Drivers of Regional Total Factor Productivity in Iran's Agriculture

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Abstract

This paper measures and analyzes total factor productivity index of the Iran's agricultural sub-sector's production in farming as well as its components including the technical efficiency change and the technological advancements in 27 provinces of the country for the period spanning from 2009 to 2018 through the non-parametric method of data envelopment analysis, and Malmquist productivity index. According to the results, the average total factor productivity in the provinces of Gilan, Ghazvin, Ardabil, Boushehr, Golestan, Razavi Khorasan, Hamedan, Kurdistan, Fars, Sistan and Baluchestan, Kohgiluyeh and Boyer-Ahmad, Isfahan, Chaharmahal and Bakhtiari, Zanjan, Tehran, Mazandaran, Hormozgan, West Azerbaijan, North Khorasan, and Khuzestan is greater than 1, which indicates its growth in the time period mentioned. However, this index is less than 1 in the agricultural sub-sectors of provinces of Kermanshah, South Khorasan, Lorestan, East Azerbaijan, Yazd, Kerman and Ilam, which indicates its reduction in the time period under examination. According to the findings, in the agricultural sub-sectors of Gilan, Ghazvin, Boushehr, Golestan, Razavi Khorasan, Hamedan, Kurdistan, Fars, Isfahan, Chaharmahal and Bakhtiari, Zanjan, and Tehran provinces, total productivity of agricultural sub-sector's growth rooted from increased technical efficiency as well as technological advancement. In the provinces of Boushehr, Sistan and Baluchestan, Hormozgan, Kermanshah, and Kerman, however, the technical efficiency remained steady, and the change of progress of technology led to total factor productivity growth of agricultural sub-sectors.

Keywords: total factor productivity, data envelopment analysis, Agriculture, Iran.

1. Introduction

According to economic theories, the growth of agricultural production comes from two resources. "resource-oriented" growth stresses quantitative expansion of human resources and physical capital, while "productivity-oriented" growth is based on an increase in production through the innovation of new technologies and improvement of the beneficiaries' efficiency on a specific level of sources (Khaksar Astaneh et al., 2019). In the past, the growth of agricultural production used to be achieved through the resource-oriented approach or more land use, capital, and intermediary institutions. However, the productivity-oriented growth in farming has become popular today due to the productivity growth that leads to an increase in the level of available resources and technologies, agricultural and food production, plus reduces the real price of agricultural products and its share from the total consumer costs while saving resources. Therefore, resource constraints and the necessity to meet the nutritional needs of an increasing population have made planners and policy-makers of the agricultural sector in different countries develop greater interest in the productivity factor growth of production.

Like other countries, Iran has also been faced with an inescapable change in productivity indexes across the country due to various reasons such as population growth, change in consumption patterns, climatic changes, land erosion, and environmental damage, and resource constraints, especially water and land. Statistical indicators, on the other hand, show the economy as having a not-so-good situation in productivity indexes, especially in the agricultural sector of the country.

According to statistical data, the average total factor productivity (TFP) growth index of the agricultural sector spanning 2005 to 2019 was 0.8%, which is lower than Asian countries as well as developing countries (Khaksar Astaneh et al., 2019). As a result, increasing productivity growth is one of the main challenges of Iran's economy. Evidently, the agricultural sector should be considered as one of the important sectors of the economy in order for productivity to rise because this sector plays an undeniably important role in supplying the nutritional needs of the society as well as the raw materials of some industries. This sector accounts for approximately 15% of the gross domestic production, 21% of employment, and 22% of non-oil exports of the country; moreover, it has supplied 80% of raw materials of the country's processing industries. Yet, the average total factor productivity growth of this sector is insignificant relative to most economic sectors and other countries, and it is a long way from reaching the 2% goal identified in the five-year plans for the development of the country. Based on the above statements, total factor productivity growth in different economic sectors, especially, the agricultural sector is considered the country's inevitable necessities (Abedi, 2015). On a regional scale, the productivity indexes of the country, and consequently, the agricultural sector is not in a decent condition, to the extent that, in terms of total factor productivity index, the country is ranked 10^{th} among the 13 countries of the Asian Productivity Organization (APO) (Khaksar Astaneh et al., 2019).

In addition to the fact that the productivity indexes of the agricultural sector are low both nationally and globally, the discrepancies in the productivity indexes of this sector in terms of the country's geographical and provincial areas have long been problematic to the country's economic planning system. In other words, the geographical (provincial) distribution of total factor productivity indexes of the agricultural sector's production are not properly harmonious and demonstrate significant differences. For instance, the range of total factor productivity changes in 27 provinces of the country varies from 0.11 to 1.14 (Rajabi Tanha & Abdollah Zade, 2010). This indicates that the policy and solutions of productivity growth do not have similar functionality in various regions of the country, the policies are different, or productivity growth has not been fundamentally considered as a political objective in some regions. Since the discrepancies of productivity growth rates in different provinces come from regional inequality, different climate, level of development, inherent abilities and the gift of resources, the structure, and orientation of governance, a study on the agricultural sector's productivity across the geographical area can be effective in identifying the factors determining regional differences to be able to develop solutions for the balanced development of the agricultural sector and provide efficient and productive use of limited factors of production according to the characteristics of each province and adopt appropriate policies.

Despite the undeniable importance, analyses indicate that researchers have not paid much attention to the topic of agricultural productivity and the necessity of its balanced growth in different parts of the country. The conducted studies are often focused on measuring different productivity indexes on a product or national level. A distinct lack of comprehensive studies and research on agricultural productivity at different levels such as sub-sectors, effective structures, and regional differences of agricultural productivity across the geographical area of the country is apparent. Thus, based on the matters mentioned above, the present research attempts to segregate geographical regions (provinces) of the country and identify its components (technical efficiency and technological advancement) with the purpose of measuring total factor productivity growth index of the agricultural sub-sector as the most important agricultural sub-sector of the country.

Various reasons stress the necessity of conducting this research and its importance some of which are the low productivity indexes of the agricultural sector compared to other countries as well as the world average. In addition to the necessity of concentration on total factor productivity indexes of the agricultural sub-sector and its resources in different provinces of the country, they stress the necessity of conducting research and the reason why. Therefore, this research can provide policy-makers with a viewpoint to improve productivity in agricultural uses.

2. Literature Review

Choosing a proper methodology for the research requires analyzing and distinguishing the literature review. Studying world literature clarifies the aspects and challenges related to the topic as well as its theoretical foundations. Moreover, analyzing the attempts made in the country not only helps better understand the topic and the country's situation compared with developed countries, but it also reveals the existing gaps in the field of research. Therefore, analyzing the researches of other countries, mainly developed nations, can be the first step in conducting a proper methodology. This section, thus, presents the literature review of the domestic and international areas.

Measuring total factor productivity index of production in various economic sectors, especially the agricultural sector has a rather long history. In some of these studies, components and the contributing factors on total factor productivity growth have been taken into consideration. Mao & Gu (1993) analyzed total factor productivity of production and its components (technical efficiency and technological advancement) of the agricultural sector spanning 1984 to 1993 (the economic reform period in rural China) through the data envelopment analysis method. According to the results, total factor productivity growth during the said period was positive, having been influenced by technological advancements. Low technical efficiency in most regions of China indicates the great capacity of productivity growth through technical efficiency improvement. Therefore, investment in rural education, as well as research and development in farming have been suggested. The studies of Piesse et al. (2000) on agriculture of different regions of Botswana indicated that first, the productivity growth in ranching areas is higher than in other areas, and second, this growth is affected by technological change (advancement) since the technical efficiency has decreased. Ali & Moshtagh (2012) stress that the analysis of factor (component) determining productivity is more important than the presenting productivity indexes As Olhan (2013) has stated, breaking down total factor productivity into its components makes it possible to evaluate how productivity grows. Hsu et al. (2003) analyzed the productivity growth of agricultural sectors spanning 1984 to 1999 in 27 provinces in China through Panel data. To do so, output-oriented Malmquist productivity indexes were first measured through the non-parametric method of data envelopment analysis. Afterward, they fitted the main factor determining total factor productivity growth and their components through the Tobit Regression model. González)2011) has investigated the level and process of agricultural productivity and production of 14 developing countries, which make up the majority of Central America and The Caribbean. He used the data of 1979-2008 time period, as well as the data, envelopment analysis to extract the Malmquist productivity indexes. The results reveal that the 1.5% annual growth of total factor productivity is accompanied by a 0.1% and 1.4% change in technical efficiency and technological advancement during the year, respectively. Through Tornqvist Index, Conan (2011) has aimed at the measurement of total factor productivity of ten major products of Karnataka, India, and its determining factors. According to the results, most products had low productivity growth. The analysis of contributing factors on total factor productivity indicate that the government's costs for research, education, irrigation canals, precipitation, and balanced use of fertilizer are some of the important factors affecting the productivity of products in Karnataka. Therefore, it is essential that public and private investments be strengthened in researches, agricultural technology, and rural infrastructure for long-term productivity growth.

Choudhry (2012) conducted research to estimate total factor productivity in India's agriculture at the state level from 1983/1984 to 2005/2006. Total productivity changes have been measured through non-parametric data envelopment analysis (Malmquist Index). According to the results, in all the states, the technological change (advancement) share in total factor productivity exceeded the technical efficiency change share. Rahman & Salim (2013) examined the agricultural total factor productivity of 17 regions in Bangladesh spanning 1948 to 2008. The results revealed that total factor productivity growth was generally due to technological advancement; whereas technical efficiency improvement was insignificant and the mix efficiency dwindled. Kaliji et al. (2013) conducted research to measure total factor productivity in the production of wheat and its components in three Northern provinces of Iran. This study estimated the Malmquist index through the data envelopment analysis approach.

The output was the wheat production and the inputs included the land, seeds, pesticide, fertilizer, workforce, and machinery per hectare. The results demonstrated that during the study period (2000-2010), the changes of total factor productivity in Golestan province occurred under the influence of technological advancement, while Gilan and Mazandaran provinces were mainly affected by efficiency variation. Hakkuma et al. (2019) examined total factor productivity and some of the contributing structures on it, and also the limitations of increase in production among yeoman farmers in the agricultural areas of Nigeria. According to the results, the size of the farm, rental workforce, household size, and seed reduces the multi-factor productivity in yam farms by 8.6%, 1.05%, 2.2%, and 0.45% respectively. Whereas, a 10% increase in age, income, access to credit facilities, and experience improve total factor productivity up to 0.061%, 0.133%, 0.543, and 0.139% respectively. The problems and limitations of increased productivity include insufficient land, finance, high transportation costs, rental workforce, pests and diseases, improper infrastructure, network, insufficient storage, etc. The results emphasize active policies aiming to intensify extension services, encourage farm mechanization, and provide low-priced credits in the state.

Leo et al. (2020) estimated total factor productivity and its o components, technological advancements, and technical efficiency change through the panel data of 30 provinces in China spanning 2002 to 2017 using the stochastic frontier method. According to the results, the technical efficiency fluctuated between 80% to 91% with a static trend and a slight reduction in the next years; whereas, total factor productivity consistently improved throughout time, which is majorly a result of technological changes (technological advancement). Among the determining factors, the government's investment in agricultural development projects significantly causes technological changes and technical efficiency, while experienced labor force dramatically increases technical efficiency. Drought rate (natural hazard) decreases technical efficiency but leads to technological advancement and total factor productivity. The literacy rate substantially improves technological advancement and total factor productivity. Nonetheless, the government's expenses in "agriculture, forestry, and water" reduces the technical efficiency, technological advancement, and total factor productivity.

Young et al. (2020) examined total factor productivity growth of soy production in China through the panel data of 10 main soy manufacturing provinces spanning 2005 to 2017. They found out that during the examined period, total factor productivity of the whole period had an average growth of 1.3% with a 2.3% technological advancement and a 1% efficiency change. Therefore, it can be argued that technological advancement is the effective factor in total factor productivity in soy production. The positive growth of total factor productivity in the provinces of Liaoning and Inner Mongolia, and its negative growth in Hebi and Anhui was mainly influenced by efficiency change. According to the results, in order to strengthen total factor productivity for soy production in China, the soy production technology first needs to improve for the high-quality process of the numbers to consistently upgrade for compatibility with various soils, and have resistance against uncertain factors (i.e. drought and the natural disaster and water-related natural disasters in the soybean yield).

3. Materials and Methods

In the first step of the research, the growth changes of total factor productivity of the agricultural sub-sector in 27 provinces of the country were measured through the non-parametric data envelopment analysis approach and the Malmquist index calculation (DEA-MQI), and the year years' data spanning 2008 to 2018. The average yield-per-hectare of the agricultural products of each province were considered as the output and the average chemical fertilizer, workforce, chemical pesticides, seed per hectare, and the extent of the farm's fertility as the input. In the following section, the data envelopment analysis method and the Malmquist index will be explained.

3.1. Data Envelopment Analysis and Malmquist Index

The data envelopment analysis and the Malmquist index are a common method of calculating changes of total factor productivity index, which has been introduced by different researchers such as Färe, Grosskopf, Norris & Zhang, Farrel, Chávez, Christensen, and Diewert (Coelli & Rao, 2003). This method uses the Malmquist index to create a distance function and the data envelopment analysis to measure the distance function. Afterward, it measures total factor productivity according to the distance function amount. In other words, the basic principle of generating productivity index is with the distance function ratio, meaning total factor productivity is measured through the ratio of each data point's distance to the conventional technology, and dividing total factor productivity by change component (technological advancement) and technical efficiency (pure efficiency change and scale efficiency change). Therefore, measuring the distance function is the key to the Malmquist index (Mojaverian, 2003).

The non-parametric data envelopment analysis approach and the Malmquist index measurement (DEA-MQI) measure changes in productivity (increase/ decrease rate) between two time periods (Keskin et al., 2013), which is widely used nowadays since it does not require frontier production function estimation. The Malmquist productivity index has been accepted in the data envelopment analysis for measuring productivity change in different economic sectors and agencies (Jiangu & Kamruzzaman, 2017).

The nature of data envelopment analysis is a non-parametric statistical analysis for evaluating the relative efficiency of each decision-making unit (in this research: the agricultural sub-sectors of each province) by comparing its angle of deviation to the boundary surface of effective production of data envelopment analysis. The advantage of data envelopment analysis is the avoiding subjectivity of the evaluation results through the linear planning method, which does not require the output-input functional relation, pre-estimation of parameters, and hypothesis testing. In the meantime, no units are needed for measuring the output/ input variables, nor data compatibility, integration, and other processing. Total factor productivity of Malmquist shows productivity deviation in two periods. The productivity changes can be positive indicating the improved production level compared to before, or negative indicating production reduction. A Malmquist productivity index of above (below) 1 indicates increased (decreased) efficiency with technological advancement (degradation). The Malmquist productivity index based on index variables is as follows:

$$M_0^t = \frac{D_{oc}^t(x_{t+1}, y_{t+1})}{D_{oc}^t(x_t, y_t)} \qquad (1)$$

$$M_0^{t+1} = \frac{D_{oc}^{t+1}(x_{t+1}, y_{t+1})}{D_{oc}^{t+1}(x_t, y_t)} \qquad (2)$$

Where *c* denotes technology under constant returns to scale (CRS). (Y_t, Y_{t+1}) and (X_t, X_{t+1}) are respectively input and output vector during the t and t+1 periods. (D^t) and (D^{t+1}) denote the obtained distance function by comparing the production point to the boundary surface technology during the same period. M_0^t and M_0^{t+1} denote the technical efficiency change from the time period *t* to *t+1* using technology during *t* and *t+1*. The Malmquist index is calculated with the geometric means of M_0^t and M_0^{t+1}:

$$M_o(x_t, y_t, x_{t+1}, y_{t+1}) = \frac{D_{oc}^{t}(x_{t+1}, y_{t+1})}{D_{oc}^{t}(x_t, y_t)} + \frac{D_{oc}^{t+1}(x_{t+1}, y_{t+1})}{D_{oc}^{t+1}(x_t, y_t)} \qquad (3)$$

If $M_o(x_t, y_t, x_{t+1}, y_{t+1})$ is above 1, it means that total factor productivity has increased from the time period t to t+1, and on the contrary, if it's below 1, it has decreased. Equation 28 can be broken down as below, in which the technical efficiency is divided into the two components of pure efficiency change and scale change.

$$M_o(x_t, y_t, x_{t+1}, y_{t+1}) = \frac{D_{oc}^{t+1}(x_{t+1}, y_{t+1})}{D_{oc}^{t}(x_t, y_t)} + \left(\frac{D_{oc}^{t}(x_{t+1}, y_{t+1})}{D_{oc}^{t+1}(x_t, y_t)} \times \frac{D_{oc}^{t}(x_t, y_t)}{D_{oc}^{t+1}(x_t, y_t)}\right)^{1/2} \qquad (4)$$

With the assumption of constant returns to scale, equation 29 is divided to technological (TECH) advancement and efficiency change (EFFCH).

$$TECH = \left(\frac{D_{oc}^{t}(x_{t+1}, y_{t+1})}{D_{oc}^{t+1}(x_{t+1}, y_{t+1})} \times \frac{D_{oc}^{t}(x_t, y_t)}{D_{oc}^{t+1}(x_t, y_t)}\right)^{1/2} \qquad (5)$$

$$EFFCH = \frac{D_{oc}^{t+1}(x_{t+1}, y_{t+1})}{D_{oc}^{t}(x_t, y_t)} \qquad (6)$$

With the assumption of variable returns to scale (VRS), efficiency change is divided to pure efficiency change (PEFFCH) and scale efficiency change (SEFFCH).

$$PECH = \frac{D_{oc}^{t+1}(x_{t+1}, y_{t+1})}{D_{oV}^{t}(x_t, y_t)} \qquad (7)$$

$$SECH = \frac{D_{ov}^{t}(x_t, y_t) / D_{oc}^{t}(x_t, y_t)}{D_{oV}^{t}(x_{t+1}, y_{t+1}) / D_{oc}^{t+1}(x_{t+1}, y_{t+1})} \qquad (8)$$

Where c denotes technology under VRS. Therefore, this total factor productivity change may be written as below.

Total Factor Productivity Change= technical change+ efficiency change= technical change+ (scale efficiency change * pure technical efficiency change)

Total Factor Productivity Index (change) = technical change (technological advancement) *technical efficiency change

Technical Efficiency Index (change) = scale efficiency change* pure technical efficiency change

Change in technical efficiency has been described as efficiency of approximation with production limit, and technological change as change of curve with productivity limit. On the other hand, Multiplying change in technical efficiency and technological change leads to a change in total factor productivity. As mentioned, total productivity index is more than just an indicator of increased total factor productivity during the time period of *(t)* and *(t+1)*, while an index lower than 1 denotes degradation or reduction. In other words, the components making up total productivity, technical efficiency change, and technological change of above 1 show that the agency is able to meet its production limit. Accordingly, technological advancement index of above 1 indicates the agency can use its efficiency level. The negative amount of the technological change index means that the amount produced is reduced by the similar amount of input. Dividing the Malmquist total factor productivity index by the mentioned components plays a fundamental role in identifying the main resources that generate total factor productivity.

While employing the data envelopment analysis method to create the Malmquist total factor index, an array of the linear planning problem (LPP) should be modeled. According to the assumption of the declining returns to scale and the input-oriented approach, the linear planning model used in creating the Malmquist total factor productivity index is as follows:

$$[D_I^t(y_{t,}x_t)]^{\ 1} = \min_{\theta,\lambda}\theta \qquad (9)$$
$$st$$
$$y_{it} + Y_t\lambda \geq 0$$
$$\theta x_{it} \quad X_t\lambda \geq 0$$
$$\lambda \geq 0$$

$$[D_I^{t+1}(y_{t+1,}x_{t+1})]^{\ 1} = \min_{\theta,\lambda}\theta \qquad (10)$$
$$st$$
$$y_{i,t+1} + Y_{t+1}\lambda \geq 0$$
$$\theta x_{i,t+1} \quad X_{t+1}\lambda \geq 0$$
$$\lambda \geq 0$$

$$[D_I^{t+1}(y_{t,}x_t)]^{\ 1} = \min_{\theta,\lambda}\theta \qquad (11)$$
$$st$$
$$y_{it} + Y_{t+1}\lambda \geq 0$$
$$\theta x_{it} \quad X_{t+1}\lambda \geq 0$$
$$\lambda \geq 0$$

$$[D_I^t(y_{t+1,}x_{t+1})]^{\ 1} = \min_{\theta,\lambda}\theta \qquad (12)$$
$$st$$
$$y_{i,t+1} + Y_t\lambda \geq 0$$
$$\theta x_{i,t+1} \quad X_t\lambda \geq 0$$
$$\lambda \geq 0$$

The two linear planning models are first evaluated using the period's efficiency limit as the basis. Model (36) compares the data of *(t)* period with the efficiency limit of the *(t+1)* period, while model (37) compares the data of the *(t+1)* period with the efficiency limit of the *(t)* period. Each of the four linear planning models should be used for each period and observation to quantify the Malmquist total factor productivity. Therefore, the number of the problems Nx (3T-3) should be solved according to the number of periods (T) and observations.

In this paper, total factor productivity change indexes of the agricultural sub-sectors of investigated provinces were measured as decision-making units (DMU), and separately through the data of 2008 to 2018, and by using the Malmquist total factor productivity index hidden in the non-parametric data envelopment analysis method. For this purpose, one output (the average yield of agricultural products of the province) and five inputs including average workforce per hectares (per person/per day), the average NKP chemical fertilizer consumption per hectare, the average chemical pesticide consumption per hectare, the average seed consumption per hectare, and the average land value (the quality alternative variable and the province's farming lands' fertility). This data was extracted and gathered from the production cost statistics of the Ministry of Agriculture Jihad spanning 2008 to 2018. A specific and clear understanding of various decision-making units is obtained through the non-parametric data envelopment analysis method; in contrary to parametric methods that only emphasize the society's parameters, it pays attention to the characteristics and features of all observations. To evaluate total factor productivity indexes with the input-based (input-oriented) non-parametric approach, the MDEAP software with the Windows operating system. Although the results of the output-oriented approach were also an emphasis on the results of the input-oriented approach.

4. Results and Discussion

In this research, total factor productivity index of the provinces' agricultural sub-sectors were first evaluated through the Malmquist productivity index (MPI), and then its components (technical efficiency and technological advancement) were calculated through the data envelopment analysis approach (DEA). In other words, the research method was a combination of the non-parametric data envelopment analysis approach and the Malmquist productivity index (DEA-MPI). The time range under examination was 10 years (from 2009 to 2018), and studied materials were all the agricultural products of the selected provinces recorded in the production cost statistics of the Ministry of Agriculture Jihad. Later, evaluation results of total factor productivity index and its components including technical change (technological advancement) and technical efficiency change of each province will be broadly analyzed.

4.1.Regional Total Factor Productivity Index

Table 1 demonstrates total factor productivity index amounts of the agricultural sub-sector's production and their average in 27 provinces of the country. According to the results, total factor productivity index amounts of all the provinces had annual fluctuations, however, the provinces of Gilan, Ghazvin, Ardabil, Boushehr, Golestan, Razavi Khorasan, Hamedan, Kurdistan, Fars, Sistan and Baluchestan, Kohgiluyeh and Boyer-Ahmad, Isfahan, Chaharmahal and Bakhtiari, Zanjan, Tehran, Mazandaran, Hormozgan, West Azerbaijan, North Khorasan, and Khuzestan's numbers were above 1, which hindicates total factor productivity growth in the agricultural sub-sector of the mentioned provinces. Among the provinces, Gilan has the biggest change index or total factor productivity growth at 22.9%. Khuzesan, on the contrary, is the lowest positive total factor productivity growth at an average 0.1%. The average total factor productivity index of the other provinces were within the 0.1% to 22.9% range, which indicates positive changes or total factor productivity growth in them. According to the results, after Gilan, the agricultural sub-sectors of Ghazvin, Ardabil, Boushehr, Golestan, Razavi Khorasan, Hamedan, and Kurdistan have the biggest index or average of total factor productivity growth at 9.2%, 8.7%, 6.4%, 5.7%, 5.6%, 5.2%, and 5.1% respectively.

The results of table 1 reveal that during the examined time range, the agricultural sub-sectors of the provinces of Kermanshah, South Khorasan, Lorestan, East Azerbaijan, Yazd, Kerman and Ilam have experienced total factor productivity degradation so much so that their average total factor productivity indexes were below 1 (0.981, 0.963, 0.953, 0.943, 0.925, 0.923, and 0.703), and subsequently, their total factor productivity growths were negative at -1.9%, -3.7%, -4.7%, -5.7%, -7.5%, -7.7%, and 29.7% respectively. Therefore, according to the results of the agricultural sub-sectors of Golan and Ilam have experienced the maximum and minimum of total factor productivity growth and index mentioned within the time range examined.

Table 1. Calculated Total Factor Productivity

Year	Province								
	Gilan	Ghazvin	Ardabil	Boushehr	Golestan	Khorasan Razavi	Hamedan	Kurdistan	Fars
2009	1.141	0.991	1.4	1.215	1.111	0.647	1.093	0.7	0.686
2010	1.316	1.603	1.696	1.288	1.227	1.155	1.512	1.37	1.131
2011	1.871	0.916	0.952	0.681	1.124	0.714	0.981	1.166	1.63
2012	0.916	1.347	1.12	1.380	1.287	1.192	1.055	1.141	0.827
2013	0.78	1.384	0.762	1.137	0.71	0.869	1.194	0.753	1.304
2014	1.672	0.894	0.894	1.026	2.065	0.718	0.952	1.145	2.097
2015	0.493	0.886	1.093	1.133	0.622	1.475	0.68	0.7	0.683
2016	1.045	1.204	1.043	0.841	0.589	0.846	1.188	0.83	0.895
2017	2.612	0.855	1.081	1.062	1.551	1.032	1.008	0.87	1.078
2018	1.141	0.991	1.4	1.215	1.111	0.647	1.093	0.7	0.686
Average	1.226	1.092	1.087	1.064	1.057	1.056	1.052	1.051	1.048

Table 1. (cont)

Year	**province**								
	S & B	K & B	Isfahan	Ch & B	Zanjan	Tehran	Mazandaran	Hormozgan	South A.
2009	1.02	0.679	0.835	0.854	1.244	1.093	0.617	0.89	0.919
2010	1.154	1.284	1.599	1.293	0.921	1.112	2.223	1.349	1.433
2011	0.83	1.371	0.989	1.514	1.929	0.97	2.21	1.105	0.937
2012	0.935	1.104	0.956	1.352	0.863	1.115	0.927	0.954	1.107
2013	1.212	0.399	1.236	0.712	0.788	1.26	0.635	0.673	1.115
2014	1.011	1.168	1.099	0.751	1.454	1.096	1.216	1.055	0.85

2015	1.001	1.359	1.002	1.197	0.552	1.025	0.912	1.084	0.889
2016	0.893	1.015	0.875	1.055	1.154	0.851	0.499	0.903	1.056
2017	1.148	1.743	0.955	0.928	0.993	0.781	1.137	1.155	0.889
2018	1.02	0.679	0.835	0.854	1.244	1.093	0.617	0.89	0.919
Average	1.048	1.044	1.041	1.039	1.037	1.024	1.013	1.02	1.008

Table 1. (cont)

Year	Province								
	North-Kh.	Khuzestan	Kermanshah	South Kh.	Lorestan	East A.	Yazd	Kerman	Ilam
2009	0.794	0.803	0.898	0.817	1.039	0.82	1.24	0.613	0.933
2010	1.182	1.359	0.772	1.235	1.215	1.162	0.952	1.291	1.264
2011	0.88	0.816	0.985	1.246	1.26	1.258	1.06	0.409	1.122
2012	1.684	1.577	1.265	0.754	0.969	1.142	0.696	1.686	0.778
2013	1.029	0.839	1.136	1.144	0.691	0.717	0.457	2.101	1.014
2014	0.924	0.716	0.88	2.733	1.222	1.318	1.14	1.154	1.009
2015	0.859	1.506	0.991	0.26	0.785	0.545	1.146	0.372	0.382
2016	0.852	0.9	0.710	1.386	0.789	1.107	0.927	0.699	0.961
2017	1.086	0.881	1.376	0.668	0.8	0.759	1.027	1.418	0.109
2018	0.794	0.803	0.898	0.817	1.039	0.82	1.24	0.613	0.933
Average	1.006	1.001	0.981	0.963	0.953	0.943	0.925	0.923	0.703

4.2.Total Factor Productivity Growth and its Components

Productivity comes from technological change (advancement) and the promotion of technical efficiency. These two have been analyzed as the parts or components of total factor productivity growth. The effect of these two components on the index changes or total factor productivity growth in the agricultural sub-sectors of the selected provinces has also been analyzed in this research, and the results can be seen in table 2.

The data recorded in the third and fourth columns of table 2 indicate the average index of technical efficiency and technological change (advancement) in the farming sector's agricultural sub-sector of the examined provinces spanning 2009 to 2018. According to this, Gilan has obtained the biggest technical efficiency index and technological advancement, which are 1.081

and 1.134 on average, respectively. These indexes demonstrate the average 8.1% and 13.4% growth or change of the technical efficiency and the technological advancement in the agricultural sub-sector of Ilam province at 0.712 and 0.988 respectively. These indexes indicate the average degradation or reduction of -28.8% and -1.2% of technical efficiency and technological advancement, respectively, during the examined time period.

According to the findings of table 2, in the agricultural sub-sectors of the provinces of Gilan, Ghazvin, Boushehr, Goestan, Razavi Khorasan, Hamedan, Kurdistan, Fars, Isfahan, Chaharmahal and Bakhtiari, Zanjan, and Tehran, the increased technical efficiency of the farmers and the technological advancement have been the root of total factor productivity growth in the agricultural sub-sector. For instance, the technical efficiency change and the technological change (advancement) on Ghazvin province during the time range examined have been 2.5% and 6.5% on average, respectively.

However, in the provinces of Boushehr, Sistan and Baluchestan, Hormozgan, Kermanshah, and Kerman, the technical efficiency has been static, and technical change or advancement have made total factor productivity growth of the agricultural sub-sector happen; the technological change (advancement) index has been positive (above 1) in most provinces, and indicating the continuous improvement of the production technology or the consistent upward transfer of the frontier function. According to the results, the average technical efficiency of the farming sector's agricultural sub-sector of Kohgiluyeh and Boyer-Ahmad, Mazandaran, North Khorasan, Khuzestan, Lorestan, East Azerbaijan, Yazd, and Ilam has dwindled during the examined time period. The lowest technical efficiency of the agricultural sub-sector has taken place in Ilam. Accordingly, the average technical efficiency was 0.712 in this province, which indicates an average reduction of 28.8% during the examined time range. The lowness of the technical efficiency in most provinces denote their potential capacity and capability for achieving total factor productivity growth through the promotion of technical efficiency.

The results of table 2 demonstrate that despite the significant technological advancement in some provinces, total factor productivity growth of the agricultural sub-sectors were reduced due to the technical efficiency degradation of the farmers. In other words, there have been relatively inverse changes between the technical efficiency and the technological advancement. In other words, due to the lack of sufficient training or experience during the technological advancement periods, the technical efficiency of the farmers are at a low level, which has neutralized a part of the positive effects of the technical change (technological advancement). In other words, despite the technological advancement, the farmers were not able to efficiently use the resources at the existing technological level. These provinces are Mazandaran, Kohgiluyeh and Boyer-Ahmad, North Khorasan, Khuzestan, and Lorestan. For instance, despite the 5.6% technological advancement in Mazandaran, total factor productivity index has edged down to 1.013 or a 1.3% growth due to the technical efficiency degradation (0,956).

The findings of table 2 also indicate that in the provinces of East Azerbaijan, Yazd, and Ilam, both of the technical efficiency and technological advancement components have dwindled during the examined time range, and subsequently, caused the reduction of total factor productivity growth or index of the agricultural sub-sector. In these provinces, the average technical change index is below 1, at 0.976, 0.975, and 0.712 respectively. Moreover, the average technological advancement index is below 1, at 0.966, 0.948, and 0.988 in the respective order.

Table 2. Calculated Total Factor Productivity Index and Its Components

Province	Total factor productivity index	Technical efficiency change	Change (technological advancement)
Gilan	1.226	1.081	1.134
Ghazvin	1.092	1.025	1.065
Ardabil	1.087	1.045	1.041
Golestan	1.057	1.02	1.055
Razavi Khorasan	10.056	1.035	1.022
Hamedan	1.052	1.033	1.019
Kurdistan	1.051	1.029	1.031
Fars	1.048	1.03	1.064
Isfahan	1.041	1.013	1.028
Chaharmahal and Bakhtiari	1.039	1.031	1.008
Zanjan	1.037	1.033	1.004
Tehran	1.024	1.017	1.006
Sistan and Baluchestan	1.048	1	1.048
Bushehr	1.064	1	1.064
Kohgiluyeh and Boyer-Ahmad	1.044	0.993	1.052
Hormozgan	1.02	1	1.02
Mazandaran	1.013	0.956	1.056
West Azerbaijan	1.008	1.008	1
North Khorasan	1.006	0.997	1.008
Khuzestan	1.001	0.996	1.005
Kermanshah	0.981	1	0,981
South Khorasan	0.963	1.008	0.955
Lorestan	0.953	0.949	1.004

East Azerbaijan	0.943	0.976	0.966
Yazd	0.925	0.975	0.948
Kerman	0.923	1	0.923
Ilam	0.703	0.712	0.988

*The averages in the DEA-MPI approach are of the geometric mean

5. Conclusion

The analysis results of total factor productivity of the agricultural sub-sector of the country's 27 provinces through the Malmquist index- data envelopment analysis method (DEA-MPI), with the Mdeap software package has shown that in most provinces, the average productivity growth within the examined time range has been positive/ has had an increase. Nevertheless, the agricultural sub-sector of some provinces including Yazd, Lorestan, South Khorasan, Kermanshah, Kerman, and Ilam has experienced total factor productivity index degradation. Based on the research's findings, the productivity indexes have not had a regular upward or downward trend but rather annual fluctuations. These fluctuations indicate the absence of stability in the factor productivity of the agricultural production. These indexes have had a dramatic increase in some years, and a dramatic decrease in other years.

According to the results and findings of the research within the examined time range, the highest and lowest total factor productivity index average has occurred in the agricultural sub-sectors of Gilan and Ilam at 1.225 and 0.703 respectively. Total factor productivity index in the agricultural sub-sector in other provinces are in the mentioned range. Moreover, the agricultural sub-sector of Gilan has had the biggest technological change with an average growth of 13.4%, and Kerman has experienced the highest technological degradation at -7.7%. According to the obtained results, some changes of total factor productivity index between the provinces may be due to the structural difference of the agricultural productivity (for instance the size of the farm, the farmers' age, or the climatic conditions) or the different levels of managerial skill among the farmers. In the previous state, the balancing (reformation) or the structural limitations can improve technical efficiency, scale, and subsequently, productivity; whereas in the second state, the improvement of managerial systems in the farms can lead to total factor productivity growth.

According to the results and findings of the research, it can be inferred that in the agricultural sub-sector of 12 provinces, the technical efficiency and the technological advancement components were the root of total factor productivity during the time range examined. Moreover, the improvement of total factor productivity in the agricultural sub-sector in 20 provinces is due to the technological change or advancement of the farming sector inclusively, and the agricultural sub-sector exclusively, and the technical efficiency improvement has only played the role of total factor productivity index propeller in the agricultural sub-sector of some provinces. Additionally, in the agricultural sub-sector of the 4 provinces of Lorestan, East Azerbaijan, Yazd, and Ilam, the technical efficiency of the farmers as well as the technology level have declined, and subsequently, reduced total factor productivity growth or index in the agricultural sub-sector.

The other results reveal that despite the significant technological advancement in some provinces, total factor productivity growth of the agricultural sub-sector's production has decreased due to technical efficiency degradation; during the technological advancement period, the technical efficiency is at a low level due to a lack of sufficient training or experience and managerial skills of the farmers, which neutralizes a part of the positive effects of technological advancement (change). In fact, despite the technological advancement and the improvement of infrastructure, the farmers were not able to efficiently use the potential capacity of their resources at the existing technological level.

In some provinces such as Razavi Khorasan, Chaharmahal and Bakhtiari, Zanjan, and Tehran, the technical efficiency index (change) of the farmers exceeded the technological advancement; therefore, it can be concluded that total factor productivity of these provinces has mainly been obtained through the improvement of technical efficiency, although technological advancement has had a its share in the factor productivity growth. As a result, to increase productivity, the institutions in charge of agriculture, such as extension coordination management of Agriculture Jihad Organization of the provinces should pay attention to training the agriculture beneficiaries and improving their managerial skills as well as farming knowledge.

In some provinces, technological advancement alone has provided the ground for total factor productivity growth. Therefore, this unity between the productivity changes and its components, especially technological advancement or change, can be see in some of the provinces. Moreover, the technical efficiency in the provinces of Kohgiluyeh and Boyer-Ahmad, Mazandaran, North Khorasan, Khuzestan, Lorestan, East Azerbaijan, Yazd, and Ilam has decreased, while it has been static in Sistan and Baluchestan, Boushehr, Hormozgan, Kermanshah, and Kerman. The low technical efficiency in these provinces denotes their potential capacity and capability in total factor productivity growth through training and improving the managerial skills of the farmers. Despite total factor productivity growth of the agricultural sub-sectors were reduced due to the technical efficiency degradation of the farmers. In other words, due to the lack of sufficient training or experience during the technological advancement periods, the technical efficiency of the farmers are at a low level, which has neutralized a part of the positive effects of the technical change (technological advancement). In such provinces, an attempt at improving the managerial skills of the farmers can increase their technical efficiency, and subsequently, total factor productivity in agricultural activities.

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