشود، و تنها در صورت بهبود عملکرد برنج از طریق استمرار سیاست‌های حمایتی تحقق خودکفایی ممکن خواهد بود.

واژه‌های کلیدی: پیش‌بینی خودکفایی برنج، کشش، وقفه توزیع شده خودرگرسیونی

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Factors Affecting the Purchase Intention of Chocolate by Consumers

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Abstract

This research was conducted to investigate the motivations and attitudes of consumers to choose chocolate and their effects on purchase intention. For this purpose, the effects of health variables, mood, weight control, chocoholism, sensory, packing, price, and brand trust on the purchase intention of chocolate have been investigated using the structural equation model. The results of this research indicate that only the variable of mood has a positive and significant effect on chocoholism. Additionally, the variables of brand trust, packaging, and price have a positive, direct, and significant impact on the intention to purchase chocolate. Mood and packaging stood out with a notable difference, indicating that these two factors are especially important from the consumer's perspective. Furthermore, attractive packaging has the ability to attract the attention of consumers and convey important information about the product, including taste, ingredients, and nutritional value. Also, most consumers buy chocolate products from their trusted brands, so in this case, famous and reliable brands usually have an advantage, price sensitivity is different in consumer groups. These factors are often interrelated and their importance may vary depending on individual preferences, demographics, and market trends.

Keywords: Attitude, Chocolate, Choice motivation, Purchase intention

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Introduction

The chocolate sector is an important part of the confectionery industry and its global market value exceeded EUR 105 billion in 2021 and is expected to grow at an annual rate of 3.7 % from 2022 to 2030. The global chocolate market is segmented by product type (dark, milk, or white chocolate and with other ingredients), distribution channel (online e-commerce and physical shops), and geographically. In the world, some regions have a higher share of the financial market, including Western Europe with 33%, followed by Eastern Europe, the Middle East and Africa with 24%, and North America with 22%, which is 14% in Asia and the Pacific and America South will decrease by 7% (Statista, 2023). Also, the rapid growth of the chocolate market is characterized by changing consumer preferences for new and innovative products. Such conditions force manufacturers to regularly update the list of factors influencing the consumption of chocolate products, and they seek to identify purchase intention drivers in the chocolate market by considering groups of factors. The individual preferences of consumers, along with the sensory and non-sensory characteristics of the product (Fortune Business Insights., 2020). In Iran, the increase in competition, the entry of various foreign companies, diverse products, and the advancement of technology has made it difficult to maintain customer satisfaction and loyalty (Asgar Nejad *et al*., 2012). Confectionery and chocolate industry are among the luxury industries. Also, due to the large investments of the private sector in the last two decades, it has become a modern and up-to-date industry, and it has been the leader in the export of the food industry group for many years (Ministry of Industry, Mine and Trade, 2022). Today, many companies are competing in the confectionery and chocolate industry in the country, to the extent that in some areas, the market is completely occupied by domestic competitors. What is certain is that customer orientation is the key to the success of companies active in this field (Jafar Nejad *et al*., 2010). With 900 candy and chocolate production units, Tabriz has become one of the most important hubs in the Middle East and also a supplier of about 50% of Iran's chocolate. Also, with large factories such as Shirin Asal, Anata, Shoneys, Aydin, etc., it has various and high-quality chocolates. Some of them are planning to supply their products daily to domestic, European, Central Asia, Caucasus, as well as Iraq, Afghanistan, Pakistan, Ivory Coast, Azerbaijan, UAE, and Qatar markets (Asgar Nejad *et al*., 2012). The history of the confectionery and chocolate industry in Iran has made the added value of this industry from raw materials and production and packaging machines to distribution, sales, and human resources facilities in Iran to an acceptable level (Sadat *et al*., 2014). In addition, company managers need to understand buyers' motivations and respect their motivations, values, lifestyles, insights, attitudes, and needs. The broad field of customer behavior includes three separate activities, which are: buying, selling, and consumption, which have made significant progress in determining the dimensions of buying behavior and the number of buying behavior theories (Henzai & Bahrami Jah, 2015). Therefore, a systematic study on the relationship between chocolate choice motives, attitudes, and purchase intention is needed to explain consumer behavior in the chocolate industry. Analyzing consumer choice behavior is very important according to the types of production, because chocolate choice behavior is different for chocolates sold in hypermarkets and supermarkets and chocolates available in handmade chocolate shops (Lybeck *et al*., 2006). In the field of human behavior, there are factors that not only force us to act but also lead us to a specific goal. Psychologists call these factors motivation. Motivation is the driving factor that motivates people to buy (Goldsmith *et al*., 2011). Therefore, these motives have a specific role in customer behavior. Similarly, regarding attitude, since most consumers have low expertise in food selection, they tend to make attitudes or food choices depending on their sensory response (Stanovich & West,

2000). For example, the dynamic sensory experience that occurs when consuming chocolate is very important for the consumer (Giller, 2017). Consumers' attitudes can predict consumer buying behaviors, as they choose specific products from different types (Costell *et al.*, 2010). Because visual perceptions of packing designs can increase the consumer's understanding of the taste, quality and performance of the product and increase the consumer's purchase intention (Metcalf *et al.*, 2012).

Each of the conducted studies has focused on some motivations and attitudes effective on the purchase intention by consumers, which can be summarized and categorized in a different way:

Demographics of consumers, including age, size of household, and household income. Each of these factors has had different effects in different studies. The study by Konttinen *et al.* (2012) they investigated whether the absolute or relative importance of different food choice motivations contributes to low socioeconomic status (SES) disparities in the consumption of energy-dense food, vegetables, and fruits. Cross-sectional data from the study were analyzed using the structural equation model. The obtained results showed that the motivation for choosing food based on income and education level, high-income consumers valued health more, and low-income consumers were more concerned about price. Sondhi & Chawla (2017) this study was a mixed approach by conducting three focus group discussions (FGD) on 301 chocolate consumers in different age and gender groups, and three suitable clusters were considered. Then k-means cluster analysis was performed on the data. The results showed that the sensory characteristics of chocolate, such as the aroma of cocoa, its texture, and softness, which are understood by the cognitive function of the brain, cause more craving for chocolate among women.

Consumer motivation has been investigated in various studies. The study by Lee & Yun (2015) investigated how consumers perceive the characteristics of organic food. 725 questionnaires were collected for this research. The data analysis was also done with the structural equation model and the findings showed that the sensory appeal factor of food selection motivation plays an important role in the hedonistic attitude towards organic food and the purchase intention variable. Mohammadian & Dehdashti (2016) in investigating the effect of emotional attachment on consumers' purchase intention, 390 questionnaires were collected and analyzed using the structural equation model. The results showed that emotional attachment has a positive and direct effect on purchase intention and investing in emotional relationships with customers leads to loyalty. Also, store image, perceived transaction value, and consumers' trust in the store play an important role in creating emotional attachment. Bryła (2016) investigated the selective aspects of organic food consumption in Poland. A survey of 1000 consumers was conducted using the CAWI (Computer Assisted Web Interview) method. The findings showed that the main motivations for choosing organic food in Poland are: Healthiness, product environmental features, food safety considerations, superior taste, and quality assurance.

The attitude of consumers toward the intention to purchase chocolate has been explored in several studies. Maleki et al. (2020) also suggest that managers should focus on enhancing consumers' positive attitudes toward the brand by improving packaging and graphic design, thereby increasing their willingness to purchase from the company. Kita *et al.* (2020) in a study determined the effect of long-term storage time and type of packaging on the quality of chocolate in Poland. Statistical analysis was performed using the principal component method (PCA) and its findings show showed that storage and type of packaging simultaneously affect the quality of chocolate. Baptista *et al.* (2021) investigated how packaging colors affect the expectations of sweetness, bitterness, fruitiness and liking of chocolates in Brazilian and French subjects.

Data analysis was done with variance (ANOVA), Tukey-Kramer test and multi-factor analysis (MFA). The findings showed that there are several significant effects of packaging color on the expectations of Brazilian and French consumers. Also, the effect of packaging color did not differ significantly between cultures, but depending on the type of chocolate (sweet, bitter, fruity, etc.), packaging color may have a negative effect on attractiveness and enjoyment. Brown *et al.* (2020) conducted a study to understand American premium chocolate consumers among members of the Pennsylvania State University campus community. The results showed that consumers pay attention to the characteristics of chocolate type classification, price, availability, packaging, organic, Fairtrade label, brand trust, and nostalgia to determine the quality and choice of chocolate.

The purchase intention of consumers has been investigated in various studies. For example, in the study of Henzai & Bahrami Jah (2015), purchase motivation is one of the main concepts in the field of customer purchasing behavior. In this study, the attitude of 400 students of Qazvin Islamic Azad University was analyzed using the structural equation model. The obtained results help business owners and brand managers to segment their customers based on purchase motives and attitudes and to better understand what reasons motivate customers to buy. Thaichon *et al.* (2018) in a semi-structured in-depth interview study on repeat purchases of Australian consumers, the results showed that factors such as taste, quality, texture, price, and variety significantly influence consumers' repeat purchases of a particular brand. Also, attractive packaging and variety of flavors also play a more important role in attracting customers. Kim & Jeon (2020) investigated the effect of motivations for choosing chocolate on attitude and willingness to buy, which were analyzed in a sample of 487 people using the structural equation model. The results showed that mood and health have a positive effect on chocoholism and the desire to buy again, and the effect of these factors depends on the type of consumer. Semenova *et al.* (2023) measured the effects of packaging on purchase intention for chocolate. Electroencephalography (EEG) method, which is relatively cheap and efficient, was used to investigate this research. The results showed that attractive packaging for famous brands has a positive effect on the willingness to pay for chocolate.

In the present study, the factors influencing consumers' purchase intention of chocolate are analyzed using the structural equation model (SEM). SEM is a powerful tool in multivariate data analysis, allowing for the examination of relationships between multiple variables within a single model. Its strength in theory development has led to its widespread use in various scientific fields such as psychology, social sciences, management research, and business (Azar et al., 2012). Given the active role of the chocolate industry in driving exports and supporting the national economy, it is crucial to identify the motivations and attitudes of different consumer groups, as well as effective strategies for meeting their needs, in order to develop products and sales strategies for chocolate companies. To help in the decision to buy chocolate and predict the future behavior of consumers, because there has been no study in this field in Iran, and this study is innovative in this regard.

According to the review of the conducted studies, the hypotheses can be expressed as follows:

H1. The motivation to choose chocolate has a positive and significant effect on attitude.

H1-1. Health variable has a positive and significant effect on chocoholism.

H1-2. Weight control variables have a positive and significant effect on chocoholism.

H1-3. Mood variable has a positive and significant effect on chocoholism.

H1-4. Sensory variable has a positive and significant effect on chocoholism.

H2. The attitude towards chocolate has a positive, direct, and significant effect on purchase intention of chocolate.

H2.1. Chocoholism Variable has a positive, direct, and significant effect on purchase

intention of chocolate.

H2.2. Packaging variable has a positive, direct, and significant effect on purchase intention of chocolate.

H2.3. Brand trust variable has a positive, direct, and significant effect on purchase intention of chocolate.

H2.4. price variable has a positive, direct, and significant effect on purchase intention of chocolate.

Materials and Methods

In structural equation modeling, there are six stages that include data collection, model specification, diagnosis, fitting, evaluation, and model modification (Kline, 2013). The first stage of this research is data collection using a questionnaire.

The next steps are the diagnosis and fitting of the structural model. In this research, in order to check the validity of the questionnaire, confirmatory factor analysis test is used. In conducting factor analysis, the common criterion for establishing convergent validity is the average variance extracted average variance extracted (AVE) which was suggested by (Fornell & Larcker, 1981). This criterion is defined as the sum of the second power of times divided by the number of reagents. The method used in this research to check the fit of the measurement model includes three criteria: construct validity, diagnostic or convergent validity, and reliability based on Cronbach's alpha coefficient. Construct validity is a composite concept that requires the investigation of several stages and is measured by concurrent validity, predictive validity, discriminant validity, and convergent validity. Construct validity is the degree of accuracy of the scale in measuring the theoretical construct or desired characteristic (Mohammad Beigi *et al*., 2015). Decomposition of the detection function is also used to check diagnostic validity. In this method, there is an initial grouping of subjects, and the purpose of this analysis is to confirm the initial grouping based on other data (Mesrabadi *et al*., 2016). Finally, Cronbach's alpha coefficient shows the internal consistency of the questions. The last step is to modify the model, which is to ensure the fit of the model with the data. If the proposed model does not fit the data, it needs to be modified (Akinyode, 2016). In this research, Smart PLS 3 software was used to analyze the structural model.

The statistical population under study is the community members of Ferdowsi University of Mashhad, which is one of the largest integrated campuses in the country and includes all faculties, research institutes, buildings, and a large part of cultural, welfare, sports complexes, cooperatives, and dormitories. As a result, many people from different cities are working and studying there. Likewise, the data used has been calculated using Cochran's formula equal to 300 numbers. The tool for collecting information in this research is a questionnaire that includes 44 questions, the demographic part of which includes questions about the general characteristics of the respondents such as gender, age, level of education, and income of the respondents. The next section is specific questions based on the variables selected in the above section. The scale used is a five-point Likert scale. This scale uses the basis of strongly disagree, disagree, neutral, agree, and strongly agree. Also, the data was collected by available sampling method in 1402. In the following, the conceptual model of the research is presented in Fig. 1:

Table 1 shows the number of items for each variable and the source of variables extraction, which includes variables: health (3), mood (4), weight control (3), sensory (3), chocoholism (3), packaging (4), price (3), brand trust (3) and purchase intention chocolate (5).

Results and Discussion

The analysis of the demographic characteristics of the respondents is shown in Table 2. Most of the respondents are women and people aged 20-29 with a bachelor's degree and single.

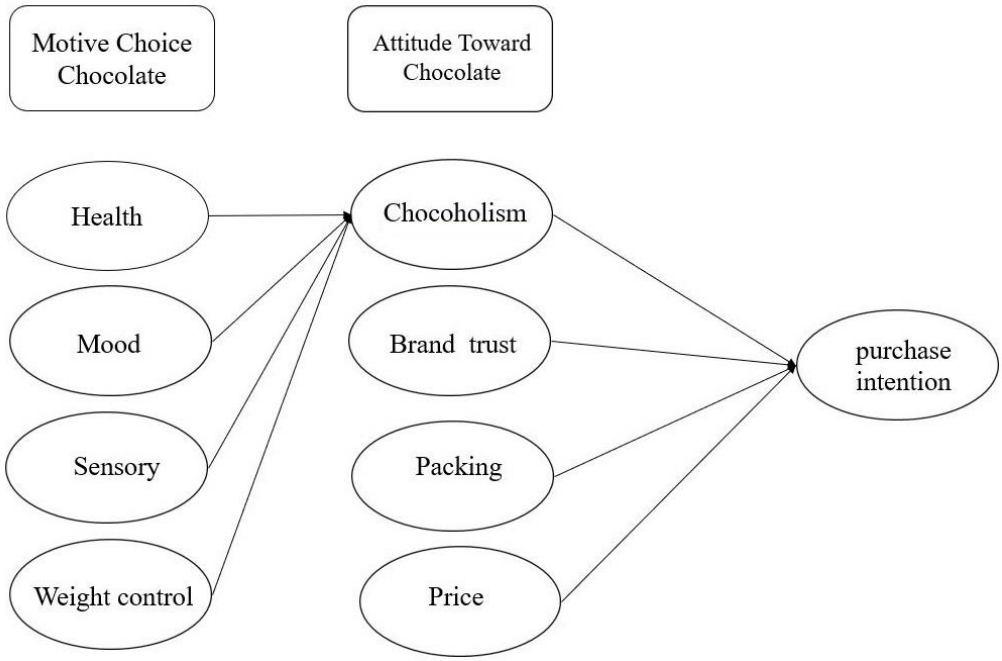

Figure 1- Conceptual model of research

The results of construct validity, diagnostic validity, and convergent validity as well as reliability including Cronbach's alpha coefficient for all questions of the questionnaire are presented in Table 3. The results show that all 9 indicators are accurate because the reliability of each question is more than 0.5, and the reliability by Cronbach's alpha method is more than 0.6 and the composite reliability is more than 0.7. CR[1] values for the factors of this research are CR > AVE, and therefore, because the AVE index is higher than 0.5, this questionnaire has good reliability.

There are three necessary conditions for the realization of convergent validity: 1. The composite reliability value should be greater than 0.7; 2. The average value of the extracted variance should be greater than 0.5; and 3. The composite reliability value is greater than the average variance extracted (Davari & Rezazadeh, 2016). Finally, convergent validity is a relatively strong correlation between the question and the main variable shown in Table 4, which is smaller than the range of 0.812 to 0.900 and indicates the appropriate internal stability for measurement models. Therefore, all latent variables had convergent validity.

Fig. 2 shows the results of the hypothesis test and it shows the relationships between the impact of choice motivation and attitude factors in the form of reflective measurement models along with path coefficients between variables, coefficient of determination, and Student's t-statistics, these results are shown in Table 5.

Based on Table 5, hypothesis (H1-1): It shows that the path coefficient of the exogenous latent variable of health on chocoholism is (0.039) and its t-statistic is (0.572), which has a positive but not significant effect. Therefore, the null hypothesis that there is no relevant coefficient is rejected, which is confirmed by the studies (Kim & Jeon, 2020). In relation to taking care of their health, people consume chocolates with healthy and nutritious ingredients.

1- Composite Reliability (CR)

Table 1- Research variables, number of items, and source

Symbol	Variable	Source	Components
Health		(Kim & Jeon, 2020)	Motive
XHE1	Iranian chocolates keep me healthy.		
XHE2	Iranian chocolates contain fiber, vitamins, and minerals		
XHE3	Iranian chocolates are nutritious.		
Mood		(Kim & Jeon, 2020)	Motive
XMO1	Eating chocolate reduces my stress		
XMO2	Eating chocolate changes my mood.		
XMO3	Eating chocolate gives me energy.		
XMO4	Eating chocolate makes me happy.		
Sensory		(Kim & Jeon, 2020)	Motive
XSE1	Iranian chocolates smell good.		
XSE2	Iranian chocolates have a good taste.		
XSE3	Iranian chocolates have a pleasant texture.		
Weight control		(Kim & Jeon, 2020)	Motive
XWE1	Iranian chocolates help me control my weight.		
XWE2	Iranian chocolates are low in fat.		
XWE3	Iranian chocolates are low in calories.		
Chocoholism		(Kim & Jeon, 2020)	Attitude
XCH1	I indulge in eating chocolate.		
XCH2	I have an addiction to eating chocolate.		
XCH3	When shopping at the store, looking at the shelves of chocolates is attractive to me.		
Packing		(Brown *et al*., 2020)	Attitude
XPA1	Packing of Iranian chocolates is modern and up-to-date.		
XPA2	Iranian chocolates have beautiful packaging.		
XPA3	The packaging of Iranian chocolates is suitable for gift-giving.		
XPA4	In terms of packaging, Iranian chocolates can compete with foreign chocolates.		
Price		(Brown *et al*., 2020)	Attitude
XPR1	In my opinion, chocolates with thick or metal packaging are more expensive and of better quality.		
XPR2	In my opinion, quality chocolates have luxury packaging and expensive prices.		
XPR3	The price of Iranian chocolates is reasonable compared to foreign chocolates		
Brand trust		(Brown *et al*., 2020)	Attitude
XBR1	I have been consuming chocolate from Iranian brands for years.		
XBR2	It is important for me when buying a chocolate brand.		
XBR3	The brand I buy focuses on quality.		
purchase intention		(Kim & Jeon, 2020)	
YRE1	I plan to purchase intention Iranian chocolate in the future		
YRE2	If Iranian chocolates keep me healthier than foreign ones, I will buy them.		
YRE3	If the taste of Iranian chocolates is better than foreign ones, I will buy Iranian chocolates.		
YRE4	If Iranian chocolates have more nutrients than foreign ones, I will buy them.		

Source: Research findings

Table 2- Description of demographic variables (N = 300)

Variable		Abundance	%
Gender	Female	241	80
	Male	59	20
Age	Below 20 Years	20	7
	20-29 years	192	64
	30-39 years	52	17
	40-49 years	19	6
	Above 50 years	17	6
Marital status	Single	223	74
	Married	77	26
Educational level	Lower than diploma	4	1
	Diploma	40	13
	BSc	152	51
	MSc	86	29
	PhD	18	6
Occupation	Self-employed	41	14
	Employee	33	11
	Student	203	68
	Retired	4	1
	Housewife	19	6
Income	Below 7 Milion	131	44
	7 – 15 Milion	66	22
	15 – 25 Milion	54	18
	25 – 35 Milion	21	7
	Above 35 Milion	28	9
Monthly consumption of chocolate	Below 500 gr	148	49
	500-750 gr	98	33
	750-1000 gr	42	14
	1000-1500 gr	9	3
	Above 1500 gr	3	1

Source: Research findings

Table 3- The results of the validity and reliability test

Variable	Cronbach's α	AVE	CR	Rho-R
Brand trust	0.826	0.559	0.887	0.666
Chocoholism	0.842	0.559	0.895	0.682
Health	0.859	0.672	0.914	0.780
Mood	0.922	0.752	0.945	0.812
purchase intention	0.894	0.743	0.934	0.824
Sensory	0.886	0.723	0.929	0.814
Weight control	0.869	0.689	0.920	0.793
Packing	0.895	0.741	0.934	0.826
Price	0.703	0.579	0.867	0.766

Source: Research findings, Abbreviations: CR, Composite reliability; AVE, Average Variance Extracted.

Table 4- Fornell and Locker

Variable	Brand Trust	Packing	Sensory	Mood	Health	Chocoholism	Purchase intention	Price	Weight control
Brand trust	0.892								
Packing	0.317	0.813							
Sensory	0.197	0.736	0.888						
Mood	0.470	0.212	0.225	0.900					
Health	0.148	0.484	0.431	0.215	0.869				
Chocoholism	0.394	0.097	0.091	0.615	0.141	0.838			
Purchase intention	0.381	0.568	0.517	0.377	0.300	0.206	0.731		
Price	0.223	0.148	0.111	0.215	0.230	0.157	0.271	0.812	
Weight control	0.096	0.392	0.353	0.174	0.724	0.108	0.193	0.124	0.843

Source: Research findings

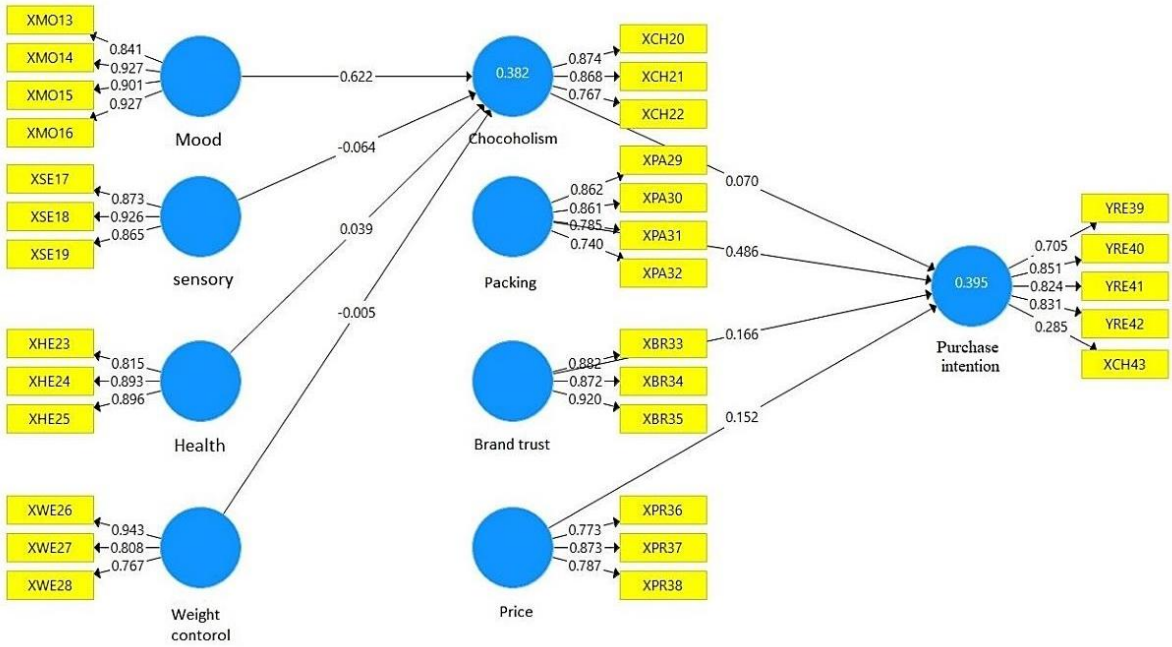

Figure 2- Structural model of attitude and purchase intention towards chocolate: the effects of choice motivation

Table 5- The results of the hypothesis test

Relationship	Hypotheses	*β*	t-value	p-value	Decision
H2-3	Brand trust -> Purchase intention	0.166	2.876	0.004	Accept
H2-2	Packing -> Purchase intention	0.486	9.689	0.000	Accept
H1-4	Sensory -> Chocoholism	-0.064	1.052	0.293	reject
H1-3	Mood -> Chocoholism	0.622	15.666	0.000	Accept
H1-1	Health -> Chocoholism	0.039	0.572	0.568	reject
H2-1	Chocoholism -> Purchase intention	0.070	0.734	0.463	reject
H2-4	Price -> Purchase intention	0.152	2.797	0.005	Accept
H1-2	Weight control -> Chocoholism	-0.005	0.070	0.945	reject

Source: Research findings

Hypothesis (H1-2): It shows that the path coefficient of the exogenous latent variable of weight control on chocoholism is (-0.005) and its t-statistic is (0.070) which has a negative and significant effect and the null hypothesis is rejected. Studies by Kim & Jeon (2020) confirm this, and Kroese *et al.* (2009) believe that consuming high-calorie chocolates leads to an anticipated feeling of guilt towards gaining weight, which can be a negative

feeling after consumption.

Hypothesis (H1-3): It shows that the path coefficient of the exogenous latent variable of mood on chocoholism is (0.622) and its t-statistic is (15.666) which has a positive and significant effect and the hypothesis zero is accepted. The results of studies by Urala & Lähteenmäki (2004) confirm that consumers experience a greater amount of chocolate orientation when they need to reduce stress, happiness, and energy in their daily lives. Their study by Luomala *et al*. (2009) showed that from a practical point of view, mood is the most important influencing factor on the tendency to chocolate and chocolate consumption in increasing positive emotions and decreasing negative emotions.

Hypothesis (H1-4): It shows that the path coefficient of the exogenous latent variable of sensory on chocoholism is (-0.064) and its t-statistic is (1.052), which does not have a positive and significant effect. Therefore, the null hypothesis is rejected. The studies by Kim & Jeon (2020) confirm this. However, contrary to the findings of Thaichon *et al*. (2018), the bitter aroma of chocolate and its texture causes addiction and turns consumers into chocolate lovers, which in turn causes continued consumption. Thomson *et al*. (2010) that the intensity of chocolate softness has a significant effect on the quality and these sensory factors play an important role in the intention to buy chocolate.

Hypothesis (H2-1): It shows that the path coefficient of the exogenous latent variable of chocoholism on purchase intention of chocolate is (0.070) and its t-statistic is (0.734), which does not have a positive, direct, and significant effect. Therefore, the null hypothesis is rejected. The study by Kim & Jeon (2020) confirms this. Mooney *et al*. (2009) In fact, the feeling of guilt caused by the consumption of chocolate can cause internal conflict about the consumption of chocolate Hypothesis (H2-2): It shows that the path coefficient of the exogenous latent variable of packaging on purchase intention of chocolate is (0.486) and its t-statistic is (9.689), which has a positive, direct, and significant effect. Therefore, the null hypothesis is accepted. Studies by (Semenova *et al*., 2023), (Brown *et al*., 2020), (Maleki *et al*., 2020), and (Ranjbaran *et al*., 2010) confirm this. In the food industry, packaging plays a significant role in attracting customers and creating attractiveness and psychological expectations for consumers and it can affect the customer's perspective and purchase intention.

Hypothesis (H2-3): It shows that the path coefficient of the exogenous latent variable of brand trust on purchase intention of chocolate is (0.166) and its t-statistic is (2.876), which has a positive, direct, and significant effect. Therefore, the null hypothesis is accepted. The studies (Semenova *et al*., 2023), (Brown *et al*., 2020), (Thaichon *et al*., 2018), and (Thomson *et al*., 2010) state that taste and brand are effective in stimulating positive emotional reactions. Also, it will lead to frequent purchases by consumers.

Hypothesis (H2-4): It shows that the path coefficient of the exogenous latent variable of price on purchase intention of chocolate is (0.152) and its t-statistic is (2.797), which has a positive, direct, and significant effect. Therefore, the null hypothesis is accepted. The study by Brown *et al*. (2020) confirms this. The most influential factors for purchase intention chocolate among all chocolate consumers investigated by NCA were mood, brand, and price (NCA, 2019).

Conclusion and Suggestions

In the comments section of the questionnaire, many respondents expressed a preference for purchasing domestic chocolates to support the local industry. While they acknowledged that foreign chocolates are superior in quality, taste, aroma, and flavor, they found them unaffordable. Additionally, due to concerns about the expiration dates and storage conditions of imported chocolates, they tend to prefer domestic options, indicating significant potential for growth in the local market. Given the popularity of chocolate production and consumption in Iran, this theoretical framework can serve as a

foundation for future studies on consumer behavior in the chocolate industry. It is recommended that chocolate manufacturing companies pay more attention to quality, taste, aroma, and smell. Also, in the chocolate industry, they should focus on product development, increasing brand trust, improving packaging, appropriate pricing, attractive marketing and advertising, continuous market research, active customer support, and paying attention to the demographic diversity of consumers. Based on the results of the research, by planning and using appropriate marketing strategies, they can successfully market their products, manage the market effectively, achieve good sales, and find a good position in the domestic and foreign markets.

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عوامل مؤثر بر قصد خرید شکلات توسط مصرف‌کنندگان

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چکیده

این پژوهش با هدف بررسی انگیزه‌ها و نگرش‌های مصرف‌کنندگان به انتخاب شکلات و تأثیر آن بر قصد خرید انجام شد. برای این منظور با استفاده از مدل معادلات ساختاری تأثیر متغیرهای سلامت، خلق و خو، کنترل وزن، شکلات‌گرایی، حسی، بسته‌بندی، قیمت و اعتماد به برند بر قصد خرید شکلات بررسی شده است. نتایج این تحقیق حاکی از آن است که تنها متغیر خلق تأثیر مثبت و معناداری بر اعتیاد به شکلات دارد. همچنین متغیرهای اعتماد برند، بسته‌بندی و قیمت بر قصد خرید شکلات تأثیر مثبت، مستقیم و معناداری دارند. متغیرهای خلق و خو و بسته‌بندی با تفاوت زیادی تأیید شده‌اند که نشان می‌دهد این دو عامل از نظر مصرف‌کننده بسیار مهم هستند. بنابراین روحیه مصرف‌کنندگان می‌تواند تأثیر بسزایی در مصرف شکلات داشته باشد. علاوه بر این، بسته‌بندی جذاب این قابلیت را دارد که توجه مصرف‌کنندگان را به خود جلب کند و اطلاعات مهمی را در مورد محصول از جمله طعم، مواد تشکیل دهنده و ارزش غذایی منتقل کند. همچنین اکثر مصرف‌کنندگان محصولات شکلات را از برندهای مورد اعتماد خود خریداری می‌کنند، بنابراین در این مورد معمولاً برندهای معروف و معتبر دارای مزیت هستند، حساسیت قیمت در گروه‌های مصرف‌کننده متفاوت است. این عوامل اغلب به هم مرتبط هستند و اهمیت آنها ممکن است بسته به ترجیحات فردی، جمعیت‌شناسی و روند بازار متفاوت باشد.

واژه‌های کلیدی: انگیزه انتخاب، شکلات، قصد خرید، نگرش

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Decomposition of Factor Productivity Growth of Rice in Iran: Application of Stochastic Frontier Analysis Approaches

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Abstract

Rice is a crucial agricultural product, and enhancing its productivity is essential for increasing production. This study aims to analyze the total factor productivity growth of rice production in Iran from 2000 to 2020. Using parametric (stochastic frontier analysis) approaches, the research evaluated the rice productivity growth and its components, including scale and technological changes. Based on the estimated Translog Cost Function, the annual total factor productivity growth was 2.1%, with positive technological change as the primary driver of these improvements. To further enhance productivity, the study recommends utilizing improved seeds, modern machinery, fertilizers, and nutritional solutions during rice cultivation. Additionally, the research suggests the application of parametric approaches in future studies to assess the impact of technological changes on crop yields.

Keywords: Iran, Productivity growth, Rice, SFA, Technological changes

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Introduction

Economically, increasing agricultural production to feed boosting population is an important priority to deal with food insecurity. One of the best solutions to increase production is to improve total factor productivity. Because the increasing food demand of a growing population, combined with limited resources, productivity in the process of sustainable development is desirable. Economists believe that achieving a high economic boom, most often measured by Gross Domestic Product (GDP), is no longer the best reflection of wealth, social welfare, and the potential to expand entrepreneurship, but it's also important to continuously balance economic, environmental, and social development (e.g. Surya *et al.*, 2021).

Improving the production and factor productivity of rice can help to match the four dimensions of food security, i.e. food availability, food access, food use and quality, and food stability because of its range of distribution pattern, and its current production and demand, especially in developing countries where poverty, hunger and malnutrition ensues (Mijena *et al.*, 2022). In order to achieve sufficient productivity growth in different sectors of the country, including agriculture, it is necessary to have a true understanding of the productivity growth rate of all factors of production and to know its components. Therefore, it is very important and necessary to calculate productivity by separating different sectors of the economy through an appropriate quantitative measure (Ansari *et al.*, 2017). Total factor productivity (TFP) growth is the ratio of total output to all inputs used in the production process and measures the efficiency of all factors of production (Houedjofonon *et al.*, 2020) and represents the combination of technological change, efficiency change and scale change that determine the productivity growth rate altogether (Li *et al.*, 2017). Limited overall productivity growth is currently a major economic challenge for many countries. To address this issue, planners and administrators are prioritizing productivity growth in all sectors, but particularly in agriculture. Increasing productivity in this sector can support economic growth while meeting nutritional needs, given the unique economic make-up of nations (Duernecker *et al.*, 2017).

Considering the importance and position of productivity growth and its determinants, several researches have been carried out on productivity growth and the factors influencing it. Datta and Christoffersen (2005) investigated the scale and technological changes in order to found the TFP growth of US in textile and apparel industries. The results with translog cost function revealed that the rate of technical change is higher in textiles than in apparel, however, scale effect is more important in apparel industry. Dashti *et al.* (2015) investigated the direction and trend of total factor productivity change of production and the factors affecting the Iranian cotton product applying non-parametric (Tornqvist-Theil index) and parametric (Translog cost function) approaches. The results showed that the annual growth of total factor productivity increased by 1.7% according to the Tornqvist-Theil index and by 1.53% according to the annual growth of translog cost function, which was mainly due to technological change. Translog distance function and Malmquist index were used to calculate total factor productivity (TFP) growth and its components by Xie *et al.* (2021) in China's electricity industry. It was found that scale effect, technological change and efficiency change affect productivity growth, and scale effect has the largest impact on productivity growth. Raei *et al.* (2021) investigated the analysis of the total factor productivity growth of the wheat production by translog cost function in the counties of Fars province. They found that total factor productivity grew by 0.029% on average over the period considered, and thus the contribution of scale effect to total factor productivity growth was greater than the contribution of technological change. Djoumessi, (2022) calculated the trend in total

factor productivity growth in the agricultural sector and the factors influencing it were assessed in 23 African countries using the translog cost function. The results showed that most of the changes were mainly due to technological change.

Iran's production and yield of rice were respectively 1.9 million ton and 3571 Kg/ha in 2010 and 3 million ton and 5395 Kg/ha in 2020 (Ministry of Agriculture Jihad, 2022). Therefore, due to the growing population and the resource constraint, it is necessary to identify the factors that affect the total factor productivity growth of this product in the country, so that production can be increased through investment and planning in this sector. This research, at the micro-level research helps farmers to understand the productivity process of production factors and the factors influencing it and at the macro level, it also helps policy makers in the agricultural sector by identifying the main factors affecting productivity growth and studying them in order to plan how to increase agricultural productivity. In this study, we want to measure the total productivity growth of rice production factors from a parametric approach, decomposing it into its components and analyzing the rate of productivity growth and the most important factor affecting the rice crop during the years 2000-2020.

Materials and Methods

There are two main methods of measuring total factor productivity: the parametric approach indirectly estimates total factor productivity after estimating the respected function and the non-parametric approach directly calculates total factor productivity without using a function (Murray & Sharpe, 2016). In this study we estimated the total factor productivity with parametric method and decompose it to scale and technological changes. In parametric methods a cost or production function can be used to estimate the productivity growth and its components. In the economic literature, the cost function is said to have a number of advantages over the production function, the most important of which is the lack of collinearity between input price variables. Therefore, the cost function approach is used. In this study, a translog cost function, which does not impose any restrictions on the structure of production and shows substitution between inputs, was considered as a suitable functional form to estimate total productivity growth. The flexibility and reliability of the results are the main reasons for the widespread use of this function by researchers (Datta & Christoffersen, 2005).

The empirical form of the Translog Cost Function can be given as follows (Kamruzzaman *et al*., 2021):

$$LnC_{it} = \alpha_0 + \alpha_{qi} lnQ_{it} + \alpha_l lnP_{lit} + \alpha_f lnP_{fit} + \alpha_m lnP_{mit} + \beta_t lnT + \frac{1}{2}\gamma_{qq}(lnQ_{it})^2 + \frac{1}{2}\gamma_{il}(lnP_{lit})^2 + \frac{1}{2}\gamma_{if}(lnP_{fit})^2 + \frac{1}{2}\gamma_{im}(lnP_{mit})^2 + \frac{1}{2}\beta_{tt} lnT^2 + \gamma_{lf}\, lnP_{lit} lnP_{fit} + \gamma_{lm}\, lnP_{lit} lnP_{mit} + \gamma_{fm}\, lnP_{fit} lnP_{mit} + \gamma_{lq}\, lnP_{lit} lnQ_{it} + \gamma_{fq}\, lnP_{fit} lnQ_{it} + \gamma_{mq}\, lnP_{mit} lnQ_{it} + \theta_{lt}\, lnP_{lit} lnT + \theta_{ft}\, lnP_{fit} lnT + \theta_{mt}\, lnP_{mit} lnT + \theta_{qt} lnQ_{it} lnT \quad (1)$$

In Eq. (2), P_{lit} is the price of labor in the province at time *t*, P_f is the price of chemical fertilizer, P_m is the price of farmyard manure, Q is the quantity of product and T is the time trend variable, i is the target area, α, β, γ and θ are the parameters of the model. After estimating the parameters of the cost function, the rate of technological change can be calculated by taking the derivative of the estimated cost function with respect to the time trend variable in the form of Eq. (2) (Kant & Nautiyal, 1997):

$$TC = -\frac{\partial \ln C_{it}}{\partial \ln T} = \beta_t + \beta_{tt} \ln T + \theta_{lt} \ln P_{lit} \theta_{ft} \ln P_{fit} + \theta_{mt} \ln P_{mit} + \theta_{qt} \ln Q_{it} \quad (2)$$

The basic assumption is that cost will decrease with time and that as a consequence

technology will improve. A negative value on the right-hand side indicates technology improvement, while a positive value indicates deterioration in the technology. The cost elasticity reveals the percentage rise in cost associated with a one percent change in production (Datta & Christoffersen, 2005) which offers information on returns to scale (Kuroda, 1989). The cost elasticity is given by Eq. (3). If EC is less than one, it indicates that the product is economically efficient to produce

$$EC = \frac{\partial \text{ Ln } C_{it}}{\partial \text{ Ln } Q_{it}} = \alpha_{qi} + \gamma_{qq} \ln Q_{it} + \gamma_{lq} \ln P_{lit} + \gamma_{fq} \ln P_{fit} + \gamma_{mq} \ln P_{mit} + \theta_{qt} \ln T \quad (3)$$

Productivity growth of production factors is one of the most important and fundamental aspects of economic production. By estimating the cost function the changes in the productivity growth index are estimated in the form of Eq. (4) (Datta & Christoffersen, 2005):

$$T\dot{F}P = \left(1 - \frac{\partial \text{ Ln } C}{\partial \text{ Ln } Q}\right) \frac{\partial \text{Ln} Q}{\partial T} + \frac{\partial \text{Ln } C}{\partial T} \quad (4)$$

The scale effect , indicating that the rate of increase in costs was higher than the rate of increase in the quantity of product, this variable is the product of (scale economies +1) the output growth rate, so the sum of the scale effect and technological change variables equals total factor productivity growth (Datta & Christoffersen, 2005). Eq (5) is used to calculate the production growth rate:

$$\dot{Q} = \frac{\partial \text{Ln} Q}{\partial T} = \frac{\text{Ln } Q_t - \text{Ln} Q_{t-1}}{\text{Ln} Q_{t-1}} \quad (5)$$

where, $\text{Ln}Q_t$ is the logarithm of the product value in year t and LnQ_{t-1} is the logarithm of the product value in year t-1.

As the data were collected from five major rice producing provinces (Mazandaran, Guilan, Golestan, Khuzestan and Fars) over a period of 21 years (2000-2020), they can be classified as panel data. Limer's F-test is used to confirm this classification. When working with panel data, the first step is to determine whether to use a fixed or random effects model before estimating the function. In this study, real prices are used for the estimation, with the year 2000 serving as the base year. Since relative prices are used in cost estimation, the costs and prices of all facilities are normalized by dividing them by the input price of pesticides.

Data

The necessary statistics and information at the national level for this study were obtained from the Ministry of Agricultural Jihad and the Statistical Center of Iran. The variables used in this research, including price, rice production, prices and cultivated area, chemical fertilizers, manure, pesticides, labor and seeds, were collected for the period of 2000 to2020. The data were analyzed in Excel 2017 and STATA 17 software to calculate total factor productivity.

Results and Discussion

Before estimating the translog cost function, we ensured that the data were either panel data or pool data based on the information available. For this purpose, the Limer's F test was used as part of our research. Note that in this test we rejected the null hypothesis based on pooling data at a 5% significance level and thus, the model was used for further analyses. Then, the Hausman test was applied for testing whether our panel data is a fixed effect (FE) or random effect (RE), and accepting the null hypothesis the model was realize to be FE. Based on the results, the cost of rice production is significantly affected by input prices (labor, farmyard manure and chemical fertilizer), product quantity, and the time trend variable (technology). Therefore, the translog cost function was estimated using these three inputs. In addition, the quantity of product and the time trend variable (t) were also included in the cost function. The estimated coefficients are shown in Table 1.

Considering the obtained coefficients from Table 1, the trend of total factor productivity change, including scale and technological change, are calculated for the years 2000-2020 and shown in Table 2. As shown, the annual technological change is -0.206 on average

implying that technological change has led to cost reductions over time. In fact, the use of new technologies has had a positive impact on the quantity of rice produced in the country and on total productivity growth. Dashti *et al.* (2015), Vahidi *et al.* (2022), Bragagnolo *et al.* (2010) and Djoumessi (2022) found similar results and identified technological change as the main factor in total factor productivity growth in their researches. The annual average of the scale effect is 1.223, indicating that the rate of increase in costs was higher than the rate of increase in the quantity of product during the studied years. The total factor productivity growth over this period was subject to irregular fluctuations and finally resulted in a slight increase of 2.1%, which shows a positive and growing rate of total factor productivity.

Table 1- Coefficients of the translog cost function

Parameters	Coefficients	t-statistic	Parameters	Coefficients	t-statistic
γ_{lf}	-0.2***	-3.33	α_0	39.4***	2.67
γ_{lm}	-0.84***	-2.68	α_{qi}	1.3	-0.67
γ_{fm}	0.004	0.09	α_l	-6.39**	-2.01
γ_{lq}	0.6*	1.73	α_f	2.9***	3.20
γ_{fq}	-0.2***	-2.74	α_m	4.1*	1.89
γ_{mq}	-0.1	-0.70	β_t	-0.7***	3.36
θ_{lt}	-0.01	-0.12	γ_{qq}	0.02	0.17
θ_{ft}	0.04	0.86	γ_{il}	0.05***	6.38
θ_{mt}	-0.84***	-3.71	γ_{if}	0.1***	3.84
θ_{qt}	-7.2***	-3.8	γ_{im}	-0.1	-0.89
			β_{tt}	0.3***	5.65

Table 2- Decomposition of rice TFP in Iran during 2000-2020

Year	Scale change	Technological change	Productivity growth
2000	-	0.520	-
2001	0.118	-0.433	-0.437
2002	0.516	-0.056	-0.057
2003	0.681	0.398	0.7
2004	0.821	-0.845	-0.477
2005	1.06	-0.495	-0.123
2006	1.437	-0.856	-1.007
2007	1.640	-1.250	-1.117
2008	1.240	0.543	0.591
2009	1.395	-0.035	0.083
2010	1.304	-0.094	0.177
2011	1.612	-0.605	-0.640
2012	1.682	-0.665	-0.807
2013	1.211	0.771	0.943
2014	1.342	0.058	0.070
2015	1.35	-0.236	0.080
2016	1.247	0.367	0.834
2017	1.466	-0.741	0.236
2018	1.344	-0.559	-0.005
2019	1.658	-0.080	0.692
2020	1.344	0.420	0.448
Average	1.223	-0.206	0.021

Conclusion

In this study, the total factor productivity of rice production in the main producing provinces of Iran, including Mazandaran, Guilan, Golestan, Fars and Khuzestan, was calculated over a period of 21 years (2020-2000) using parametric methods. The prices of labor, manure, chemical fertilizer, product and technology are used to estimate the cost production function. The results show that total factor productivity growth in rice production is positive. Therefore, the total factor productivity of the production in the country had increased during the studied years, and the most of this growth had been due to technological change. Technological change according to the parametric method had a negative sign, which confirm the positive effect of new technologies on rice production and therefore improved productivity. According to parametric approaches, since technological change has a positive effect on the total factor productivity in rice production, it is recommended to pay attention to new technologies such as machines, improved seeds and the use of nutritional supplements on farms. The scale effect has caused a decrease in total factor productivity growth, so it is recommended that studies be carried out at farm level to have a better understanding of its effect, in order to be more confident about the direction and extent of the impact of scale change on total factor productivity that can be expressed.

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مقاله پژوهشی

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تجزیه رشد بهره‌وری عوامل تولید محصول برنج در ایران: کاربرد رهیافت تحلیل مرزی تصادفی

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چکیده

برنج یکی از محصولات مهم کشاورزی بوده که بهبود بهره‌وری عوامل آن پیش‌شرط اساسی افزایش تولید این محصول است. هدف مطالعه حاضر تجزیه رشد بهره‌وری کل عوامل تولید محصول برنج در ایران است. داده‌های موردنیاز برای استان‌های مختلف و مربوط به دوره زمانی ۱۳۹۹-۱۳۷۹ از وزارت جهاد کشاورزی و مرکز آمار ایران تهیه گردید. با بکارگیری رهیافت پارامتریک (رهیافت مرزی تصادفی)، رشد بهره‌وری و مؤلفه‌های اثرگذار آن ازجمله تغییرات مقیاس و تکنولوژی مورد ارزیابی قرار گرفتند. با برآورد تابع هزینه ترانسلوگ، میانگین رشد سال‌های مورد مطالعه بهره‌وری کل عوامل ۲/۱ درصد محاسبه شد. بر طبق یافته‌ها، رشد بهره‌وری عوامل تولید در کشور مثبت بوده است وعمده این تغییرات ناشی از بهبود تکنولوژی‌های مورد استفاده بوده است. از آنجائی‌که تغییر تکنولوژی سهم قابل ملاحظه‌ای در ارتقای بهره‌وری عوامل در این رهیافت دارا است لذا توصیه می‌شود که در فرآیند تولید محصول برنج از نمادهای فناوری شامل بذر اصلاح شده، ماشین‌های مناسب، کودها و محلول‌های تغذیه‌ای بهره‌گرفته شود. نتایج حاصله از اطمینان کافی برخوردار بوده و پیشنهاد می‌شود در مطالعات آتی نیز حتی‌الامکان از رویکرد پارامتری استفاده به عمل‌آید.

واژه‌های کلیدی: برنج، تحلیل مرزی تصادفی، تغییرات تکنولوژی، رشد بهره‌وری، ایران

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Prioritizing Iran's Saffron Target Markets Based on Market Competition Indices

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Abstract

Exporting agricultural products is considered as one of the strategies for developing non-oil exports and achieving sustainable economic growth in developing countries. Saffron, as an export commodity, holds particular significance in Iran's non-oil exports. Given Iran's position among the top four saffron-exporting countries globally, this study aims to prioritize Iran's saffron target markets based on market competition indices and calculate its relative advantage and export stability index in the world market and Iran's export target countries. Comparison of the global market structure of the product during 2003 to 2022 revealed that despite the significant shares of Iran, Spain, England, and Nigeria in most years, the market structure has been characterized by a multi-sided monopoly, open and closed, and in some years dominated by oligopoly, indicating an increase in the number of competitors and the competitiveness of the export market for this product. Iran, with an average share of 13.6% in the saffron export market and producing over 80% of saffron, does not have a direct share in global exports, and most of Iran's saffron is exported to countries such as the UAE, Spain, China, and Oman, and then re-exported to other countries, for which strategies such as market expansion and branding need to be prioritized. The results showed that in 2022, four countries, Nigeria, Sri Lanka, Iran, and Spain, accounted for 93% of the total world exports, and Iran ranked second in terms of export volume in the saffron export market during the study period. Also, Iran had an export stability index of less than one (0.96) but the trend of this index indicates a decrease in Iran's stability. The results showed that the majority of Iran's saffron exports are concentrated in only four countries, with the composition of these countries varying over time. To enhance market stability and growth, it is crucial to expand the target export markets. Prioritization should be given to China, UAE, Spain, India, USA, Germany, France, Italy, Sweden, and Kuwait, with average priority ranks of 4.15, 6.85, 7.7, 7.95, 8.9, 12.3, 14.35, 15.25, 15.5, and 16.45 respectively. Furthermore, the results indicated that the export market for saffron is oligopolistic. Therefore, it is essential for all exporting countries to collaborate in determining the price and market share for each country. This collaborative approach can help in stabilizing the market, ensuring fair pricing, and promoting sustainable growth in the saffron industry.

Keywords: Export stability index, Iran, Market structure, Saffron export, Target markets

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Introduction

One of the primary objectives of developing countries is achieving sustainable economic growth and development, and expanding exports can be a direct factor in economic growth. Therefore, countries are always striving to develop their exports to benefit from opportunities, financial resources, income, and assistance to other countries based on their relative advantages (Behzadnia *et al*., 2019). Exporting goods to foreign markets is done to earn profit and continuous income while satisfying consumers. In this regard, the capabilities and abilities of each country in producing and exporting goods, as well as understanding export markets and target markets, are essential. One of the effective factors in determining a suitable strategy for the economic development of any country is having an export development strategy and relative advantage in the production and export of products. Additionally, the organizational structure of the market indicates the characteristics of the market, which can be used to determine the relationship between market components, competition, and pricing nature (RasekhJahromi & Norani Azad, 2023). Iranian saffron, as the most expensive agricultural and medicinal product in the world, plays a significant role in the country's non-oil export revenues. The main origins of this plant are regions such as Khorasan Razavi, Southern, and Northern provinces, and its cultivation and production also take place in provinces like Fars, Kerman, and Yazd. Saffron production in countries such as Spain, India, Greece, Azerbaijan, Morocco, and Italy has also been economically beneficial (Kafi *et al*., 2010). According to the International Trade Center statistics, Iran has had an average share of approximately 13.6% of the global saffron export volume during the years 2003-2022 (Fig. 1). Additionally, in 2022, Iran accounted for around 60% of the global saffron export value, with an export value of approximately $85,000 (Itc, 2023). According to global statistics, Iran is recognized as the largest producer of saffron in the world, accounting for 85 percent of the total global saffron consumption (FAO, 2019). Iran ranked first among saffron-producing countries in 2022, with the production of approximately 408 tons of saffron, which accounts for 86.2% of the world's saffron production (Agriculture Jihad, 2023). As depicted in (Fig. 1), the share of saffron exports from production in Iran increased from 61% in 2003 to 184% in 2008, reaching its highest level during the study period, and then fluctuated, reaching approximately 53% in 2022.

(Fig. 2) illustrates the value and quantity of saffron exports from Iran during the period 2003-2022. The weighted quantity of exports of this product decreased from approximately 141 tons in 2003 to about 66 tons in 2009, indicating a reduction of approximately 53%.

Fig. 3 illustrates the status of Iran's saffron exports in 2022. As observed, Iran exported saffron to 60 countries worldwide, with a total export value of $201.6 thousand. The most important of these countries include the UAE, Spain, China, Qatar, India, and Afghanistan, with export values of $77.8, $44.2, $30.4, $8.4, $7.6, and $5.4 thousand, respectively.

A study on the saffron market structure during the period of 2001-2018 was conducted using the Herfindahl-Hirschman index and numerical taxonomy method to prioritize Iran's target markets based on criteria such as market continuity, average price in US dollars, average share of imports by the target country, price volatility coefficient in US dollars, and share of import volatility coefficient by the target country. The results of this research indicated that the saffron market during the period of 2001-2018 was of the monopolistic, oligopoly, and closed type.

The examination of the global market structure and comparative advantage, along with the measurement of export and import sustainability indices, and prioritization of target markets for Iran in the saffron market, are subjects that always require attention from actors in this sector and agricultural policymakers. This research intends to address these aspects. While most studies have primarily focused on identifying the type of

market structure of a product using comparative advantage methods and non-price indicators to select target markets, this study goes further. In addition to investigating the global saffron market structure, Iran's market structure, and Iran's export advantage to other countries, it also examines the sustainability indices of exports and imports of global countries. Moreover, a more precise prioritization of Iran's target markets is conducted using the Topsis method. These objectives aim to provide a comprehensive framework for making strategic decisions regarding saffron export from Iran, contributing to improving the efficiency and effectiveness of the country's agricultural and trade policies.

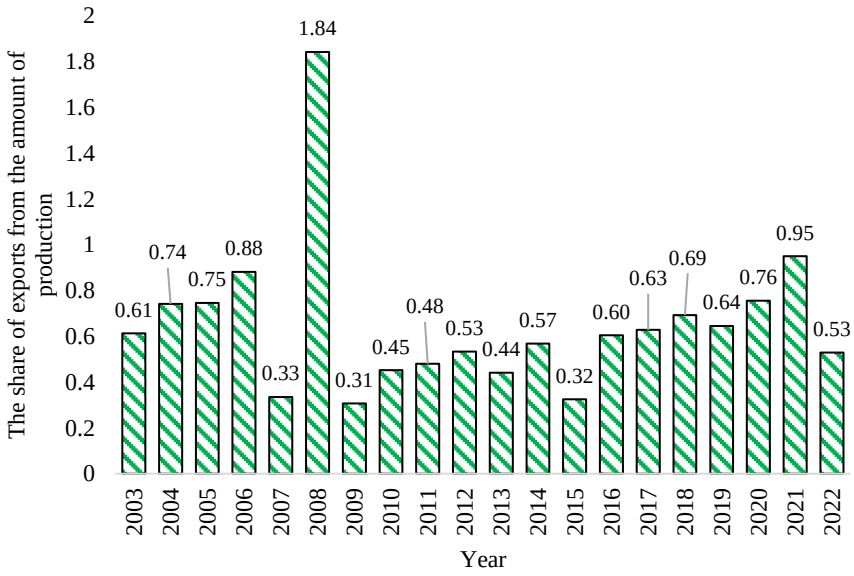

Figure 1- The share of Iran's saffron exports from production during the years 2003-2022

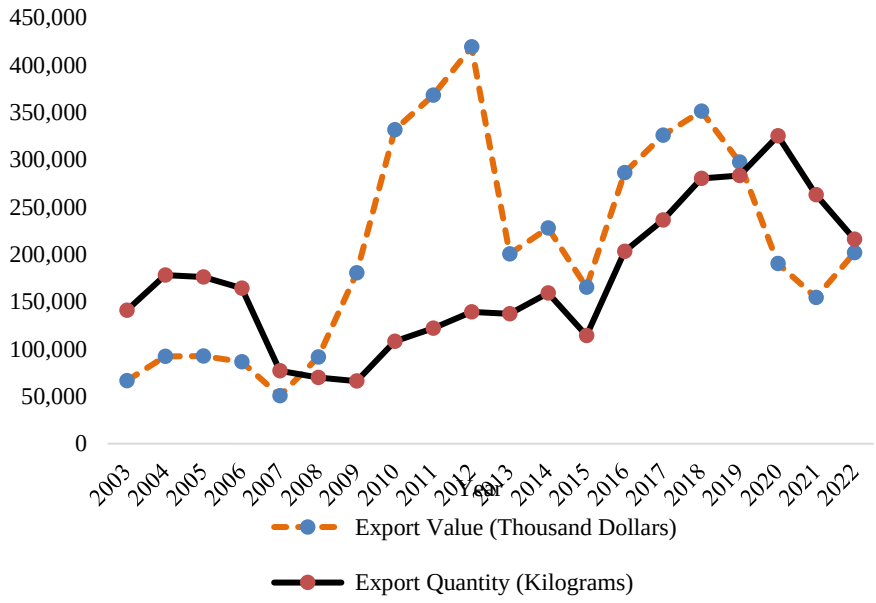

Figure 2- Export value and export quantity of Iranian saffron products during the years 2003-2022

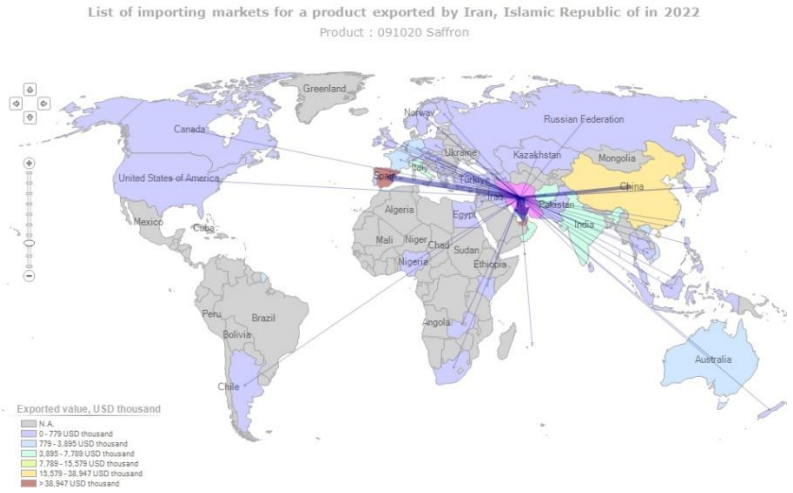

Figure 3- The value export map of Iranian saffron to the world in 2022
Source: International trade center 2023

Methodology

According to theories of international trade, actions must be taken for export development in every country. These actions include identifying relative advantages, ranking industries with comparative advantages, and investing in the development of export activities. This entails first identifying the potentials and advantages that a country possesses, deciding on which industries and economic sectors to concentrate on, and ultimately deploying resources and investments towards the development of export activities (RasekhJahromi & Norani Azad, 2023). According to the law of comparative advantage, if a country can produce and export a product at a lower cost than other countries, it can profit more from trading this commodity (Hanson *et al*., 2015). There are various methods for measuring comparative advantage, which are explained below.

One of the most common indices used to measure comparative advantage is Revealed Comparative Advantage (RCA), which is calculated using equation (1).

$$RCA_{ij} = \frac{\frac{x_{ij}}{\sum_i x_{ij}}}{\frac{\sum_j x_{ij}}{\sum_i \sum_j x_{ij}}} \quad (1)$$

Which x_{ij} represents the value of commodity i exports by country j, $\sum_i x_{ij}$ is the total value of exports by country j, $\sum_j x_{ij}$ is the total value of commodity i exports in the world, and $\sum_i \sum_j x_{ij}$ is the total value of world exports. In other words, the numerator represents the share of commodity i in the country j total exports, and the denominator represents the share of commodity i in total world exports. The value of the index ranges from zero to one, indicating the absence of comparative advantage in the examined commodity (Raheli, 2017). An improvement in this index over time can be seen as an indication of a country's improved competitive position in the global market. Since there is an asymmetry in this index, researchers also use the Symmetric Revealed Comparative Advantage index (Equation 2), (Brasili *et al*., 2000):

$$RSCA_{ij} = \frac{RCA_{ij} - 1}{RCA_{ij} + 1} \quad (2)$$

The range of changes in this index is between positive one and negative one, where negative values indicate a lack of comparative advantage and positive values indicate the presence of comparative advantage in exporting a product.

One of the objectives pursued in this research is to examine market structure. The market structure refers to the organizational characteristics of the market, including the

concentration of sellers, the centrality of buyers, entry conditions, and product homogeneity, which, when identified, can determine pricing nature, market competition, and market type. Market structure indicates the organizational features of the market that can be used to determine the relationship between market competition components and pricing nature (Gajurel & Pradhan, 2012). The number of producers and their scale are two important factors in determining market structures. Therefore, the fewer the number of producers in the market and the larger share of the market held by a limited number of producers, the greater the likelihood that the market structure is monopolistic.

A. Concentration Ratios (CR_n): This index indicates the concentration of production of a product in several countries and can also indicate various market structures between perfect competition and perfect monopoly. This index is defined by (Equation 3):

$$\boldsymbol{CR_n = \sum_{i=1}^{n} S_{i_{2,\dots,k}} \quad k > n} \tag{3}$$

In this equation, k represents the total number of producers, n denotes the number of major producers, S_i is the market share of producer i, and CR_n is the concentration ratio of n producers.

B. Herfindahl-Hirschman Index (HHI): To address some of the shortcomings of the concentration ratios, the Herfindahl-Hirschman Index has been proposed to measure market power, which is calculated as the sum of squared market shares of all producers. This index is obtained from (Equation 4), (Gajurel *et al*., 2012):

$$\boldsymbol{HHI = \sum_{i=1}^{k} S_i^2} \tag{4}$$

In this equation, k represents the number of countries producing the product worldwide, and S_i denotes the market share of the i-th producer. If there is an infinite number of firms with equal-sized shares in the market, the Herfindahl-Hirschman Index (HHI) will be very small, and if there are few producers with unequal shares in the market, the index value will be close to one. In other words, the closer its value is to zero, the higher the competitive degree of the market, and the closer it is to one, the higher the degree of monopoly and concentration. One advantage of this index is that it considers the market shares of all producers and reflects the market type (the number of firms with equal shares). The reason for choosing these two indices in this study is that they are the best indicators for measuring the degree of competition and monopoly. The determination of market structure using a combination of concentration ratios and the Herfindahl-Hirschman Index is shown in (Table 1), (Liaghati *et al*., 2017). Competitive markets, monopolistic competition, monopolistic markets, dominant firms, and perfect monopoly each have their characteristics. In a perfectly competitive market, most economic actors are competing to attract customers, and no country can set prices; prices are determined by supply and demand equality. A monopolistic competition market is similar to a perfectly competitive market, but the goods are heterogeneous, differing in packaging and quality. In an oligopolistic market, a country or group of countries controls a portion of the market and interacts with customers, suppliers, and other market participants, with free entry and exit of countries. However, in a closed oligopolistic market, laws and regulations impose restrictions on the behavior of countries, limiting free entry and exit. In a dominant firm scenario, one country or a group of countries exerts control over others and can influence market conditions. A perfect monopoly market means that one country or a group of countries controls the market, and no other country enters this market, holding the complete market share (100%), (Table 1).

Table 1- Types of market structures

The main feature of the market	(HHI)	Concentration ratio (Percentage)	Market
There are more than 50 competing firms without a monopoly on a significant market share.	$\mathrm{HHI} \to 0$	$\mathrm{CR}_1 \to 10$	Perfect competition
None of the competing firms monopolizes more than 10% of the market.	$(1/\mathrm{HHI}) \to 10$	$\mathrm{CR}_1 < 10$	Exclusive competition
4 companies have a monopoly of up to 40% of the market.	$6 < (1/\mathrm{HHI}) \leq 10$	$\mathrm{CR}_4 < 40$	Open multilateral monopoly
Firms have at least 60% of the market. 4	$3 < (1/\mathrm{HHI}) \leq 6$	$\mathrm{CR}_4 > 60$	Closed Multilateral monopoly
More than 50% of the market is monopolized by one firm.	$1 < (1/\mathrm{HHI}) \leq 3$	$\mathrm{CR}_1 \geq 50$	Dominant enterprise
One firm monopolizes the entire market.	$\mathrm{HHI} \to 1$	$\mathrm{CR}_1 \to 100$	Complete monopoly

Source: (Maddala *et al.*, 1995)

One of the most common methods for prioritizing markets based on several indicators is the Topsis approach, which is used to rank regions in terms of relative advantages, potentials, and capacities. The Topsis approach is a multi-criteria decision-making method (Chen & Hwang, 1992). To combine multiple indicators that can provide different perspectives on a specific subject, various methods have been proposed, such as factor analysis, cluster analysis, principal component analysis, and numerical taxonomy. Among these methods, the Topsis approach can calculate both positive ideals (most efficient state) and negative ideals (least efficient state) for each indicator and then measure the distance of each option from these positive and negative ideals. In this method, the selected option is the one with the shortest distance from the positive ideals and the longest distance from the negative ideals. This technique is designed in a way that allows for assessing the type of indicators in terms of their positive or negative impact on the decision-making objective in the evaluation model, and by assigning weights to them, it determines the importance of each indicator in the model, which can be considered an advantage over other methods.

If there are m options and n indicators, the following steps should be taken for prioritization:

Formation of a data matrix based on *m* options and *n* indicators:

$$\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \quad (5)$$

Standardizing the data and forming the standard matrix can be achieved through the following equation:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} (a_{kj})^2}} \quad (6)$$

Determining the weight of each indicator (W_i) based on $\sum_{i=1}^{n} w_i$. In this regard, indicators with greater importance have higher weights. In this study, entropy has been used for weighting the indicators. The matrix (V) is the result of multiplying the standardized values of each indicator by their respective weights.

$$\begin{bmatrix} w_1 r_{11} & \cdots & w_n r_{1n} \\ \vdots & \ddots & \vdots \\ w_1 r_{m1} & \cdots & w_n r_{mn} \end{bmatrix} \quad (7)$$

Determining the distance of the i-th alternative from the ideal alternative (the highest performance of each indicator), denoted by (A^+).

$$A^+ = \{(MaxV_{ij} | j \varepsilon J), (MinV_{ij} | j \varepsilon J')\}$$

$$A^+ = \{A_1^+, A_2^+, \ldots, A_n^+\} \quad (8)$$

Determining the distance of the i-th alternative from the minimum alternative (the lowest performance of each indicator), denoted by (A^-).

$$A^- = \{(MaxV_{ij}|j\varepsilon J),(MinV_{ij}|j\varepsilon J')\}$$

$$A^- = \{A_1^-, A_2^-, \dots, A_n^-\} \quad (9)$$

Determining a distance metric for the ideal alternative and the minimum alternative S_i^- is as follow:

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(V_{ij} - A_j^+)^2} \quad (10)$$

Determining the coefficient equal to the distance of the minimum alternative divided by the sum of the distance of the minimum alternative and the distance of the ideal alternative, denoted as C_i^*, calculated from the following equation:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+} \quad (11)$$

The value of C_i^* ranges between zero and one, where a value closer to one indicates a higher rank.

The factors considered for the Topsis approach in this study include saffron export value, saffron export quantity, saffron export price, geographical distance between countries, per capita income of countries, Gross Domestic Product (GDP), economic size, and economic structure difference index between countries and population. The reasons for choosing each are as follows:

Population: This indicator reflects the market demand potential of the target country in the future. Assuming other factors remain constant, the larger the population in the coming years, the higher the demand for imported goods will be.

Geographical distance: This indicator shows the distance between the importing and exporting countries. It is evident that, under equal conditions, the shorter the geographical distance, the higher the possibility of imports due to lower costs. Therefore, it is considered inversely in the final ranking.

Per capita Gross Domestic Product (GDP): This indicator indicates the purchasing power of consumers. Assuming other factors remain constant, the higher the per capita income of a country, the higher its demand for goods will be.

Per capita income of saffron-importing countries: Some researchers have incorporated Gross Domestic Product (GDP) and population variables separately in the model, while others have used various variables to prevent an increase in the number of variables. In this study, the per capita income of saffron-importing countries, representing their income effect on the demand for Iranian saffron due to this group of countries, has been used.

Economic structure difference index: The economic difference index between Iran and its trading partners is another variable used in this study. The greater the similarity between two countries in terms of traded products, the greater the commercial potential. Furthermore, as the gap in economic structure decreases, the similarity in exports and imports between them increases. In other words, countries with more similarities are more inclined to trade with each other compared to dissimilar countries. The economic structure difference index in this study has been calculated using (Equation 8), (Antonucci & Manzocchi, 2006).

$$DISSIZE = Ln\left[1 - \left(\frac{GDP_{it}}{GDP_{it} + GDP_{jt}}\right)^2 - \left(\frac{GDP_{jt}}{GDP_{it} + GDP_{jt}}\right)^2\right] \quad (12)$$

Economic Size: In this study, the variable of economic size has been used to assess the impacts of the economy's magnitude. In other words, this variable indicates that the larger the economies of exporting and importing countries, the greater their effect on export volume. Therefore, in this research, the economic size variable, obtained by multiplying the gross domestic product of the exporting and importing countries, has been employed.

Additionally, the stability index of saffron-exporting countries in (equation 13) is introduced to determine the stability of saffron exporters (Ji *et al*., 2014).

$$XSI_i = \frac{\frac{Q_i^{out}}{Q^{out}}}{\frac{K_{i\to M}^{out}}{K_M}} \quad (13)$$

In this equation, XSI_i represents the stability index of the exporting country *i*, Q_i^{out} and Q^{out} denote the total value of saffron exports of country *i* and globally, respectively. Moreover, $K_{i\to M}^{out}$ indicates the number of countries importing saffron from country *i*. Finally, K_M represents the total number of importing countries in saffron trade. Essentially, (equation 9) illustrates the ratio of country *i* exports to the total global exports. If this index is greater than one, it indicates that country *i* is more reliant on its saffron exports. Additionally, the share of this country's exports of total global exports exceeds the share of its partners from all importing countries. The larger this ratio, the fewer countries the country exports to, indicating less diversity in partners. Therefore, if there is an issue with limited trading partners, the likelihood of instability for this country increases.

Similar to the stability index of saffron exporters, (equation 10) represents the stability index of saffron importers (Ji *et al*., 2014).

$$MSI_i = \frac{\frac{Q_i^{in}}{Q^{in}}}{\frac{K_{i\to x}^{in}}{K_X}} \quad (14)$$

In which MSI_i represents the stability index of the importing country *i*, Q_i^{in} and Q^{in} respectively represent the volume of saffron imports of country *i* and globally. Moreover, $K_{i\to x}^{in}$ indicates the number of markets supplied by country *i*, and K_X represents the total number of saffron exporters globally. This equation illustrates the contributions of country *i* to the global saffron imports. The denominator of this index represents the ratio of countries to country *i* that import saffron from all saffron-exporting countries. If a country's share of imports is greater than one of the total global imports, it indicates that this country relies more on its imports and has less diversity in partners from a limited number of countries. Therefore, if there are issues with limited trading partners for this country, the likelihood of instability increases.

Data

The statistical data required for this research, including export and import values, export prices, geographical distance, per capita income, gross domestic product (GDP), and population of countries was collected from the World Bank for the years 2003-2022, and from the International Trade Centre (ITC) database. It's worth mentioning that for the calculations of Topsis and the coefficients related to each country in this study, an extensive spreadsheet (Excel) was utilized.

Results

The results of the examination of the saffron export showed in (Table 2) indicate that during the years 2003-2022, Iran, England, Indonesia, and Spain held the first to fourth positions among the top exporting countries of this product in the world, respectively. However, in recent years, with Nigeria's continuous and extensive growth in the export of this product, Nigeria has joined the top four saffron-exporting countries in the world, so that in 2022, the first four positions have changed to Nigeria, Sri Lanka, Iran, and Spain, respectively. Studies show that despite Iran's high potential for production and export of this product, it has not been able to maintain its position in exports, and Iran's position has fluctuated between first and fourth variably.

The results of the examination of the structure of the global saffron export market indicate that the export market structure of this product in the world has been monopolistic, bilateral monopolistic, open, closed, and dominant firm variable. Also, in 2022, the top four saffron-exporting countries accounted for 93 percent of the total world exports, and this share has varied between 47 percent and 93 percent in the years under review. Iran's average rank in the 2003-2022 period in the

saffron export market has been second globally, and Iran's average export share in the global market during this period has been about 13.6 percent. Based on market structure indices, the most important export rivals of Iran's saffron product in the years under review have been Spain, England, Nigeria, Bangladesh, Afghanistan, India, and China (Table 2).

The results of the examination of the saffron export sustainability index, with an emphasis on the global market structure, are presented in (Table 3). As observed, Afghanistan, Spain, India, Iran, England, Bangladesh, China, and Nigeria are among the most stable exporting countries, with average sustainability indices of 0.33, 0.81, 0.85, 0.96, 1, 3.11, 3.7, and 9.95, respectively. The results indicate that Afghanistan has more target markets and higher export sustainability compared to its competitors. This is while Iran, as the largest producer of this product, ranks approximately fourth in terms of export sustainability. The coefficient of fluctuation in the sustainability index indicates that among saffron-exporting countries, Iran had less fluctuation, suggesting that its export volume and target markets have experienced fewer changes compared to other countries. England, Bangladesh, China, and Nigeria have sustainability index values greater than one, indicating instability in their exports.

Table 2- Global Saffron Export Market Structure

Market Structure	Active business competitors	1/HHI	HHI	CR_4	CR_1	Year
Closed Multilateral monopoly	Indonesia, Iran, China, Togo	4.22	0.24	0.77	0.43	2003
Closed Multilateral monopoly	Iran, England, Indonesia, Kenya	6.52	0.15	0.62	0.34	2004
Open and closed Multilateral monopoly	Iran, England, Ethiopia, Spain	9.98	0.10	0.55	0.19	2005
Open and closed Multilateral monopoly	Iran, England, Cambodia, Ethiopia	9.42	0.11	0.59	0.19	2006
Closed Multilateral monopoly	Cambodia, England, Portugal, Iran	7.33	0.14	0.63	0.28	2007
Open and closed Multilateral monopoly	England, Portugal, Spain, Iran	10.74	0.09	0.50	0.21	2008
Open and closed Multilateral monopoly	Ethiopia, England, Bulgaria, Indonesia	10.40	0.10	0.53	0.19	2009
Closed Multilateral monopoly	Indonesia, China, England, Spain	7.10	0.14	0.69	0.26	2010
Closed Multilateral monopoly	England, Iran, Spain, Indonesia	6.50	0.15	0.61	0.34	2011
Closed Multilateral monopoly	Indonesia, England, Iran, America	4.88	0.21	0.79	0.36	2012
Closed Multilateral monopoly	Indonesia, England, Iran, India	4.03	0.25	0.76	0.45	2013
Dominant enterprise	Indonesia, Iran, England, Ethiopia	3.36	0.30	0.75	0.52	2014
Open and closed Multilateral monopoly	China, Bangladesh, England, Iran	12.94	0.08	0.47	0.15	2015
Open and closed Multilateral monopoly	Iran, Ethiopia, England, China	12.28	0.08	0.48	0.13	2016
Open and closed Multilateral monopoly	Iran, England, India, Spain	11.73	0.09	0.52	0.19	2017
Open and closed Multilateral monopoly	Iran, China, England, Bangladesh	9.14	0.11	0.58	0.24	2018
Open and closed Multilateral monopoly	Spain, Iran, Bangladesh, England	9.82	0.10	0.57	0.19	2019
Closed Multilateral monopoly	Nigeria, Spain, Iran, Afghanistan	6.21	0.16	0.69	0.32	2020
Dominant enterprise	Nigeria, Spain, Iran, England	2.03	0.49	0.85	0.69	2021
Dominant enterprise	Nigeria, Sri Lanka, Iran, Spain	2.51	0.40	0.93	0.51	2022

Table 3- The sustainable development index of world countries in saffron export

Year	Iran	Spain	England	Bangladesh	Afghanistan	India	China	Nigeria
2003	1.42	0.46	0.33	-	-	1.04	4.57	-
2004	2.49	1.68	0.85	-	-	2.64	8.31	-
2005	1.18	0.37	0.88	-	-	1.04	2.82	-
2006	1.43	0.46	1.20	-	-	1.20	4.23	-
2007	0.59	0.23	0.98	-	-	1.86	3.85	0.17
2008	0.86	0.68	1.27	1.76	-	0.76	1.85	-
2009	0.58	0.32	0.54	1.33	-	0.88	3.05	-
2010	0.49	0.76	0.68	0.28	-	0.45	4.44	-
2011	0.79	0.47	1.58	0.51	-	0.45	5.77	-
2012	1.17	1.21	1.08	0.22	0.22	0.63	2.39	-
2013	1.28	1.28	2.95	1.09	0.16	0.90	8.39	6.54
2014	0.54	0.25	0.50	0.08	0.05	0.92	4.92	-
2015	0.41	2.55	0.45	1.03	0.15	0.59	3.42	-
2016	0.81	0.26	0.79	5.75	0.16	0.30	4.59	-
2017	0.63	1.44	0.48	3.01	0.15	0.22	3.26	-
2018	1.54	0.34	0.98	5.78	0.61	1.02	6.57	-
2019	1.03	0.81	0.43	13.83	0.36	0.39	0.36	1.17
2020	0.68	0.63	0.23	1.24	0.52	0.11	0.48	10.19
2021	0.65	0.94	1.17	5.48	0.53	0.66	0.24	23.22
2022	0.72	1.01	2.55	5.33	0.76	0.98	0.55	18.43
Average	0.96	0.81	1.00	3.11	0.33	0.85	3.70	9.95
Coefficient of variation	0.51	0.73	0.70	1.18	0.70	0.68	0.65	0.93

Source: Research Findings

The market structure of Iran's saffron exports based on the concentration ratio and Herfindahl-Hirschman index over the study period is examined and reported in (Table 4). As observed, Iran's export market structure has been a closed bilateral monopoly (with a dominant firm in 2003). The combined market share of the top four importing countries of Iranian saffron (based on the CR_4 index) has ranged from 66 to 88 percent, with changes in the composition of these countries over time. The high share of these four countries in saffron imports from Iran indicates that Iran's export target countries have been limited, posing a risk that if imports from these countries are restricted, Iran may face challenges and lose its export power and bargaining power. It is worth mentioning that the most important importing countries of Iranian saffron during the study period have been the UAE, Spain, Saudi Arabia, China, Hong Kong, Italy, and Oman (Table 4).

(Table 5) illustrates the sustainability index of the top importing countries of saffron in the world during the years 2003-2022. The results indicate that Oman, Italy, China, Saudi Arabia, Spain, Hong Kong, and the UAE are respectively the most significant importers of saffron globally, with average import sustainability indices of 0.12, 0.15, 0.17, 0.23, 0.25, 0.26, and 0.47. The results show that among saffron-importing countries, Oman enjoys greater sustainability compared to its competitors, and the number of countries from which it imports saffron is higher than other countries.

Table 4- Structure of Iran's saffron export market

Market Structure	Active Commercial Competitors in Imports from Iran	1/HHI	HHI	CR4	CR1	Year
Dominant enterprise	Emirates, Spain, Italy, France	2.88	0.35	0.88	0.50	2003
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, France	3.27	0.31	0.84	0.44	2004
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, India	3.57	0.28	0.80	0.45	2005
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, Italy	3.90	0.26	0.83	0.38	2006
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, Italy	3.85	0.26	0.84	0.36	2007
Closed Multilateral monopoly	Spain, Emirates, Italy, Saudi Arabia	4.06	0.25	0.83	0.39	2008
Closed Multilateral monopoly	Spain, Emirates, Italy, Saudi Arabia	3.35	0.30	0.86	0.42	2009
Closed Multilateral monopoly	Emirates, Spain, Italy, Saudi Arabia	3.44	0.29	0.86	0.38	2010
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, China	3.98	0.25	0.79	0.39	2011
Closed Multilateral monopoly	Emirates, Spain, China, Saudi Arabia	4.41	0.23	0.81	0.36	2012
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, Hong Kong	3.93	0.25	0.82	0.39	2013
Closed Multilateral monopoly	Emirates, Spain, Saudi Arabia, China	3.78	0.26	0.82	0.44	2014
Closed Multilateral monopoly	Emirates, Spain, China, Saudi Arabia	4.39	0.23	0.81	0.38	2015
Closed Multilateral monopoly	Emirates, Spain, Hong Kong, Afghanistan	4.47	0.22	0.84	0.33	2016
Closed Multilateral monopoly	Hong Kong, Emirates, Spain, Afghanistan	4.82	0.21	0.84	0.27	2017
Closed Multilateral monopoly	Emirates, Spain, Hong Kong, Vietnam	5.67	0.18	0.80	0.28	2018
Closed Multilateral monopoly	Emirates, Hong Kong, Spain, Vietnam	6.06	0.17	0.75	0.25	2019
Closed Multilateral monopoly	Hong Kong, Spain, Emirates, China	6.61	0.15	0.73	0.23	2020
Closed Multilateral monopoly	China, Emirates, Spain, Oman	4.83	0.21	0.79	0.33	2021
Closed Multilateral monopoly	China, Emirates, Spain, Oman	6.83	0.15	0.66	0.27	2022

Source: Research Findings

In the current study, to examine the relative export advantage of Iranian saffron, the Revealed Comparative Advantage (RCA) index has been utilized, and the symmetric Revealed Comparative Advantage (SRCA) index has been used, the results of which are presented in (Table 6). As observed, the relative export advantage of Iranian saffron has experienced fluctuations but has consistently been present throughout the study period and has increased in recent years. This indicates an increase in Iran's competitive power in the global market for saffron.

The Topsis approach was used to prioritize the target countries for Iranian exports, and the results are presented in (Table 7). As observed in (Table 4), China, the UAE, Spain, Oman, Saudi Arabia, and Hong Kong have respectively accounted for the highest share of Iran's exports. However, according to the results in (Table 7), these countries are ranked 1, 2, 3, 12, and 25, respectively. As mentioned in previous sections, criteria such as export quantity, export value, export price, geographical distance, per capita income, gross domestic product, economic structure difference index, and population of countries were used for prioritizing the export target

markets of Iran. The results show that among the importing countries of saffron from Iran, China, the UAE, Spain, India, the United States, Germany, France, Italy, Sweden, and Kuwait are in the top priority ranks. Other countries are specified in (Table 7) according to their priority. It is worth noting that there is no significant difference between potential markets and current markets for Iranian saffron.

Table 5- The sustainability index of the most important saffron importing countries from Iran in the world

Year	Emirates	Spain	Saudi Arabia	China	Hong Kong	Italy	Oman
2003	1.16	0.52	0.34	-	2.45	0.13	-
2004	1.27	0.54	0.14	-	-	0.22	0.13
2005	0.76	0.26	0.19	0.05	0.03	0.21	0.10
2006	0.07	0.07	0.03	0.01	0.01	0.02	0.02
2007	0.17	0.20	0.06	0.21	0.02	0.10	0.10
2008	0.33	0.25	0.24	0.03	0.17	0.22	0.11
2009	0.21	0.16	0.33	-	0.15	0.18	0.06
2010	0.42	0.30	0.11	0.06	0.63	1.05	0.04
2011	0.56	0.47	0.13	0.06	0.08	0.11	0.12
2012	0.28	0.29	0.07	0.11	0.06	0.07	0.04
2013	0.24	0.12	0.13	0.07	0.03	0.03	0.02
2014	0.13	0.06	0.08	0.04	0.01	0.02	0.05
2015	0.12	0.12	0.06	0.09	0.02	0.03	0.03
2016	0.23	0.27	0.06	0.04	0.25	0.07	0.06
2017	0.25	0.18	0.06	0.05	0.21	0.07	0.11
2018	0.37	0.24	0.03	0.03	0.12	0.05	0.12
2019	0.27	0.26	0.09	0.08	0.28	0.25	0.17
2020	0.31	0.24	0.24	0.27	0.30	0.05	0.42
2021	1.37	0.29	0.55	0.78	0.10	0.07	0.51
2022	0.95	0.24	1.71	0.96	0.11	0.13	0.09
Average	0.47	0.25	0.23	0.17	0.26	0.15	0.12

Source: Research Findings

Table 6- Iran's saffron export advantage

Year	RCA	RSCA	Year	RCA	RSCA
2003	149.0	0.987	2013	143.4	0.986
2004	151.0	0.987	2014	146.3	0.986
2005	125.2	0.984	2015	167.3	0.988
2006	133.5	0.985	2016	144.2	0.986
2007	80.9	0.976	2017	139.6	0.986
2008	75.2	0.974	2018	148.9	0.987
2009	96.2	0.979	2019	280.6	0.993
2010	102.9	0.981	2020	248.9	0.992
2011	107.9	0.982	2021	157.7	0.987
2012	115.8	0.983	2022	707.2	0.997

Source: Research Findings

Table 7- Results of prioritizing target countries for Iran's saffron exports for the years 2003-2022

Priority based on TOPSIS	The average weighted importance coefficient	The average rank of importing countries from Iran	Country	Priority based on TOPSIS	The average weighted importance coefficient	The average rank of importing countries from Iran	Country
22	0.009807673	29.45	Greece	1	0.030242027	4.15	China
23	0.009603794	29.55	Austria	2	0.033468714	6.85	Emirates
24	0.010125	30.75	Bahrain	3	0.028946286	7.7	Spain
25	0.0101	32.7	Oman	4	0.024623211	7.95	India
26	0.011303	32.75	Netherlands	5	0.028389397	8.9	United States
27	0.010592	33.2	Kazakhstan	6	0.014952526	12.3	Germany
28	0.009474	33.35	Finland	7	0.014465873	14.35	France
29	0.01159	33.55	England	8	0.014498992	15.25	Italy
30	0.010799	33.7	Afghanistan	9	0.0143701	15.5	Sweden
31	0.010514	34.05	Romania	10	0.01225312	16.45	Kuwait
32	0.010416	34.3	Russia	11	0.012929441	17.1	Qatar
33	0.009619	34.45	Belgium	12	0.014522008	19.1	Saudi Arabia
34	0.00911	36.3	Azerbaijan	13	0.010759091	22.7	Pakistan
35	0.009232	37	Ukraine	14	0.014539867	24.45	Hong Kong
36	0.009293	37.85	Slovakia	15	0.010066546	24.75	Iraq
37	0.009396	39	Denmark	16	0.009976362	25.05	Egypt
38	0.009033	39.6	Czech	17	0.013724528	25.15	Japan
39	0.010055	39.8	Hungary	18	0.010413286	26.05	Bangladesh
40	0.00906	40.4	Poland	19	0.011506631	26.55	Switzerland
41	0.009078	40.5	Thailand	20	0.010237802	27.05	Turkey
42	0.009713	42.75	Norway	21	0.010281649	29.05	Indonesia
69	0.008120155	63.15	Macau	43	0.009187	43	Algeria
70	0.008814274	63.3	Slovenia	44	0.010468	43.05	Nigeria
71	0.008070041	63.95	Georgia	45	0.008974	43.6	Turkmenistan
72	0.00812959	68	Morocco	46	0.008946	44.7	Uzbekistan
73	0.007900674	68.25	Lithuania	47	0.010144	45.7	Vietnam
74	0.007837067	70.25	Nepal	48	0.009121	47.75	Singapore
75	0.007934116	70.85	Kyrgyzstan	49	0.009186	47.85	Ireland
76	0.008509062	71.55	Bosnia and Herzegovina	50	0.0089	50.05	Syria
77	0.007995967	72.1	Estonia	51	0.008721	50.1	Lebanon
78	0.007775057	72.6	Tajikistan	52	0.009657	50.1	Malaysia
79	0.008100592	73.35	Tunisia	53	0.010417	50.2	Argentina
80	0.008370596	74.25	Kenya	54	0.010438	50.25	Jordan
81	0.007650348	74.9	Zambia	55	0.008911	51.4	Australia
82	0.007492555	76.15	South Africa	56	0.010918	52	Luxembourg
83	0.007163496	77.75	Colombia	57	0.008543	53.65	Bulgaria
84	0.007134313	78.45	New Zealand	58	0.008542	54.4	Korea
85	0.007138522	78.95	Mexico	59	0.009345	55.1	Armenia
86	0.006950576	79.75	Chile	60	0.00906	55.95	Portugal
87	0.006782278	82.65	Malta	61	0.008431	56.15	Libya
88	0.007565742	83.2	Tanzania	62	0.008354	56.95	Brazil
89	0.007335999	85.1	Uganda	63	0.008561	58.35	Sri Lanka
90	0.006315378	86.2	Cambodia	64	0.008317	59.3	Croatia
91	0.00633173	87.05	Laos	65	0.008302	59.4	Canada
92	0.005836798	89.3	Brunei	66	0.008316318	60.05	Philippines
93	0.006997772	89.8	Uruguay	67	0.009475527	62.65	Myanmar
94	0.005936474	90.5	Mauritius	68	0.008407745	63.1	Serbia
95	0.005883516	90.85	Madagascar				
96	0.005112691	91.95	Panama				
97	0.003542596	95.05	Namibia				
98	0.00320185	95.6	Mauritania				

Source: Research Findings

(Table 8) illustrates the relative export advantage of Iranian saffron to the most important target markets. The most important target countries for Iranian exports are determined based on the export market structure, with Afghanistan, the UAE, Spain, Saudi Arabia, Oman, Hong Kong, and China being the top priorities. Although China is a major market for Iranian saffron, the results show that Iran's export advantage to Afghanistan is greater than to China, possibly due to the proximity of Iran and Afghanistan and the cooperation between these two countries in expanding saffron cultivation and production. Examining the coefficient of changes in relative export advantage indicates that the highest fluctuation is related to China and the lowest fluctuation is related to Spain, which can indicate the market risk in these two countries and be considered as a criterion for instability in a country's trade system (Salami & Pishbahar, 2001). Based on the coefficient of changes, Iran's relative export advantage to Spain, the UAE, Saudi Arabia, Oman, Afghanistan, Hong Kong, and China has had the least fluctuation, indicating market stability despite competitiveness.

Table 8- Relative advantage for saffron exports to Iran's export target countries in 2003-2022

Year	Emirates	Spain	China	Afghanistan	Oman	Saudi Arabia	Hong Kong
2003	51.23	7.53	0.01	0.00	8.70	5.30	0.10
2004	53.53	6.65	0.00	0.14	5.89	9.97	0.14
2005	64.20	6.77	0.02	0.00	9.90	16.81	0.32
2006	36.78	6.74	0.00	0.23	8.21	15.00	0.21
2007	19.39	10.46	0.00	0.51	7.02	7.62	0.18
2008	15.29	11.84	0.00	0.00	5.49	5.65	0.24
2009	19.51	10.09	0.02	0.01	4.66	4.04	0.10
2010	37.36	7.74	0.01	0.07	4.13	8.36	0.26
2011	43.15	6.22	0.02	0.00	3.77	11.38	0.25
2012	68.04	12.74	0.03	0.03	5.25	20.60	0.49
2013	32.57	12.27	0.03	2.27	4.76	10.62	0.54
2014	42.12	10.93	0.04	38.87	4.27	11.23	0.34
2015	23.79	13.20	0.03	62.65	4.08	5.54	0.32
2016	31.28	12.22	0.16	118.40	5.18	4.95	1.08
2017	28.72	10.82	0.54	135.79	4.92	8.18	2.37
2018	33.34	5.97	0.11	158.26	4.39	6.80	10.37
2019	32.16	7.43	0.10	228.18	29.18	9.04	5.02
2020	13.87	5.89	0.35	143.21	16.14	6.93	4.07
2021	20.73	6.69	1.12	43.24	15.60	7.14	1.49
2022	2.45	12.29	0.66	0.00	1.75	1.85	0.25
Average	33.48	9.22	0.16	46.59	7.67	8.85	1.41
Maximum	68.04	13.20	1.12	228.18	29.18	20.60	10.37
Minimum	2.45	5.89	0.00	0.00	1.75	1.85	0.10
Coefficient of variation	0.50	0.29	1.81	1.51	0.81	0.51	1.79

Source: Research Findings

Conclusion

This research has conducted a comprehensive analysis of the global saffron market structure, focusing on the saffron supply chain and the relative export advantage of Iran. The study spans the period from 2003 to 2022, examining export market dynamics, target countries for Iranian exports, and the competitive landscape. We concluded that i) the global saffron market structure oscillated

between oligopoly and dominant firm configurations; ii) Iran's export market structure was oligopolistic, with Iran being the dominant firm in 2003; iii) by 2022, Nigeria, Sri Lanka, Iran, and Spain accounted for 93% of global saffron exports, with Iran holding a 13.6% share; iv) Spain, England, Nigeria, Bangladesh, Afghanistan, India, and China emerged as the main competitors for Iranian saffron exports; v) Afghanistan, Spain, India, Iran, England, Bangladesh, China, and Nigeria were identified as the most stable exporting countries; vi) Iran's export stability index was 0.96, indicating a trend of decreasing stability and potential challenges for export revenues; vii) the CR4 index showed that the top four importers of Iranian saffron accounted for 66% to 88% of imports, although the composition of these countries varied over time; viii) this high concentration highlights the limited and unstable nature of Iran's export target markets, posing risks if import restrictions are imposed by these countries. Despite challenges, Iran maintained a relative export advantage in saffron, with an increasing trend in recent years. From the 98 countries importing Iranian saffron, 53 were identified as target markets, with China, the UAE, Spain, India, the USA, Germany, France, Italy, Sweden, and Kuwait being top priorities. However, exports to the USA, Germany, Sweden, and Kuwait were minimal. We suggested that given the increasing production by competitors like Afghanistan, India, and Morocco, Iran should invest in saffron production technology to sustain its leading position. Although Iran produces over 80% of the world's saffron, it only holds a 13.6% market share in exports. Most Iranian saffron is re-exported by countries such as the UAE, Spain, China, and Oman. Therefore, expanding market presence and enhancing branding should be prioritized. As the saffron market is oligopolistic, price setting and market share distribution should involve all exporting countries. Iran should leverage international cooperation to regain its influence in the market. With exports concentrated in a few countries, and the composition of these countries being unstable, Iran should focus on market retention and maintenance strategies. Developing strong diplomatic and trade relations with target countries is crucial to mitigate risks and ensure sustained export volumes and revenues. These strategic recommendations aim to enhance Iran's competitiveness and stability in the global saffron market, ensuring sustainable growth and profitability for its saffron exports.

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اولویت‌بندی بازارهای هدف زعفران ایران بر اساس شاخص‌های رقابت بازاری

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چکیده

صادرات محصولات کشاورزی یکی از راهبردهای توسعه صادرات غیرنفتی و رشد پایدار اقتصادی در کشورهای در حال توسعه به شمار می‌آید. زعفران به‌عنوان یک محصول صادراتی دارای اهمیت ویژه‌ای در صادرات غیرنفتی ایران است. از آنجاکه ایران در صادرات زعفران در بین چهار کشور برتر جهان قرار دارد، هدف این مطالعه اولویت‌بندی بازارهای هدف زعفران ایران بر اساس شاخص‌های رقابت بازاری و محاسبه مزیت‌نسبی و شاخص پایداری صادرات آن در جهان و کشورهای هدف صادراتی ایران می‌باشد. مقایسه ساختار بازار جهانی محصول طی دوره ۲۰۰۳-۲۰۲۲ نشان داد که با وجود سهم بالای کشورهای ایران، اسپانیا، انگلیس و نیجریه در بیشتر سال‌ها، ساختار بازار به شکل انحصار چند جانبه باز و بسته و در برخی سال‌ها بنگاه مسلط بوده است که بیانگر افزایش تعداد رقبا و رقابتی شدن بازار صادراتی این محصول است. ایران با متوسط سهم ۱۳/۶ درصدی در بازار صادرات زعفران و تولید بیش از ۸۰ درصد زعفران، به‌طور مستقیم سهمی در صادرات جهانی نداشته و بیشتر زعفران ایران به کشورهایی مانند امارات، اسپانیا، چین و عمان صادر می‌شود و از آنجا مجددا به سایر کشورها صادر می‌گردد که لازم است برای این منظور استراتژی‌هایی مانند توسعه بازار و برندسازی در اولویت قرار داده شود. نتایج نشان داد در سال ۲۰۲۲ چهار کشور نیجریه، سریلانکا، ایران و اسپانیا ۹۳ درصد از کل صادرات جهان را به خود اختصاص داده‌اند و میانگین رتبه مقدار صادرات برای کشور ایران در دوره مورد مطالعه در بازار صادراتی زعفران رتبه ۲ را به خود اختصاص داده است. همچنین ایران با شاخص پایداری صادرات کمتر از یک (۰/۹۶) صادرات پایداری داشته است اما روند تغییر این شاخص بیانگر کاهش پایداری ایران است. نتایج نشان داد که عمده صادرات زعفران ایران تنها به چهار کشور صورت می‌پذیرد و ترکیب این کشورها نیز ثابت نیست، لذا توجه به گسترش بازارهای هدف صادراتی به‌ترتیب با اولویت کشورهای چین، امارات، اسپانیا، هند، آمریکا، آلمان، فرانسه، ایتالیا، سوئد و کویت به‌ترتیب با میانگین رتبه ۴/۱۵، ۶/۸۵، ۷/۷، ۷/۹۵، ۸/۹، ۱۲/۳، ۱۴/۳۵، ۱۵/۲۵، ۱۵/۵ و ۱۶/۴۵مورد توجه قرار گیرد. همچنین نتایج نشان داد که بازار صادراتی این محصول انحصار چندجانبه بوده است، بنابراین باید از طریق مشارکت تمامی کشورهای صادرکننده به تعیین قیمت و سهم بازار هر یک از کشورها اقدام نمود.

واژه‌های کلیدی: ایران، بازارهای هدف صادرات زعفران، ساختار بازار، شاخص پایداری صادرات

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Impact of Adopting Strategies to Cope with Climate Change on the Technical Efficiency of Wheat Farmers in Sistan Region-Iran

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Abstract

The negative and destructive impact of climate change on the efficiency and productivity of agricultural inputs has been demonstrated in many regions of the world, particularly in arid and semi-arid areas. In this context, the adoption of innovative strategies to increase farmers' flexibility and adaptability to climate change has increased. Hence, understanding the impact of climate adaptation strategies on agricultural efficiency and yields is crucial. This study examined the effects of climate change adaptation strategies, input utilization, and external factors beyond farmers' control on technical efficiency using the Endogenous Modified Stochastic Frontier (EMSF) model. Data were collected from 265 questionnaires distributed among wheat farmers during the 2022-2023 cultivation period, using a stratified random sampling approach. The climate adaptation strategy index was formulated using the Principal Component Analysis (PCA) technique. The PCA revealed that changes in farm size (0.812), adaptation of conservation tillage (0.797), and adjustments in planting dates (0.619) were the most influential factors. Conversely, rainwater harvesting (0.219) and biofertilizer application (0.327) emerged as the adaptation strategies with the lowest factor loadings among farmers. In this study, the average technical efficiency of wheat farmers was calculated to be 82%. The model estimation results showed that labor input, chemical pesticides, chemical fertilizers, water, and machinery significantly and positively contribute to wheat production efficiency. Additionally, the implementation of climate adaptation strategies by farmers reduces technical inefficiency. Variables such as education level, farming experience, access to climate information, and access to credit also effectively reduce technical inefficiency.

Keywords: Logit regression, Principal components analysis, Socio-economic characteristics, Stochastic frontier model

Introduction

Climate change is emerging as a significant threat to agriculture, food security, and the livelihoods of millions of people worldwide (IPCC, 2017). Agricultural activities are particularly vulnerable to climate change as they are directly influenced by climatic factors such as temperature and precipitation (Shaffril

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et al., 2018). Phenomena like rising temperatures, erratic rainfall patterns, and droughts are manifestations of climate change that lead to fluctuations in crop yields (Zaveri *et al*., 2020). Projections suggest that by 2030, global maize and wheat production, two staple food crops, will decrease by 3.8% and 5.5%, respectively, due to the impacts of climate change (FAO, 2015). However, empirical data reveals that the adverse effects of climate change on agricultural sector in developing countries are even more profound. Consequently, the negative impact of climate change on exacerbating economic issues and increasing the vulnerability of farmers in these regions has been substantiated (Ado *et al*., 2018). Therefore, addressing climate change challenges in agriculture highlights adaptation and mitigation measures (Mirzaei *et al*., 2022).

A review of studies reveals that the strategies employed to adapt to climate change vary widely across different regions of the world. These strategies include limiting the use of nitrogen fertilizers, avoiding conventional ploughing methods in favor of conservation tillage, reducing water consumption through modern irrigation systems, maintaining or enhancing soil fertility, and supporting farm mechanization (Bonzanigo *et al*., 2016; Camarotto *et al*., 2018; Ogundari *et al*., 2018). However, although farmers are exposed to climate change, the decision to change their farming practices has not been pervasive (Pagliacci *et al*., 2020). In this regard, studies on farmers' acceptance and continued voluntary use of climate change adaptation plans show that farmers' choices are influenced by a wide range of factors related to the environment, technology, policy characteristics, institutions, farm structure, farmers' economic characteristics, attitudes, motivations, and social aspects (Deng *et al*., 2016; Luo *et al*., 2016; Page *et al*., 2015).

According to the Seventh Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate change has occurred in Iran in recent decades and will continue to intensify in the future (IPCC, 2017). Data indicate that Iran is experiencing frequent droughts, rising temperatures, increasingly erratic rainfall patterns, and declining groundwater resources due to climate change (Yazdanpanah *et al*., 2016; Mardani Najafabadi *et al*., 2022). Consequently, Iranian farmers need to adopt suitable adaptation strategies to cope with climate change and mitigate its effects (Bozorgparvar *et al*., 2018). Despite the adverse impacts of climate change on farmers' livelihoods and water resources in Iran, adaptation strategies have not been widely adopted by farmers, and the development of adaptation approaches has not been prioritized by government agencies (Karimi *et al*., 2018). For example, Mirzaei and Zibaei (2021) concluded that inflexibility in farmers' individual behavior has resulted in practical adaptation to climate change being lower than its potential. They demonstrated that using adaptive strategies, such as improving irrigation efficiency, leads to only a 14% reduction in water consumption. Therefore, it is crucial to assess the effectiveness of climate adaptation strategies on agricultural efficiency and yields.

The Sistan Plain, located in the north of Sistan and Baluchistan province, spans an area of 16.5 thousand square kilometers. It is the floodplain of the Helmand River and one of the most fertile regions in the province. This area ranks first in the province for the cultivation and production of wheat, barley, summer crops, and fodder. Before the recent droughts, the Sistan Plain produced 70% of the province's wheat, 84% of its barley, and 81% of its summer crops, earning it the title of the agricultural center of the province. The location of the study area is shown in Fig. 1.

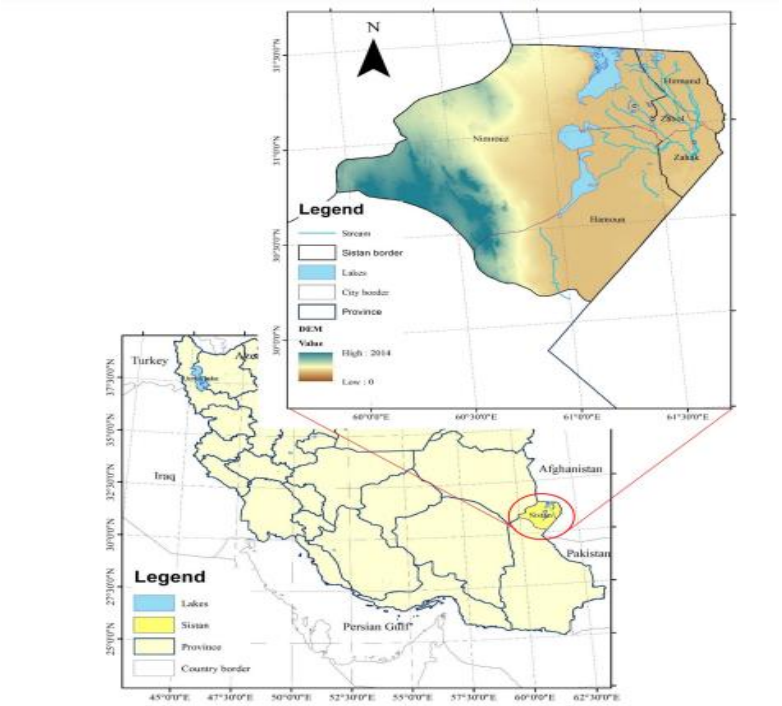

Figure 1- The location of study area
Source: Arranged by the authors

According to the 2018-2019 agricultural statistics, wheat still occupies about 60% of the cultivated area in the Sistan region (Ministry of Agricultural Jihad, 2020). However, this plain is characterized by periods of low water availability and prolonged droughts, with average annual precipitation between 50 and 55 mm and high annual evaporation exceeding 4500 mm (Khakifirouz *et al.*, 2022). Additionally, most wheat farmers in Sistan are smallholders, and one of their main challenges is the inefficient use of agricultural inputs (Sardar Shahraki & Ghaffari Moghdam, 2023). Therefore, it is essential to determine the role of farmers' management practices alongside the influence of uncontrollable factors on their performance. In this context, examining the technical efficiency of wheat production according to the strategies implemented by these farmers is necessary.

In line with this, the present study assessed the impact of climate change adaptation strategies and the inputs used by farmers on technical efficiency. An endogenous modified stochastic frontier (EMSF) model was employed for this purpose. This model not only determined the impact of changes in input consumption under the farmer's control (such as labor, water, farm size, and chemical inputs) on technical efficiency and inefficiency but also estimated the impact of climate change adaptation strategies. A key feature of this study is the consideration of endogenous effects influencing the adoption of climate change adaptation strategies, providing an unbiased and consistent estimate of farmers' technical efficiency. Additionally, the identification of strategies with significant factor loadings to construct the climate adaptation index through the principal component analysis method is another prominent aspect of this study.

Research Methodology

In the present study, we investigated adaptation strategies to climate change and other factors affecting the efficiency and technical inefficiency of wheat producers in the Sistan region. An endogenous modified stochastic frontier (EMSF) model was used for this purpose. It is worth mentioning that the Principal Component Analysis (PCA) method

was employed to create an index of climate change adaptation strategies.

The conceptual framework illustrating factors influencing the adoption of climate change adaptation strategies is presented in Fig. 2.

In the following, the methods used to achieve the mentioned goals are described.

Principal Component Analysis

Principal Component Analysis (PCA) identifies the most important components within a dataset. Rather than analyzing all features, it focuses on a subset that holds the most significance. Essentially, PCA extracts the features that contribute the greatest value. The principal components method was first proposed by Pearson (1971) for non-statistical variables. Hotelling (1933) extended the concept to random vectors. The principal components of (X) are standardized linear combinations of (X) components that have special properties in terms of variances. For example, the first component (X) of the standardized linear combination in Equation 1 is:

$$Z_1 = L'X, \qquad L = (l_1, \dots, l_P)' \in E^P \tag{1}$$

Where L is chosen such that $var(L'X)$ is maximal with respect to L. It is obvious that each weight X_i is a measure of the importance we give to the component l_i. To find a unique solution for the principal components, a specific condition $L'L = 1$ is required. In fact, the components of X are measured with one unit. Otherwise, the necessary condition $L'L = 1$ is not a sensible. The estimates of the principal components are sensitive to the units used in the analysis, resulting in different sets of weights for different units. To avoid this issue, the sample correlation matrix is sometimes used instead of the sample covariance matrix to estimate these weights. This approach ensures that the principal components remain stable despite changes in measurement units. Using the correlation matrix standardizes the variables to the sample variance unit.

The second principal component is the linear combination that has the maximum variance among all the standardized linear combinations uncorrelated with z_1, and continues to the principal component p-th of X. In this way, the initial vector X can be transformed into a vector of principal components with a rotation of the coordinate axis, which has inherent statistical properties. The weights related to the random vector X in the principal components are exactly the standardized Eigenvectors of the covariance matrix (Σ) of X. In addition, the Eigenvalue of $\Sigma$are equal to the variances of the principal components, and the largest root is equal to the variance of the first principal component (Giri, 1974).

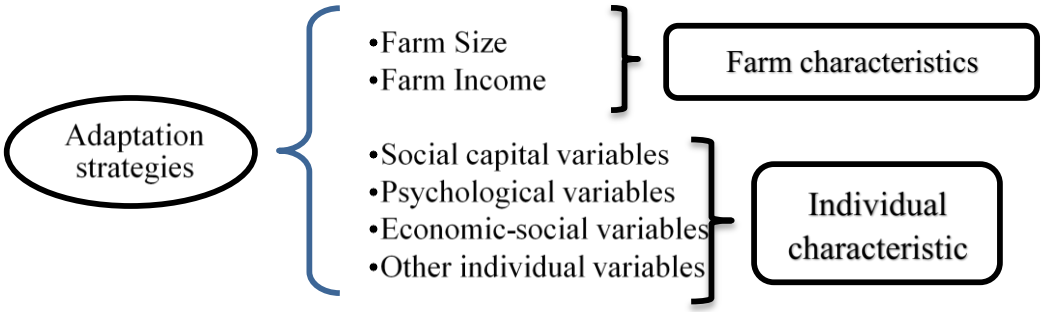

Figure 2- Conceptual framework of factors influencing the adoption of adaptation strategies

Endogenous modified stochastic frontier approach

One important issue in estimating the production function and technical efficiency is the possibility that some production factors are understood by the farmer but not considered by the researcher. In other words, when farmers allocate production factors, these selected inputs may be correlated with other observable components. Stochastic frontier analysis (SFA) models assume that production inputs are independent of the efficiency component. However, in reality, some unobservable characteristics may influence the farmer's choice of inputs, leading to an endogeneity problem in SFA estimation (Ma *et al.*, 2018). Since the decision to adopt climate change adaptation strategies is influenced by inherent characteristics such as farmers' management skills and understanding of climate change risk, this issue can lead to an endogeneity problem. Therefore, it is essential to consider the endogeneity problem when estimating the model at the farm level (Ojo & Baiyegunhi, 2020). Concerns about the endogeneity of the production function have been highlighted in several studies. The endogenous modified stochastic frontier model is statistically more efficient than traditional models. If farmers exhibit low technical efficiency, this cannot necessarily be attributed to the lack of adoption or appropriateness of adaptive strategies. Instead, this inefficiency may result from the use of different technologies compared to other production units. Based on this, the stochastic frontier model is presented as Equation 2 (Ackerberg *et al.*, 2006).

$$Q_i = X_i\beta + v_i - u_i$$
$$X_i = P_i\alpha + \varepsilon_i$$
$$\begin{bmatrix}\varepsilon_i \\ v_i\end{bmatrix} \equiv \begin{bmatrix}\Omega^{-1/2}\varepsilon_i \\ v_i\end{bmatrix} \approx N\left(\begin{bmatrix}0\\0\end{bmatrix}, \begin{bmatrix}I_p & \theta_v\rho \\ \theta_v\rho' & \theta_v^2\end{bmatrix}\right)$$
$$u_i = l\left(X'_{ui}\prod_u\right)u_i^* \quad (2)$$

Where Qi is the logarithm of the farmer's yield and Xi is the combined vector of endogenous and exogenous variables. Xi is the $p \times 1$ vector of all endogenous variables except Qi . This is possible due to statistical noise or when the level of inefficiency is affected by both the inputs and the frontier. $P_i = I_p \otimes P_i'$, where P_i represents the q × 1 vector of explanatory variables. Moreover, v_i and ε_i are two-sided random error terms. On the other hand, u_i it is related to the technical inefficiency of the units and includes management factors. $l_i = l(X'_{ui}\Pi_u) > 0, X_{ui}$ is a vector of exogenous and endogenous auxiliary variables without intercept and u_i^* is a random component independent of v_i and ε_i of producers. Here, Ω is the variance-covariance matrix εi, θ_v^2 is the variance of v_i and ρ is the vector representing the correlation between ε_i and v_i. Therefore, u_i and v_i can be considered correlated with X_i, however, ui and vi are conditionally independent of X_i and P_i. Accordingly, v_i and ε_i are conditionally independent with respect to X_i and P_i.

By using the Cholesky method of decomposition, the variance-covariance matrix $(-\varepsilon_i' v_i)'$ will be converted into the form of Equation 3.

$$\begin{bmatrix}\varepsilon_i \\ v_i\end{bmatrix} = \begin{bmatrix}\bar{\varepsilon}_i \\ \bar{w}_i\end{bmatrix}\begin{bmatrix}I_p & 0 \\ \sigma_v\rho' & \sigma_v\sqrt{1-\rho'\rho}\end{bmatrix} \quad (3)$$

Here, $-\varepsilon_i$ and $-w_i \approx N(\cdot,\cdot)$ are independent. With this operation, the stochastic frontier equation will be changed as Equation 4.

$$Q_i = X_i'\beta + \sigma_v\rho'\varepsilon_i^- + \omega_1 - u_i = X_i'\beta + (X_i - P_i\alpha)'\eta + e_i \quad (4)$$

In this regard:

$$e_i = w_i - u_i, \quad w_i = \sigma_v\sqrt{1-\rho'\rho} - w_i = \sigma_w - w_i \quad (5)$$

As well as:

$$\eta = \sigma_w\Omega^{-}1/2\rho/\sqrt{1-\rho'\rho} \quad (6)$$

For this approach, e_i is conditionally independent of the given explanatory variables X_i and P_i. As stated in equation 4, the term $(X_i - P_i\alpha)'\eta$ represents a biased correction component. Therefore, it is assumed that:

$$u_i^* \approx N^+(\nu, \delta_u^2) \quad (7)$$

$$l_i^2 \approx exp(X_{ui}' \pi_u) \quad (8)$$

Finally, the efficiency of farmers $eff_i = exp(-u_i)$ will be estimated from Equation 9.

$$\exp\left(-E\left|u_i / e_i\right|\right) = \exp\left\{-l_i\left[\vartheta_{i*} + \frac{\sigma_{i*}\varphi\left(\frac{\vartheta_{i*}}{\sigma_{i*}}\right)}{\Phi\left(\frac{\vartheta_{i*}}{\sigma_{i*}}\right)}\right]\right\} \quad (9)$$

Where φ is the standard normal probability density function. Φ also represents the standard normal cumulative distribution function. Therefore, there is heterogeneity in the model if the η component is significant. If η is not significant, efficiency can be estimated using traditional frontier efficiency models. Otherwise, the correction term should be included in the model. The joint significance test was also used to test the significance of the η component.

Data and Sampling Method

The required data were collected through questionnaires and face-to-face interviews with farmers during the summer and fall of 1401. The sample was selected using a multi-stage random sampling method. Initially, sample villages were randomly chosen from various cities in Sistan. Finally, based on Morgan's table, 265 farmers were randomly selected from these villages. SPSS 28 and Stata 17 software were used to estimate the PCA and EMSF models, respectively.

Results and Discussion

The results of the principal component analysis (PCA) were used to calculate the effective dimensions of climate change adaptation strategies are presented in Table 2. The strategies employed by farmers include changing the plot size, adjusting the planting date, using conservation agriculture techniques, applying biofertilizers, utilizing modified crop varieties, and harvesting rainwater. KMO [1] criterion and Bartlett's test were used to ensure the appropriateness of the method and the sample size, with the results shown in Table 1. The null hypothesis in this test is the equality of the unit matrix or the matrix of correlation coefficients. According to these results, the null hypothesis, which indicates the existence of a significant correlation between these variables (a minimum necessary condition for factor analysis), cannot be accepted. Additionally, the KMO statistic value is 0.89, indicating that the data amount was suitable for this method, and the existing correlation between the data is appropriate for factor analysis. Thus, it can be concluded that the adaptation strategies used effectively represent the characteristics and dimensions of farmers' adaptation to climate change and adequately address the issue of adaptation. In other words, PCA is a suitable method for extracting farmers' adaptation strategies to climate change.

As depicted in Table 2, the weights of the factors or strategies were determined through factor analysis. The coefficients obtained emphasize the significance of the strategies utilized by the sample farmers. These coefficients indicate both the ability of the identified factors to elucidate the variance of the studied variables and the appropriateness of the variables for factor analysis. For example, the factor load of the variable farm size is 0.812, indicating a high degree of correlation with the farmers studied. The variables "Conservation tillage" and "change of planting date" have weight loads of 0.797 and 0.619, respectively. In contrast, the adaptation strategies with the lowest factor loads are associated with the use of rainwater and biological fertilizer, with values of 0.219 and 0.327, respectively. According to the study by Ojo and Baiyegunhi (2020), strategies with a load exceeding 0.500 were amalgamated to create a climate adaptation strategy index, which was subsequently utilized to estimate the technical efficiency model.

Table 1- Adequacy criteria of sample size

1- Kaiser-Meyer-Olkin Measure of Sampling Adequacy

Criterion	Statistics	The amount of statistics
KMO		0.89 ***
Bartlett's test of sphericity	Statistical approximation χ^2	304.4***
	Degrees of freedom	15
	The significance level	0.00

Source: Research findings

Table 2- Dimensions of climate change adaptation strategies used by wheat farmers

Adaptation strategies	Weight PC
Use of biological fertilizers	0.327
Change of planting date	0.619
Conservation tillage	0.797
Change the land size	0.812
Use of modified varieties	0.437
Use of rainwater	0.219
Animal husbandry	0.518

Source: Research findings

The estimation results from the maximum likelihood method of the endogenously modified stochastic frontier model are presented in Table 3. The impact of labor input on production is statistically significant and positive at the 1% level (Table 3). The coefficient for this variable suggests that, holding other variables constant, a 10% increase in the labor force results in a 4.9% increase in production. Similarly, Ojo and Baiyegunhi (2020) found that a 10% increase in labor force leads to a 2.9% increase in rice production on Nigerian farms. Mensah and Bromer (Mensah *et al.*, 2016) note that smallholder farmers in Ghana heavily depend on manual labor and that agricultural operations in developing countries often face resource constraints.

The coefficients for the variables of chemical fertilizer and chemical pesticide are statistically significant at the 1% level and both have positive signs. Notably, the input coefficient for chemical fertilizer is numerically higher than that for chemical pesticide, indicating that the contribution of chemical fertilizers to production is more substantial than that of chemical pesticides. The inputs of water consumption and machinery also have a positive and significant effect on wheat production. The coefficient for water consumption in the estimated production function indicates that a 10% increase in water usage, assuming other conditions remain stable, results in a 3.06% increase in production. Consequently, all investigated variables positively impact production as expected. Among the inputs available to farmers, labor input has the highest coefficient, indicating it has the most substantial positive effect on production. Water input ranks next in importance. The exogenous variables used in the inefficiency model were selected to reflect farmers' management capabilities, access to information, and available production resources. Estimating technical efficiency alone is insufficient for determining potential policy interventions. Identifying sources of inefficiency is crucial for making farm-level policy recommendations. Therefore, a positive and significant estimated coefficient indicates a decrease in farmers' technical efficiency, and vice versa.

The results of estimating the factors affecting the technical inefficiency of wheat producers in the Sistan region are presented in Table 3. Analysis of the variables included in the inefficiency model for wheat farmers' production shows that, except for household size and off-farm income, all other variables have a negative and significant effect on inefficiency. Specifically, the effect of the farmer's education level on technical inefficiency is negative and significant at the 1% level. This indicates a direct relationship between education level and wheat production efficiency: as education increases, technical

efficiency also increases. The results also reveal that agricultural experience has a significant negative effect on technical inefficiency at the 1% level. This implies that greater agricultural experience enhances the technical efficiency of producers in the study area, resulting in a more optimal use of inputs. Furthermore, access to climate information and credit both exhibit a significant negative effect on technical inefficiency at the 1% level.

This study finding (Table 3) suggests that climate change adaptation strategies effectively address variations in inefficiency. Smallholder farmers who implement these strategies achieve increased yields and improved technical efficiency. Therefore, this research emphasizes that wheat production in Sistan can be enhanced through substantial inputs and technology, provided that smallholder farmers receive support in adopting climate change adaptation strategies. Khanal *et al.* (2018) discovered that adopting climate change adaptation strategies enhanced the technical efficiency of smallholder farmers in Nepal. Similarly, Otitoju *et al*. (2014) confirmed a positive and significant correlation between climate change adaptation strategies and farm-level efficiency in food production in southwestern Nigeria. Roco *et al*. (2017) in Chile and Anser *et al.* (2020) in Pakistan reported similar results. Ojo and Baiyegunhi (2020) also validated the positive causal relationship between the adaptation index and the technical efficiency of rice farmers in various rural areas of Nigeria. The results further indicated that the relationship between education level and inefficiency is negative, indicating that higher education levels result in lower inefficiency. This suggests that smallholders with higher education levels demonstrate greater technical efficiency. This finding is consistent with the studies of Binam *et al*. (2004) and Okonya *et al*. (2013), who identified education as a factor that enhances technical efficiency. However, it contradicts the findings of Danso-Abbeam *et al*. (2017).

The study suggests that long-term experience reduces farmers' technical inefficiency. This can be attributed to the conventional nature of some experienced farmers. Dissatisfaction with basic farming practices often motivates these farmers to adopt new methods, thereby enhancing their production efficiency. This finding aligns with the results of Danso-Abbeam *et al.* (2017) and Baiyegunhi *et al.* (2019), who observed a negative relationship between farming experience and technical inefficiency among Ghanaian farmers. Additionally, Baiyegunhi *et al.* (2019) noted that farming is considered a profession, and as farmers gain more years of experience, they acquire greater knowledge and skills, further improving their efficiency.

The effect of access to climate change information on inefficiency is negative and statistically significant. This indicates that farmers with better access to information are more efficient than those with limited access. Consequently, wheat farmers who have better access to agricultural and climate change information tend to be more innovative and efficient. Table 3 shows the negative and significant effect of access to credit on farmers' inefficiency. Ojo *et al.* (2020) discovered that access to credit significantly enhances the ability of poor households to adopt climate change adaptation strategies. Moreover, reducing potential credit constraints through timely credit provision lowers the opportunity cost of some capital-intensive adaptation strategies. Therefore, overcoming credit constraints is likely to boost the efficiency of smallholder farmers. In other words, the significant coefficient of the credit variable indicates that access to sufficient and timely credit is crucial for improving agricultural efficiency. These findings align with those of Chandio *et al.* (2017). Ojo *et al*. (2019) also found that institutional credit facilitates and increases farmers' productivity.

Finally, the endogeneity test statistic (η) indicates that the adaptation strategy is endogenous. This can be attributed to unobserved characteristics, such as production practices and risk management behavior, that influence farmers' decisions to adopt climate change adaptation strategies.

After estimating the factors affecting

technical inefficiency, the efficiency of each producer was calculated separately. The average technical efficiency, using the endogenous modified stochastic frontier method, was found to be 82%. This indicates that wheat farmers in the study can increase their technical efficiency by an average of 18% by closing the gap with the best producer in the Sistan region. In other words, smallholder wheat farmers lose about 18% of their potential harvest due to technical inefficiency. The minimum technical efficiency observed among the farms was 0.32, while the maximum was 0.98. This 0.66 difference between the most and least efficient farmers highlights the potential for improving efficiency in the region. According to Table 4, 4.5% of the production units have an efficiency between 0.3 and 0.5, 16% between 0.5 and 0.7, and 36.6% between 0.7 and 0.9. Notably, the highest frequency of technical efficiency among wheat farmers is above 90%.

Table 3- Results of Estimated EMSF Model

Variables	Coefficients	Standard error	P-value
Efficiency variables			
Labor	0.494***	0.087	0.000
Chemical pesticide	0.059***	0.023	0.000
Chemical fertilizer	0.100***	0.038	0.010
Water	0.306***	0.050	0.034
machinery	0.201***	0.076	0.000
Intercept	-2.021***	0.488	0.000
Inefficiency model			
Education level	-0.123***	0.047	0.009
household size	-0.078	0.138	0.576
Off-farm income	0.017	0.316	0.956
Agricultural experience	-0.052***	0.012	0.000
Access to climate information	-1.546***	0.407	0.000
Access to credits	-1.630***	0.408	0.000
Climate change adaptation index	-1.143***	0.531	0.031
endogeneity test (η)	Chi2 =133.75	Chi2>Prob=0.000	
Log likelihood	-75.95		

Source: Research findings

Table 4- Frequency distribution and percentage of technical efficiency of wheat producers using the EMSF model

Range of efficiency	Frequency	Percent
0.3≤ TE<0.5	12	4.52
0.5≤ TE<0.7	43	16.22
0.7≤ TE<0.9	97	36.6
0.9≤TE	113	42.64
Average	0.82	
Maximum	0.98	
Minimum	0.32	

Source: Research findings

Conclusion and Suggestions

This study investigated the impact of adopting climate change adaptation strategies on the efficiency of wheat farmers in the Sistan

region using an EMSF model. The EMSF method allows for estimating the unbiased and consistent impact of these strategies on technical efficiency among smallholder farmers. This model effectively addresses the endogeneity of frontier variables and inefficiency.

The study results indicate that endogeneity in the model is significant. This issue can be attributed to unobserved characteristics, such as production practices and risk management behavior, which influence farmers' choices of climate change adaptation strategies. Therefore, addressing endogeneity is crucial; otherwise, estimates of efficiency parameters will be inconsistent. In this study, the average technical efficiency, calculated using the endogenous modified stochastic frontier model, was found to be 82%. The results also revealed a substantial difference between the most and least efficient wheat farmers in the Sistan region. This efficiency gap suggests that production can be significantly increased by improving management practices, without altering the level of technology and inputs used. The experimental results of the estimated model show that labor input, chemical pesticides, chemical fertilizers, water, and machinery significantly and positively impact wheat production efficiency in the Sistan region. This study also identified the combined effects of climate change adaptation strategies and socio-economic characteristics such as age, gender, education, agricultural experience, access to credit, and access to information. The results indicate that adaptation strategies adopted by small-scale wheat farmers in Sistan are essential for mitigating the negative impact of climate change and enhancing technical efficiency in wheat production. This study recommends improving technical efficiency by increasing farmers' knowledge through agricultural education, adult education, and timely access to credit to boost productivity. Additionally, technical efficiency can be enhanced by improving farmers' access to timely weather forecasts for the upcoming season. It is also important to encourage farmers to participate in society by forming farmer groups for proper interaction with other farmers. In this context, information on the inefficient use of agricultural production inputs helps smallholder farmers increase their efficiency by optimizing input use. Additionally, farmers' knowledge of local climatic changes and strategies to address them is essential for government, stakeholders, and relevant institutions. Therefore, involving farmers in the planning process to adopt climate-compatible strategies is crucial. However, while adaptation strategies may improve smallholder farmers' productivity, their implementation can be costly and may conflict with other social and environmental objectives. For example, increased use of agrochemicals and pesticides can degrade soils, and changing planting and harvesting dates may not be sustainable in the long term. Therefore, future studies should assess not only the impact of climate change adaptation strategies on the technical efficiency of wheat farmers but also their environmental and social impacts.

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چکیده

تأثیر منفی و مخرب پدیده تغییر اقلیم بر عملکرد و بهره‌وری عوامل تولید کشاورزی در بسیاری از مناطق جهان به‌خصوص در مناطق خشک و نیمه‌خشک به اثبات رسیده است. در این راستا، اتخاذ راهبردهای نوآورانه برای افزایش انعطاف‌پذیری و سازگاری کشاورزان به منظور تطبیق با تغییرات اقلیمی گسترش یافته است. بنابراین، آگاهی از میزان اثرگذاری راهبردهای تطبیق با اقلیم بر میزان کارایی و عملکرد زراعین حائز اهمیت است. بر این اساس، در پژوهش حاضر، تأثیر راهبردهای تطبیق با تغییر اقلیم همراه با مصرف نهاده‌ها و عوامل خارج از کنترل کشاورز برکارایی فنی با استفاده از مدل مرزی تصادفی اصلاح‌شده درونزا (EMSF) ارزیابی شد. داده‌ها ازطریق تکمیل ۲۶۵ پرسشنامه درسال زراعی ۱۴۰۱-۱۴۰۰ و به روش نمونه‌گیری تصادفی چندمرحله‌ای برای تولیدکنندگان گندم در منطقه سیستان جمع‌آوری شد. به منظور ساختن شاخص تطبیق از روش تجزیه و تحلیل مؤلفه اصلی (PCA) استفاده شد. نتایج PCA نشان داد تغییر اندازه زمین (۰/۸۱۲) خاکورزی حفاظتی (۰/۷۹۷) و تغییر تاریخ کشت (۰/۶۱۹) بیشترین بار عاملی و استفاده از آب باران (۰/۲۱۹) و استفاده از کودهای زیستی (۰/۳۲۷) کمترین بار عاملی راهبردهای تطبیق در بین کشاورزان را دارند. دراین مطالعه، میانگین کارایی فنی گندمکاران ۸۲ درصد محاسبه شد. نتایج برآورد مدل نشان داد که مساعدت نهاده‌های نیروی کار، سموم شیمیایی، کود شیمیایی، آب و ماشین‌آلات به کارایی تولید گندم از نظر آماری مثبت و معنی‌دار است و با اجرای راهبردهای تطبیق با اقلیم توسط کشاورزان، میزان ناکارایی فنی کاهش می‌یابد. همچنین، متغیرهای سطح تحصیلات، تجربه کشاورزی، دسترسی به اطلاعات اقلیمی و دسترسی به اعتبارات در کاهش ناکارایی فنی مؤثرند.

واژه‌های کلیدی: تحلیل مؤلفه‌های اصلی، رگرسیون لاجیت، مدل مرزی تصادفی، ویژگی‌های اجتماعی-اقتصادی

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An Analytical Study of Urban Agriculture Projects: Prison-Farm Initiatives in Kermanshah

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Abstract

Urban agriculture promotes sustainable development and fosters societal participation, including the rehabilitation of various groups, such as inmates. Therefore, this research aimed to analyze the effectiveness of prison-farm rehabilitation programs in Dizel Abad Prison in Iran. The research population consisted of two groups: one with 130 inmates, of whom 97 were selected and studied through systematic sampling via Cochran's formula, and the second group included 14 managers, offenders, and prison experts interviewed through a census. The data collection instrument was a researcher-developed questionnaire based on the Kirkpatrick evaluation model. The reliability of the questionnaire was confirmed using Cronbach's alpha coefficient, while its face and content validity were validated by a panel of experts. The findings at the first level of evaluation (i.e., reaction) showed that, with a confidence interval of 99%, the inmates were satisfied with participating in the urban agriculture training course. At the second level (i.e. learning), results indicated a significant increase in the inmates' knowledge, with a statistically significant difference between their pre- and post-test scores ($p<0.01$). At the third level (i.e., behavior), the findings suggested that urban agriculture in prisons could lead to significant behavioral changes in inmates, with 95% confidence. At the fourth level of evaluation (i.e., results), the findings showed that although the urban agriculture training course in Dizel Abad Prison caused moderate changes in the inmates, the difference in pre-and-post-test scores was not statistically significant. Overall, the findings demonstrated that the urban agriculture training course in Dizel Abad Prison could bring about changes in inmates' behavior, knowledge, and attitude. These findings support the potential of prison-farm programs within urban agriculture initiatives as viable methods for rehabilitation.

Keywords: Agricultural rehabilitation, Correctional education, Kirkpatrick model, Prison-farm, Urban agriculture

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Introduction

The concept of agricultural rehabilitation in prisons has been in existence since 1948, following World War II (Langat, 2016). These programs primarily aim to reintegrate inmates into society and support their transition to a productive and healthy life (Wormith, 2007; Mburu & Gathitu, 2022; Zivanai & Mahlangu, 2022).

The literature suggests that urban agriculture programs in prisons not only engage inmates with agricultural education but also provide therapeutic benefits. Asokhia and Agbonluae (2013) argue that agricultural rehabilitation programs equip inmates with various skills, enhance their competencies, and allow them to develop their talents. These programs are designed to reduce crime rates, develop skills, engage inmates in productive activities, and transform their knowledge and attitudes (Ajah, 2019; Listiana & Hastjarjo, 2021).

This study focuses on Dizel Abad Prison in Iran, which has been a prominent institution for urban agriculture programs since its establishment in 1975. The prison operates under the supervision of the National Prison Organization, adhering to national security and educational standards (Correctional Facilities Organization of Kermanshah Province, 2021). The National Inmates' Cooperative Foundation, which was initially established in 1949 as Shahrbani Prison Factories and later renamed, currently oversees these programs. After the Islamic Revolution, it was renamed the National Cooperative and Vocational Training Enterprise and is now known as the National Inmates' Cooperative Foundation. This foundation aims to create employment and generate income for inmates while promoting production, agriculture, and community service. Inmates receive agricultural training on 570 hectares of land (28 hectares of which are irrigated), provided by the government. This initiative focuses on rehabilitating barren lands and enhancing agricultural efficiency, thus increasing income for inmates' families and benefiting both the organization and the prison.

The study addresses several key questions regarding the urban agriculture programs at Dizel Abad Prison. Do these programs effectively change inmates' behavior and learning outcomes? What benefits do they provide to the prison? Are these programs managed effectively? To address these questions, the study utilizes the Kirkpatrick evaluation model (1996). A review of national databases revealed no prior research on rehabilitation through urban agriculture in Iranian prisons, positioning this study as a pioneering effort and a foundation for future academic research.

Literature Review

Prison farm and Relevant Programs: A Prison farm is a large correctional facility where inmates work on agricultural and production tasks. These activities primarily occur outdoors and include farming and mining. Unlike labor camps, the products generated in Prison farms are mainly used for feeding the inmates and supporting other organizations like orphanages, with any surplus sold to generate income for the inmates and the prison (Uddin *et al*., 2019; Oshinsky, 1996).

Prison farm programs encompass various activities, such as nature therapy programs. The literature indicates that most prison campuses are not designed to incorporate natural elements, with facilities typically made of concrete and wire, leading to dark, overcrowded, and isolated environments. Inmates have limited access to nature, but nature therapy programs offer an opportunity for relaxation and escape from these harsh environments (Granger, 2017). Longitudinal studies in environmental psychology and cognitive neuroscience demonstrate that exposure to natural environments can be restorative, enhancing physical and mental health, improving cognitive performance and psychological well-being, and reducing stress and hypertension. Nature can also foster cooperative behavior and social values (Van der Linden, 2015). Another significant program within Prison farms is garden

therapy, which involves activities like gardening, planting seeds, and removing weeds. This program started in the 1930s and evolved into a recognized discipline by the 1950s (Mattson *et al.*, 2004). Garden therapy can improve inmates' diets and positively impact their mental and emotional states, self-esteem, and sense of purpose. It has been shown to reduce depression and aggression (Lee et al., 2020; Brown *et al*., 2015; Zelenski *et al.*, 2015).

Animal breeding programs, including horse breeding, beekeeping, and dog breeding, are also effective rehabilitation tools in prisons. These programs aim to develop inmates' personal and emotional skills, enhancing self-confidence, responsibility, and professional abilities (Davis, 2007; Strimple, 2003; Turner, 2007). Dog breeding, in particular, has therapeutic effects, reducing anxiety and stress in inmates, and facilitating interpersonal communication (Leonardi *et al.*, 2017). Overall, human-animal interaction provides physical, psychological, and social health benefits (Beseres, 2017).

Rehabilitation of Inmates through Urban Agriculture: Rehabilitation in prison integrates the concepts of rehabilitation and correction. Dissel (2007) views rehabilitation as a process where individuals recognize themselves as integral parts of society. Howells and Day (1999) and Darmawati *et al.* (2020) define rehabilitation as empowering individuals to reintegrate into society and abide by social laws. In the context of prison, rehabilitation often equates to urban agriculture, encompassing inmates' social relations, employment, education, and professional skills development. The primary goal of prison-farm programs is to prevent recidivism and address antisocial behaviors. Studies by Listiana and Hastjarjo (2021) and Uddin *et al*. (2019) highlight the importance of evaluating inmates' participation in urban agricultural activities, given that many inmates are socioeconomically and educationally disadvantaged and struggle to find employment. Engagement in these programs improves health and fosters a sense of responsibility within society.

The Rehabilitation Theory: This study is grounded in the theories of social learning and rehabilitation. Rehabilitation theory posits that criminal behavior is not innate but results from social, economic, and environmental factors (Fedyunin & Peretyatko., 2020; Howard, 2017). The theory aims to prevent future crimes by developing individuals' socio-economic skills, enabling them to play active roles in society. According to these theories, therapeutic measures within prison rehabilitation programs can lead to positive behavioral changes in inmates (Criss & John, 2023).

Methodology

This cross-sectional descriptive study utilized the Kirkpatrick model (1996) to assess the effectiveness of prison-farm programs in Iran for the period 2016-2021. The study encompassed two groups: inmates at the prison (N= 130) and officials working at either the prison or the Kermanshah Cooperative Foundation (N= 14). Due to the COVID-19 pandemic, the prison housed 130 inmates during the study period. A sample of 106 inmates was selected through simple random sampling, while the officials were included in the study via a census. Data were collected using a researcher-developed questionnaire comprising two types of questions: general and specific. The general questions gathered demographic information (e.g., gender, age, education level, place of residence), while the specific questions were designed according to the four levels of the Kirkpatrick model.

The Kirkpatrick model, initially proposed in 1959 and refined in 1976, is a widely recognized framework for evaluating educational programs (Alsalamah & Callinan, 2021). It divides the evaluation process into four levels:

i) Reaction: This level assesses participants' satisfaction with the training. It includes 28 questions about course content, facilities, material usefulness, and trainers.

ii) Learning: This level assesses the skills and knowledge acquired. It includes 23 questions designed to measure the extent of learning, based on comparisons between pretest and posttest results.

iii) Behavior: This level examines the behavioral changes resulting from the training. It includes 13 questions answered by managers and experts to evaluate changes in inmates' behavior in their natural environment.

iv) Results: This level focuses on the overall impact of the program, including goal achievement and problem resolution. It is assessed through 14 questions addressed by managers and experts.

The third and fourth levels of evaluation were conducted four years after the completion of the training programs. A 5-point Likert scale (ranging from 1 = "to a low degree" to 5 = "to a large extent") was used for scoring and quantitative analysis of responses.

The reliability of the questionnaire was confirmed using Cronbach's alpha coefficient, and its face and content validity were established by a panel of experts, as shown in Table 1.

Data Description

Descriptive statistics showed that about half of the participants in urban agriculture programs were married. The participants' average age was 33 years, ranging from 19 to 60. More detailed information indicated that those in the 19-40 age group had a higher participation rate in the prison's urban agriculture programs than others. As the results showed, two-thirds of the participants were under-educated. Moreover, 52.8% of the participants had no prior farming experience. The average length of their sentence was 69 months, with a standard deviation of 6 months, and a minimum and maximum length of 5 and 300 months, respectively. Descriptive statistics of the officials and inmates showed that the former had an average age of 43 years with a standard deviation of 6 years. The minimum and maximum ages in this group were 30 and 52 years, respectively. The work experience variable revealed that 42.6% of the officials had less than 14 years of work experience, while 43.1% had more than 21 years of work experience. Regarding education level, 64.3% of the officials held a master's degree, 28.6% a bachelor's degree, and 1.7% a doctorate. According to the results, 85.7% of the officials believed that prison-farm programs could succeed in changing the inmates' behavior.

Results

Goal 1: the first level of evaluation (i.e., reaction) in Kirkpatrick model

The results of the one-sample T-test for the reaction variable showed that, as perceived by the inmates, with 95% confidence, the training program had an average to high level of achievement. The program adequately served its purpose (t=0.15, df=105, Sig=0.000). The ranking revealed that the training course received positive feedback on aspects such as satisfaction with the trainer's respectful and commendable behavior, the course's structured plan, the trainer's management skills, and the program's ability to enhance participants' knowledge. Among these, inmates ranked their satisfaction with the trainer's admirable behavior highest, while the lack of equipment and facilities ranked lower.

Table 1- Validity and reliability of the measurement instrument

Kirkpatrick model levels of evaluation	Number of items	Cronbach's alpha
Reaction	28	0.96
Learning	23	0.97
Behavior change	13	0.88
Results	14	0.95

Table 2- Results of Friedman Test and One-Sample t-Test for the First Level (Reaction)

Items	Mean	Mean difference	t	Sig.	Rank
Trainer's behavior and respect	4.24	1.24	22.65	0.000	1
Trainer's competence in answering questions	4.16	1.16	19.78	0.000	2
Satisfaction with course schedule	4.16	1.16	20.30	0.000	3
Course quality vs. expectations	3.9	0.99	14.09	0.000	17
Increasing inmates' agricultural knowledge	3.9	0.99	12.06	0.000	13
Holding training sessions at the right time	4.00	1.00	12.98	0.000	14
Trainer's knowledge of advanced methods	4.03	1.03	14.15	0.000	10
Trainer's awareness of the course content	4.00	1.00	12.61	0.000	11
Trainer's consideration of inmates' well-being	3.80	0.80	9.52	0.000	23
Selecting the right place to hold classes	3.99	0.99	12.76	0.000	16
Trainer's patience in responses	4.02	1.06	14.63	0.000	12
Trainer's expertise	4.06	1.06	15.51	0.000	6
Trainer's reaction to feedback	3.95	0.95	12.89	0.000	20
Trainer's management skills	4.15	1.15	18.39	0.000	4
Trainer's ability to motivate	3.98	0.98	13.15	0.000	18
Trainer's impartiality	3.75	0.75	8.70	0.000	24
Follow-up of training results	3.83	0.83	10.39	0.000	22
Availability of educational equipment	3.65	0.65	7.15	0.000	25
Availability of work equipment	3.52	0.52	5.21	0.000	27
Timely input usage	3.46	0.46	4.44	0.000	28
Encouragement to learn farming	3.51	0.51	4.43	0.000	26
Utilization of inmates' experiences	3.91	0.91	11.35	0.000	21
Real-life applicability of knowledge	4.01	1.01	15.85	0.000	15
Overall satisfaction with the training course	4.06	1.06	18.60	0.000	7
Increase in knowledge	4.07	1.07	15.24	0.000	5
Recommendation of the course	4.02	1.02	14.13	0.000	9
Effectiveness in agricultural skills	3.95	0.95	15.37	0.000	19
Increase in practical experience	4.07	1.07	18.55	0.000	8
		$X^{2=}323.66$	t=0.15	Sig=0.000	

Goal 2: the second level of evaluation (i.e., learning) in Kirkpatrick model

As the findings indicated, there was a statistically significant difference between the inmates' mean learning scores before and after the urban agriculture training course (Z = 0.000, Sig = 8.029). This demonstrates that the training course had a significant impact on increasing the inmates' level of learning. Consistent with these results, Weber *et al.* (2015) reported a significant improvement in inmates' knowledge following an environmental education course, emphasizing its positive effect on environmental knowledge. Similarly, Mattson *et al.* (2004) found that training inmates in greenhouse plant production and horticulture significantly enhanced their horticultural knowledge. These findings suggest that such training programs are highly motivating for inmates. On the other hand, Omoni and Ijeh (2009) found no significant relationship between formal education and inmate rehabilitation, highlighting that informal training methods like urban agriculture can be particularly effective in rehabilitation. Listiana and Hastjarjo (2021) also supported the idea that prison-farm programs provide valuable skills for life after prison. Zautorova (2019) emphasized the importance of environmental education in prisons, noting that a modern individual should possess a basic level of ecological knowledge and high ecological culture, which can be fostered through such educational programs. Furthermore, Kaye *et al*. (2015) highlighted an additional benefit of prison-farm programs: their role in engaging inmates in conservation efforts to protect endangered species, which contributes to reducing habitat destruction and preserving biodiversity.

In the next step, the Friedman test was conducted to evaluate the importance and value of items as perceived by the inmates. The analysis showed that before the course (the pretest), the inmates were most skilled in plowing and irrigation and had the most knowledge of agricultural tools and equipment (mechanization). The lowest-ranked skills were knowing how to sell and market the products and teamwork skills. It was observed that 52% of the participants had prior experience in agricultural activities. Naturally, they had better basic agricultural skills before the course. However, due to their low education/literacy levels, they knew less about marketing and selling the products and had less teamwork skills, likely due to distrust in others.

The ranking of items after the course (the posttest) showed that the inmates gained the best skills in areas such as knowing different types of fertilizers, knowing the right tools and equipment (mechanization) for agriculture, and knowing how to sell and market the products. It can be concluded that this course successfully improved the inmates' specialized knowledge and skills in agriculture. Similarly, Uddin *et al*. (2019) showed that inmates can integrate newly acquired agricultural skills with their previous knowledge and live an easier, crime-free occupational life outside prison. Consequently, the two items of irrigation skills and soil preparation skills were assigned the lowest rank.

The training course significantly improved the inmates' agricultural skills. In all cases, the post-course mean score for knowledge and skills reached an acceptable level compared to the pre-course scores.This is also confirmed by the findings reported by Harkrader *et al.* (2004). The research findings reported by Coppedge and Strong (2013) showed that training for professional skills can be an effective way to reduce recidivism.

Table 3- Comparison of the learning level before and after the training course

		N	Mean Rank	Ranks sums	Z	Sig
Pretest-posttest	Negative signs	9[a]	18.28	164.50	-8.029	0.000
	Positive signs	89[b]	52.66	4686.50		
	Ties	7[c]				
	Total	105				

a. pretest > posttest b. pretest < posttest c. pretest = posttest

Table 4- Friedman test and one-sample t-test results of the second level (learning)

Items	Before the Course (Pretest)		After the Course (Posttest)	
	Rank Mean	Rank	Rank Mean	Rank
Soil Preparation	6.37	7	6.13	11
Plowing	7.04	1	6.40	6
Planting	6.60	5	6.30	8
Irrigation	7.03	2	6.15	10
Pest Control	6.18	10	6.35	7
Weed Control	6.38	6	6.65	3
Teamwork	6.20	11	6.19	9
Use of Inputs	6.32	8	6.61	4
Fertilizer Knowledge	6.28	9	7.22	1
Equipment Knowledge	6.88	3	6.92	2
Timing for Planting and Harvest	6.86	4	6.42	5
Marketing Knowledge	5.85	12	6.65	3
X^2	33.36		31.76	
Df	11		11	
Sig.	0.000		0.001	

Goal 3: Testing the normal distribution of the third level (behavior)

The analysis showed a statistically significant difference (Z=0.001, Sig=3.297) between the mean score of the inmates' behavior before and after the course. The urban agriculture training course in the prison managed to significantly and positively change the behavior. Similarly, the findings reported by Brown *et al*. (2016) showed that the horticulture training intervention managed to have a significant and positive effect on drug offenders' behavior. The reason was that, in the training, the garden was described as a realistic image of a place where humanization is formed, self-esteem is increased, a socialization occurs and human is bound to the nature.

Table 5- Wilcoxon test results of the second level (learning)

Variable		Mean	Std	z	Sig.	Test result
Soil preparation skill	Pretest	2.41	1.07	-7.38	0.000	Acceptable
	Posttest	3.76	0.83			
Plowing skill	Pretest	2.56	1.05	-7.24	0.000	Acceptable
	Posttest	3.80	0.80			
Planting skill	Pretest	2.44	1.07	-7.41	0.000	Acceptable
	Posttest	3.79	0.85			
Irrigation skill	Pretest	2.55	1.06	-6.88	0.000	Acceptable
	Posttest	3.76	0.87			
Pest and disease control skills	Pretest	2.34	1.05	-7.471	0.000	Acceptable
	Posttest	3.79	0.91			
Weed control skills	Pretest	2.41	1.12	-7.54	0.000	Acceptable
	Posttest	3.86	0.87			
Team work skill	Pretest	2.31	1.09	-7.48	0.000	Acceptable
	Posttest	3.70	0.93			
Use of seeds, fertilizers and other inputs	Pretest	2.36	1.08	-7.68	0.000	Acceptable
	Posttest	3.85	0.81			
Knowledge of different fertilizer types	Pretest	2.38	1.12	-7.72	0.000	Acceptable
	Posttest	4.00	0.85			
Knowledge of agricultural tools and equipment (mechanization)	Pretest	2.51	1.13	-7.52	0.000	Acceptable
	Posttest	3.92	0.82			
Knowledge of the right time to plant and harvest	Pretest	2.50	1.12	-7.38	0.000	Acceptable
	Posttest	3.83	0.87			
Knowledge of how to sell and market the product	Pretest	2.26	1.10	-7.61	0.000	Acceptable
	Posttest	3.87	0.85			

Table 6- Comparison of the behavior level before and after the training course

		N	Mean Rank	Rank sums	Z	Sig
Pretest-posttest	Negative signs	0[a]	0.00	0.00	-3.297	0.001
	Positive signs	14[b]	7.50	105.00		
	Ties	0[c]				
	Total	14				

a. pretest > posttest b. pretest < posttest c. pretest = posttest

The results of the Friedman test for ranking behavioral items before the training course showed that the most significant behaviors perceived by the trainer and experts were aggressive behaviors, focusing solely on discharge from prison, prejudice and pride, and sufficient sleep and rest. Similarly, Granger (2017) found that inmates lacked constant access to nature and outdoor areas. Most prisons were not artistically designed to appreciate nature, with existing facilities mainly consisting of brick and wire. This researcher added that most prisons were dark, chaotic, overcrowded, and isolated, with inmates having little access to nature. These conditions seem to significantly increase aggressive behavior and isolation among inmates. However, urban agriculture and nature therapy programs can significantly modify such behavior. According to Van der

Linden (2015), nature is restorative. Even brief exposure to the natural environment can improve physical and mental health. In agreement with the present findings, Lee *et al.* (2020) found that horticulture training programs in prisons managed to reduce inmates' depression, increase self-esteem and life satisfaction, and improve mental health. Sachitra and Wijewardhana (2020) also showed that rehabilitation programs in prison can moderate potentially negative emotions such as anger, despair, and loneliness. As the findings showed, the two positive behaviors, inmates' confidence in their abilities and thinking about a healthy life, were at the lowest recognition level before the course. Moreover, Farley and Pike (2016) showed that inmates' participation in education could decrease monotony and boredom and improve critical thinking skills.

The Friedman test also showed improvement in many of the inmates' positive behaviors and a decrease in their negative behaviors. Social learning theory can probably explain this behavior change. Arguably, the inmates managed to improve their behavior within the socio-cultural context of the urban agriculture training course. This finding was also ratified by O'Connor and Perreyclear (2002). In general, after the implementation of the urban agriculture training course in the prison, group work and cooperation increased among inmates compared to before the course, and this increase was statistically significant. A body of research by Tett *et al.* (2012), Zelenski *et al.* (2015), Leonardi *et al.* (2017), and *Mims et al.* (2017) also showed that during correctional programs, inmates learn to work more effectively with each other and enhance their interpersonal communication. In other words, exposure to nature will improve their cooperative behavior and socialization values. These studies showed that horticulture curricula for inmates managed to strengthen their social ties with the community, subsequently leading to a change in attitude.

Another behavior that showed significant improvement after the training course was the inmates' farming skills. This finding was confirmed in a body of research by Davis (2007), Strimple (2003), and Turner (2007). These researchers believed that horticulture and agriculture training programs in prison could improve inmates' skills, qualifications, and work experience. Concerning the importance of the acquired farming skills, Timler *et al.* (2019) contended that gaining significant work experience would lead to increased self-esteem and personal values in the future. Robinson and O'Callaghan (2008) confirmed this finding and added that although these programs in prisons face many challenges, they can positively affect individuals. These programs can provide the basis for job training and free education for inmates as a trained workforce. These professional training programs seem to be immensely successful for inmates. According to Ross (2011), inmates are mainly considered a vulnerable population in society.

The third behavior that showed significant change after the training course was the inmates' knowledge and experience. This finding was also confirmed by Harkrader *et al.* (2004), Baybutt *et al.* (2018), and Anderson and Leal (1997). The judicious use of time was a highly ranked behavior by the trainers and officials. It was suggested that inmates spend their free time actively engaged in these programs rather than just wasting it. This approach could help reduce depression and improve mental and physical health. Generally speaking, it could have beneficial outcomes.

Among behaviors such as aggressive behavior were at a lower ranking level, although the t-test results showed this change was not statistically significant. Yet, the mean score was reduced in the posttest compared to the pretest. This finding is similar to the results reported by Lee *et al.* (2008). Their research on anger control in female inmates using horticulture therapy showed no significant effect on reducing anger in the experimental group, but the mean score of the experimental group decreased from 67.8 to 66.3. Thus, this finding is similar to the present research. It can be argued that urban agriculture, as an instance of naturopathy, can put one's mind at rest.

Braz and Gilmore (2006) contended that this peace of mind could directly affect the body and, as a result, decrease inmates' blood pressure and internal anxiety. Thus, it can be expected to balance the behaviors. Additionally, the findings reported by Lahm (2009) showed that correctional education programs in prison could successfully reduce violations of the law among inmates.

Table 7- Friedman test and one-sample t-test results of the third level (behavior)

Items	Before the Course (Pretest)		After the Course (Posttest)	
	Rank Mean	Ranking	Rank Mean	Ranking
Friendly Relationship with Trainers & Officials	6.43	7	6.57	12
Improving Knowledge & Experience	6.57	6	8.25	3
Inmates' Aggressive Behavior	9.18	1	4.96	10
Obsession with Discharge	8.54	2	7.14	7
Rest & Sleep	8.11	4	7.29	6
Group Work & Cooperation	6.57	6	8.54	1
Inmates' Patience	6.57	6	4.86	11
Confidence in Capabilities/Skills	5.36	11	7.46	8
Prejudice & Pride	8.29	3	7.04	8
Thinking about Healthy Life	5.71	10	5.82	12
Judicious Use of Time	7.14	5	8.21	4
Agricultural Skills	6.29	8	8.39	2
Feeling Responsible	6.25	9	7.04	8
X^2	22.41		26.19	
Df	12		12	
Sig.	0.03		0.01	

Table 8- One-sample t-test results of the third level (behavior change)

Items		Mean	SD	t	Sig	Test result
Friendly relationship and interaction with trainers and officials	Pretest	2.00	0.78	-5.47	0.000	Acceptable
	Posttest	3.35	1.00			
Increasing the inmates' knowledge and experience	Pretest	2.00	0.78	-6.76	0.000	Acceptable
	Posttest	3.85	0.53			
Inmates' aggressive behavior	Pretest	2.92	1.20	-0.135	0.890	Unacceptable
	Posttest	3.00	1.17			
Obsession only with discharge from the prison	Pretest	2.42	0.85	-4.05	0.000	Acceptable
	Posttest	3.64	0.63			
Rest and sleep	Pretest	2.35	0.92	-3.08	0.000	Acceptable
	Posttest	3.57	1.08			
Group work and cooperation among inmates	Pretest	2.07	0.47	-5.96	0.000	Acceptable
	Posttest	3.85	1.03			
Inmate's patience	Pretest	2.14	1.09	-2.26	0.042	Acceptable
	Posttest	3.21	1.12			
Inmate's confidence in capabilities	Pretest	1.78	0.80	-4.60	0.001	Acceptable
	Posttest	3.64	1.15			
Prejudice and pride	Pretest	2.28	0.82	-3.34	0.005	Acceptable
	Posttest	3.57	0.94			
Thinking about living a healthy life	Pretest	1.85	0.77	-4.84	0.000	Acceptable
	Posttest	3.35	1.00			
Judicios use of the inmate's time	Pretest	2.21	0.89	-5.78	0.000	Acceptable
	Posttest	3.78	0.89			
Inmate's skills in agriculture	Pretest	2.00	0.96	-5.14	0.000	Acceptable
	Posttest	3.85	0.86			
Feeling responsible	Pretest	1.92	0.61	-4.84	0.000	Acceptable
	Posttest	3.65	0.84			

Goal 4: the fourth level of evaluation (i.e., results) in Kirkpatrick model

The one-sample t-test analysis of the results showed, as perceived by the trainers and experts in agricultural training, with 95% confidence, the performance was moderate, but the goals were not achieved as expected (t= -0.106, df=13, Sig=0.917). There can be several reasons for this finding. First, not much time had passed since the operation of these programs, so we could not really expect significant outcomes. Second, these programs do not generally follow the standard steps, and according to Bachi (2013), the low experiential knowledge of the planners, experts and trainers in these programs can have a significant effect on the results.

The ranking of items using the Friedman test showed the training course had managed to achieve a moderate to high level of achievement by empowering the inmates to work on farms. This finding was also consistent with the data collected from the inmates. The findings reported by Bozick *et al*. (2019) and Hunter and Boyce (2009) also confirmed that correctional education could contribute to inmates' employment in their post-prison life.

The major outcome of the training course was the development of individual and social skills in inmates. Similarly, the findings reported by Han *et al*. (2021) showed that educational programs such as dog breeding in prison can increase self-concept, develop skills, increase participation, enhance perceived control, and positively affect life after prison. Evaluating the outcomes showed that urban agriculture programs managed to partly improve the inmates' health. The prison farm programs include various agricultural activities. Nature therapy programs and animal therapy are subsets of these activities, as are horticulture, fish therapy, and beekeeping. The benefit of fish therapy lies in the fact that watching and raising fish in water can be relaxing and can reduce stress and blood pressure. Nature therapy has certain benefits such as a psychological effect, depression reduction, and risk-taking reduction (Richards & Kafami, 1999). Bowlby (1969) contended that communication can be a source of increased comfort, security, and less stress. Nature therapy also helps regulate the mind and strike an emotional balance. Maintaining human relationships with animals is well-known in many domains. It can be concluded that these programs positively affect individuals' mental and physical health. Brown *et al*. (2016) also pinpointed the effectiveness of these training courses in improving inmates' mental health. Mitra and Agarwal (2016) defined well-being as a state of physical, mental, emotional, and social happiness. Baybutt *et al*. (2019) believed that prison farm programs, including gardening, can have the greatest effect on the participants' health and mental well-being.

The present study showed that during the prison farm program, the inmate participants' behavior improved. This is in agreement with Vandala (2019), who showed that rehabilitation programs transform criminals, promote self-esteem, humanity, and turn them into decent law-abiding citizens. As the ranking showed, the prison farm training course was not enormously successful in earning an income for the inmates. Further analysis showed that most of the income of the prison farm projects is provided for the participating inmates and their families. It seems these projects mainly seek the inmates' behavioral and social changes, and earning an income is not a priority.

Table 9- One-sample t-test analysis of the fourth level (results)

Variable	t	Df	Sig	Mean difference	Lower limit	Upper limit
Results	-0.106	13	0.917	-0.025	-0.54	0.49

Another item ranked lowest among the program's outcomes was the reduced rate of inmate recidivism. The expectation is that the prison farm program equips inmates with skills to earn an income for their families, which would reflect a positive behavioral change. If they can earn a living properly, there is little chance that they will return to criminal acts. Thus, it is expected that the rate of crime will be reduced. Brewster and Sharp (2002) showed that rehabilitative training programs are an effective means of reducing recidivism. Also, a meta-analysis by Bozick *et al*. (2018) covering 1980-2017 showed that rehabilitation training for inmates can reduce recidivism. Thus, there will be more chances that these individuals will return to prison. To confirm the present findings, it is necessary to conduct a comparative study between inmates who have taken part in rehabilitation programs and those who have not to have a more reliable evaluation of the effectiveness of the programs. Descriptive statistics indicate that for approximately 95% of the inmate participants, this was their first experience in a training course. Therefore, a comprehensive evaluation would require a parallel study on discharged inmates to assess the impact of the training on their likelihood of recidivism.Another item that got a low rank in the results was the food security level. This finding can be discussed in at least two ways. One is that agricultural products of these programs are sold outside the prison, and the earnings are used to cover expenses. This can, in turn, lighten the financial burden on the government. In other words, the income earned from the prison farm project helps to cover the costs of the prison or a similar organization. Moreover, the towns nearby may prefer to buy the farming products from the prison rather than from distant villages. This can also significantly contribute to the agricultural sector. In order to ensure food security, policymakers should focus on three important factors: 1) subsidies for prisons, 2) allocation of strategic resources, and 3) food production. Although these programs were expected to increase food security in the prison, this goal was not achieved. Research by Listiana and Hastjarjo (2021) and Moloko *et al*. (2018) showed that prison farm programs can ensure food security. It can be argued that Dizel Abad Prison has no plan for using the generated products as food. Also, as mentioned previously, the income from selling the products is used for inmates and their families. Obviously, these programs cannot lead to an increase in food security within the prison.

Conclusion

This study demonstrated the effectiveness of the prison-farm program at Dizel Abad Prison in inducing positive behavioral changes among inmates and enhancing their knowledge and attitudes. The success of this program underscores its potential benefits for both inmates and society, making it a viable solution for inmate rehabilitation and urban agriculture development. Furthermore, as highlighted by Darke and Aresti (2016), such programs can foster improved collaboration between correctional facilities and institutions like universities, which can support the needs of this vulnerable population. Similarly, Richards and Kafami (1999) found that universities can assist in the reintegration of inmates by offering educational opportunities and reducing barriers.

Based on these findings, several recommendations are proposed. First, prison regulations should be revised to remove barriers to urban agricultural programs, enabling greater integration and effectiveness. Additionally, increasing the available space for agricultural activities within prisons is essential to support more extensive and productive participation. Additionally, allocating increased funding to support urban agriculture rehabilitation programs can enhance their sustainability and impact. Strengthening partnerships between prison officials and relevant institutions can help secure necessary financial support, while recruiting agricultural experts to train inmates would provide them with valuable skills. Forming agreements with agro-industrial

complexes could ensure a steady supply of agricultural products and create employment opportunities for inmates.

The implications for future research are substantial. This study enhances the understanding of urban agriculture within the context of prison-farm programs in Iran, providing valuable insights and establishing a foundation for future research in this field. As a pioneering study in Iran, it has the potential to influence national prison-farm programs and guide subsequent investigations. It also applies and validates the theory of rehabilitation and change (Miriti and Kimani, 2017), demonstrating its practical utility. The innovative use of the Kirkpatrick model to evaluate the effectiveness of the prison-farm program provides a new approach for future studies. Furthermore, the prison-farm program can generate financial benefits by creating income for both the prison and the inmates, helping to offset costs and provide necessary support. The program's connection with nature not only improves behavior through nature therapy but also contributes to the preservation of endangered plant and animal species. However, the study has limitations that must be acknowledged. Security concerns restricted access to the prison, complicating the administration of interviews and questionnaires. The program's focus on male inmates limits the generalizability of the findings to female inmates. The study's reliance on quantitative methods means that a qualitative component could offer more in-depth insights into the program's impact. Additionally, the COVID-19 pandemic restricted access to some participants, potentially affecting the results. Finally, the absence of a control group calls for cautious interpretation of the findings, and future research should consider employing true experimental or quasi-experimental designs to more accurately assess the program's effectiveness.

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Conflict of Interest

The Authors declare that there is no confilict of interest.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Table 10- Friedman and t-test analysis of the fourth level of evaluation (results)

Items	Rank mean	Ranking	Mean	Mean difference	t	Sig	Test result
Agricultural policies and strategies	8.29	3	3.14	0.14	0.69	0.50	Unacceptable
Income from prison-farm program	6.14	10	2.71	1.37	0.93	0.36	Unacceptable
Food security level	3.79	12	2.14	0.41	4.16	0.001	Unacceptable
Improved Inmate behavior	7.89	5	3.14	0.77	0.48	0.63	Unacceptable
Better prison environment	7.25	6	2.92	0.62	0.22	0.82	Unacceptable
Positive impact on prison functioning	6.39	9	2.78	0.57	0.58	0.56	Unacceptable
Improved profile of prison in public	7.18	7	2.92	0.69	0.20	0.84	Unacceptable
Farming jobs for inmates	10.14	1	3.42	0.96	1.71	0.11	Unacceptable
Achieved training goals and better learning	9.21	2	3.28	0.76	1.29	0.21	Unacceptable
Reduced recidivism due to agricultural programs	5.68	11	2.64	0.22	1.32	0.20	Unacceptable
Improved inmate health	7.96	4	3.07	0.69	0.24	0.80	Unacceptable
Enhanced personal and social skills of inmates	10.14	1	3.5	1.16	1.61	0.13	Unacceptable
Optimal resources use and consumption correction in prison	6.69	8	2.85	0.45	0.52	0.61	Unacceptable
Support for inmates' families	7.96	4	3.07	0.99	0.16	0.86	Unacceptable

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تحلیلی بر پروژه‌های کشاورزی شهری زندان- مزرعه در کرمانشاه

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چکیده

کشاورزی شهری نه تنها امکان تحقق توسعه پایدار کشاورزی و مشارکت همه افراد جامعه را فراهم می‌آورد بلکه می‌تواند منجر به افزایش توانبخشی در اقشار مختلف جامعه از جمله زندانیان شود. لذا هدف پژوهش حاضر تحلیلی بر اثربخشی پروژه‌های توانبخشی زندان-مزرعه در زندان دیزل آباد کرمانشاه در ایران می‌باشد. جامعه آماری دو گروه از افراد بودند؛ گروه اول شامل ۱۳۰ نفر از زندانیان دیزل آباد کرمانشاه بودند که با استفاده از فرمول کوکران ۹۷ از آن‌ها به روش نمونه‌گیری سیستماتیک انتخاب و مورد مطالعه قرار گرفتند. گروه دوم نیز شامل ۱۴ نفر از مدیران و مسئولین و کارشناسان ندامتگاه بودند که به روش سرشماری (کل شماری) مورد مصاحبه قرار گرفتند. ابزار گردآوری داده‌ها پرسشنامه محقق ساخته بر مبنای مدل کرک پاتریک بود. پایایی پرسشنامه با استفاده از ضریب آلفای کرونباخ مورد تأیید قرار گرفت. روایی شکلی و محتوایی پرسشنامه نیز توسط اساتید و اعضای هیئت علمی گروه ترویج و آموزش کشاورزی دانشگاه رازی مورد تأیید قرار گرفت. به‌منظور تجزیه و تحلیل داده‌ها از نرم‌افزار SPSS استفاده شد. یافته‌ها در سطح یک الگوی کرک پاتریک نشان داد با اطمینان ۹۹ درصد می‌توان ادعا نمود زندانیان از شرکت در در دوره آموزش کشاورزی شهری رضایت داشته‌اند. در سطح دوم نیز نتایج نمایانگر آن بود که میزان آگاهی زندانیان افزایش داشته است و نمرات آگاهی آنها در دو مرحله قبل و بعد از آموزش از لحاظ آماری معنی‌دار است ($p>0.01$). علاوه بر این، یافته‌ها در سطح سوم (رفتار) الگوی کرک پاتریک نشان داد با اطمینان ۹۵ درصد می‌توان ادعا نمود سایت‌های الگویی جامع توانسته‌اند در رفتار زندانیان تغییرات قابل توجهی را ایجاد نماید. بررسی یافته‌ها در سطح چهارم مدل نشان داد اگر چه دوره‌های آموزش کشاورزی شهری در ندامتگاه آباد کرمانشاه نتایج و دستاوردهای در حد متوسط به همراه داشته‌اند. اما این دستاورد از لحاظ آماری تفاوت معناداری ندارد. به‌طور کلی بررسی‌ها نشان داد دوره‌های آموزش کشاورزی شهری در ندامتگاه دیزل آباد کرمانشاه تغییرات رفتاری، دانشی، نگرشی را در زندانیان ایجاد نمایند. به گونه‌ای که می‌توان امیدوار بود این برنامه‌های آموزشی اصلاحی بتواند منافع مورد نیاز جامعه و زندانیان را تأمین نمایند. از این رو برنامه‌های زندان مزرعه در قالب برنامه‌های کشاورزی شهری می‌تواند راهکاری مناسب برای توانبخشی زندانیان و توسعه کشاورزی شهری باشند.

واژه‌های کلیدی: آموزش اصلاحی، توانبخشی کشاورزی، کشاورزی شهری، زندان- مزرعه، مدل کرک پاتریک

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