Asian Journal of Biological and Life Sciences | Original Research

Analysis of productivity growth and technological progress on irrigated wheat crop in provinces of South-West Region of Iran

Behrooz Hassanpour*[1], Ayat Karami[2]

1 Assistant Professor, Economic, Social and Extension Research Department, Kohgiluyeh and Boyerahmad Agricultural and Natural Resources Research and Education Center, AREEO, Yasouj, Iran
2 Associate Professor of Rural Development Management Department, Yasouj University, Yasouj, Iran.

E-mail : beh_hassanpour@yahoo.com Contact No. : +989174502089

Submitted : 01.06.2017 Accepted : 28.07.2017 Published : 30.08.2017

Abstract

Wheat a staple food for humans is one the most important Iran's strategic agricultural products. Every year, more than 50% of the total cultivated area devoted to wheat crops. The objectives of study were to measure the growth of total factor productivity and then decomposed into its constituent factors, namely the growth of technical efficiency and technological change. The contribution of each factors in productivity growth in irrigated wheat farms provinces studied in the south-west region were compared. For this purpose, the method of Data Envelopment Analysis and the Malmquist index is used. Data input-output in cultivate wheat related to each of the provincial panel data during 12-year)2000-2011(from the Ministry of Agriculture, received and processed. The results showed that except Kohgiloyeh-va-Boyerahmad province, the provinces studied had growth in productivity. The greatest growth in productivity in wheat farms is concerned with an average 7.3% per year in the provinces of Fars and Khuzestan. Average annual productivity in the provinces of Ilam, Isfahan, Boushehr, Charmahal, and Kohgilouyeh as 3.1, 1.7, 1.1, 1, and -0.9 measured, respectively. Decomposition of productivity growth into its component factors in irrigated wheat fields showed that the major contribution to productivity growth, resulting from technological change)i.e., the application of modern technologies in the farms(and the change in technical efficiency)i.e., managing the use of inputs(in all provinces south-west region of the country is in recession. The investment to improve education and promotion programs appropriate for better management of the wheat fields is proposed.

Key words : DEA, Malmquist index, TFPG, Technical efficiency growth, Technological change, Wheat

INTRODUCTION

Wheat is one of the important cereals in Iran, just like many other countries and is considered in household model. Strategic role of wheat in consumption system of the country and leading it into self-sufficiency and national development goals increases the importance and the need to programming and optimal management of resources and product factors [1]. According to the recent statistics of Ministry of Jihad-e-Agriculture in 2013, among 12 million hectare annual production, about 6.4 million hectare devoted to wheat (53%), 2.5 million hectare of which (39%) have been irrigated and 3.5 million hectare have not been irrigated. Table 1, which is regulated according to the latest official statistics, demonstrated the cultivated area of wheat in Iran:

To realize the visions of development, productivity growth of total factor productivity is an important role. Legislation the increasing productivity in agriculture and natural resources law in 2010, made the issue of measuring productivity growth in the agricultural sector of the country is more important. This research analyzed the situation of productivity growth and technological progress of irrigated wheat farms during a certain period in provinces of south-west region of Iran, including seven provinces of Isfahan, Fars, Khuzestan, Charmahal-Bakhtiari, Ilam, Boushehr, and Kohgiluyeh-va-Boyerahmad. For this, it is used from measuring productivity growth of total factors in farming irrigated wheat and then dividing this growth into its productive factors, that is to say, Growth efficiency and technological changes.

Among these provinces, the most cultivated area of wheat belong to Khuzestan and Fars, with 479 and 330 thousands hectare respectively, and after them provinces of Isfahan, Ilam, Charmahal-Bakhtiari, Kohgiluyeh-va-Boyerahmad and Boushehr have respectively 56, 49, 28, 20 and 16 thousands hectare under wheat cultivation [2]. In agricultural economic research, several studies were conducted for calculating productivity and efficiency growth in Iran and abroad. Considered studies on measuring total efficiency of agriculture with several production factors were conducted in developed countries especially in United States. Compared to these countries, a number of studies have been done in developing and underdeveloped countries. All of these studies showed a low productivity; even with green revolutions happened to important products like wheat and rice [3]. Most of economists and management experts believe that Total Factor Productivity Growth (TFPG) in agriculture section or economic section is the changes complex of two main factors. That is to say change in technical efficiency and change in technology through increasing in investment and accepting new technologies. Since each of above factor has a different origin, in main policy-making of agriculture section, in which improving factors efficiency is considered as the main purpose, analyzing and measuring the role of each factors is very important [4, 5].

Some of the studies on TFPG in agriculture section is the study of Zare *et al* [6]. using data of a certain period in 1985 to 2001 and Malmquist index (MI) on some of cotton-rich provinces and the study of Rafiei *et al* [7]. On efficiency growth of corn in different provinces of the country in a 7 years period (2001-2007) by using MI. Among foreign studies on efficiency in agriculture, it can be referred to Wu *et al* [8]. on Total Factor Productivity Growth of agricultural section of China in the period of 1980 to 1950 by using the method of data envelopment analysis (DEA) and the Malmquist index.

Shaik and Perrin [9] in their study analyzed the efficiency and productivity factor in agricultural section of Mexico, by using the method of data envelopment analysis (DEA) and the Malmquist index, during the years of 1962 to 1997. The results of this research showed that TFPG is about 16%. The results of efficiency division into its components showed that high efficiency during this period is one of the reasons of efficiency growth in agricultural section in Mexico [9].

Covaci and Sojková [10] calculated the total factor productivity growth in wheat agriculture in Slovakia during a five years period of 2000-2004 and by using the method of data envelopment analysis (DEA) and the Malmquist index. In some parts of their research, they showed that during this period the average of wheat total factor productivity growth was 16.8%. The main effective reason for this growth was the advances in technology or new invents in wheat area, so that annual growth of technology has been 9.2%. In addition annual technical efficiency growth of 6.4% could improve optimal management of production resources in wheat [10].

Kiani [11] in a research calculated the TFPG of a region in Panjabi state of Pakistan in a period of 1970-2004. He determined the role and share of technological and efficiency changes. The results of this study showed that the efficiency growth of agricultural products was very low. This was resulted from the technical efficiency growth (management improvement of the farm) rather than technological growth [11].

Hassanpour *et al*. [12] calculated the total factor productivity growth of fish farms, by using input-output data of 207 Trout ponds in five provinces of Iran (Fars, Kohgiluyeh, Charmahal, Mazandaran and Tehran) during a five years period of 2004 to 2009. The results of this research showed that TFPG of the mentioned period had an increasing growth of 3.7%. Analysis of efficiency growth showed that although it was not seen any technological progress in this period, and sometimes this growth is negative, positive and increasing changes in technical efficiency in Trout ponds were the only factor in efficiency growth of these years. It is while average technical efficiency of these units is about 66% and only 10% of these units perform completely efficient [12].

While wheat is a strategic products in consuming system of the country and state has a responsibility for being self-sufficient in this products, none of the research conducted in Iran on total factor productivity growth of cereals (like what is conducted in China and Pakistan on agricultural section and Slovakia on wheat) could determine the constitutive and efficient components of productivity growth, so that planners of this section can monitor efficiency growth in the country and codify a political package for improving efficiency of wheat and for separate provinces and regions. Therefore, this research can somewhat recoup it.

RESEARCH PURPOSES

This research was conducted for reaching these purposes:

1- Calculating TFPG on irrigated wheat crop in provinces of south-west region of Iran in the period of 2000-2011

2- Analyzing technical efficiency changes growth on irrigated wheat crop in provinces of south-west region of Iran in the period of 2000-2011

3- Analyzing technological changes (or technological growth) on irrigated wheat crop in provinces of south-west region of Iran in the period of 2000-2011

RESEARCH HYPOTHESIS

This research was conducted according to the following hypothesis:

1- Total factor productivity growth on irrigated wheat crop in provinces of south-west region of Iran is positive

2- Technological growth on irrigated wheat crop in provinces of south-west region of Iran is positive

3- The share of technological progress on irrigated wheat crop in provinces of south-west region of Iran is more than technical efficiency changes

MATERIALS AND METHODS

In economic literature, the difference between output growth and consumed inputs over time is called efficiency growth [13]. For calculating total efficiency growth, two methods of parametric (econometrics) and non-parametric were proposed. This research used non-parametric and DEA method because of not requiring to a certain functional form and not applying restriction on efficiency to scale, and most importantly, the possibility to separate total factor efficiency changes index into technical efficiency and technological changes. DEA method for dividing efficiency growth into its components can introduce social implications for policy analysis and propose effective solutions [6, 14].

a) Malm quist efficiency index

Fare *et al.* [15] and Coelli *et al.* [16], in measuring Total Factor Productivity Growth (TFPG) using non-parametric Data envelopment analysis (DEA), proved that calculating a numerical index which is done by mathematical planning and distance function calculating, which is called Malmquist Productivity Index (MPI), can be a applied as a standard index for Discrete data in analyzing Total Factor Productivity Growth and its components in industrial and agricultural activities [15, 16]. This index can analyze production technology in the form of multi-input and multi-output data just by using number data and without needing to cost data (price) and behavioral assumptions. It also can measure efficiency growth between two periods through distance functions ratio. Fare *et al.* [15] showed that MPI index is calculated via two certain statements product. First statement is technical efficiency changes (EFFCH) [15]. This index demonstrates changes in Production unit ability to reach the maximum production using a stable resources and technologies existed in a certain period.

The second statement is MPI index, or technological changes (TECHCH) of production unit. This index demonstrates changes in used technologies in that production unit in a certain period.

(1) $m_0 = MPI = TFPCH = [EFFCH] \times [TECHCH]$

Through distance function, Malmquist Productivity Index (MPI) is as following:

$$(2)\ m_o(y_t, x_t, y_{t+1}, x_{t+1}) = \underbrace{\frac{d_o^{t+1}(y_{t+1}, x_{t+1})}{d_o^t(y_t, x_t)}}_{EFFCH} \times \underbrace{\left[\frac{d_o^t(y_{t+1}, x_{t+1})}{d_o^{t+1}(y_{t+1}, x_{t+1})} \times \frac{d_o^t(y_t, x_t)}{d_o^{t+1}(y_t, x_t)}\right]^{\frac{1}{2}}}_{TECHCH}$$

Where t and t+1 are the distance of observations in period of t and t+1, x and y are respectively the amount of input and output. M_0 is Total Factor Productivity Growth (TFPG). M_0 more and less

than 1 respectively demonstrates positive and negative growth from t to t+1

b) Definitions of variables in model

In this research all input-output data on irrigated wheat considering to provinces of south-west region of Iran, including more developed province (Isfahan, Fars and Khuzestan) and less developed provinces (Charmahal, Boushehr, Ilam, and Kohgiluyeh) in a 7 years period from 2000 to 2007, were collected in Panel data. These data were received from cost of production bank of agricultural products for each province of the country and other resources in ministry of agriculture. Input-output variables in the Malmquist index are defined as follow:

Y_{it}+1 and Y_{it}: production amount of irrigated wheat in the province of "i" in the years of t and t+1 (as output variable)

Then 6 main variables are used as input variable as following:

X_{1it}+1and X_{1it}: cultivated area of wheat per ha in the province of "i" in the years of t and t+1

X_{2it}+1 and X_{2it}: used seeds in kg/ha in the province of "i" in the years of t and t+1

X_{3it}+1 and X_{3it}: consumed chemical fertilizer in kg per hectare in the province of "i" in the years of t and t+1

X_{4it}+1 and X_{4it}: used work force per hectare in the province of "i" in the years of t and t+1

X_{5it}+1 and X_{5it}: applied pesticide in Kg per hectare in the province of "i" in the years of t and t+1

X_{6it}+1 and X_{6it}: the cost of used Agricultural machinery with the fix rate of 2011 in the province of "i" in the years of t and t+1

Since there was not any data about the physical amount of used machinery, it is used from the costs paid for buying those [6]. In order to omit the effect of inflation affect, figures paid for the machinery were calculated and adjusted according to the general prices of the base year of 2011.

This study answers to this question: what is the share of technical efficiency growth (resulted from improving in using resources and managing farms) and the share of technological growth and progress (resulted from investment and accepting new invents and technologies by the farmers) in increasing the production efficiency of irrigated wheat crop in provinces of south-west region of Iran?

RESULTS

a) The average use of inputs in irrigated wheat

The average use of inputs in irrigated wheat farms in a 12 years period was calculated and summarized in table 2. According to this table, the highest amount of cultivated area devoted to Fars province with 371 thousand hectare under wheat cultivation and the lowest one belongs to Boushehr with 18 thousand hectare. In the case of using seed input, the highest and the lowest using belong respectively to Fars and Kohgiluyeh-va-Boyerahmad (KB) provinces with the averages of 295 and 169 kg per hectare. Generally, the amount of using seed in these provinces is close to each other, except KB province, which is very low. In the case of consuming chemical fertilizer, there was not any significant difference between these provinces, so that the highest consumption belongs to Isfahan, with the average of 544kg per hectare, and the lowest one belongs to Kohgiluyeh-va-Boushehr provinces with the average of 260 kg per hectare.

In the case of using pesticides, the highest and lowest amounts belong respectively to Isfahan and Boushehr with the averages of 677.1 and 564.0 kg/ha. Isfahan province uses the most number of

Table 1: Cultivation area, production, and yield of wheat in agricultural year of 2010-2011

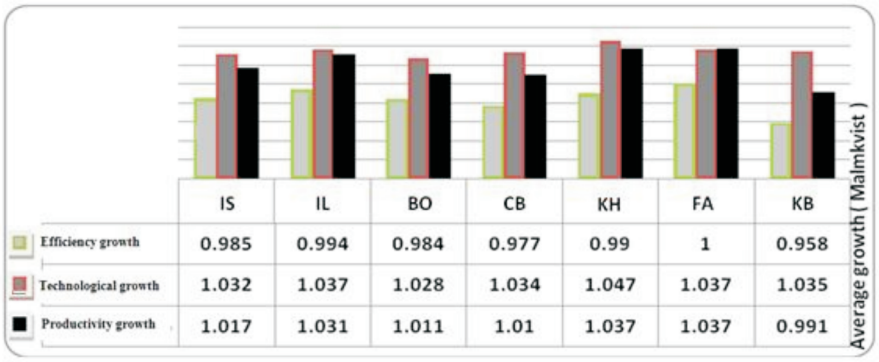
Product	Cultivated area (Hectare)	Producing (Ton)	Yield (Kg/Ha)
Irrigated wheat	2466994	8523457	3455
Non-irrigated wheat	3908599	3815902	976
Total	6375594	12339359	1935

Source: Research findings

Table 2: The average of using inputs in the irrigated wheat farms in considered provinces during the period of 2000-2011

Provinces / Inputs	Kohgiluyeh	Fars	Khuzestan	Charmahal	Boushehr	Ilam	Isfahan
Cultivated area (ha)	26273	381312	371648	30409	18444	39346	90177
Seed (kg/ha)	169	295	228	293	211	246	276
Chemical fertilizer (kg/ha)	260	512	328	323	260	356	544
Pesticides (kg/ha)	0.859	1.941	1.398	1.588	0.564	1.228	1.677
Labor (man-day/ha)	15.2	18.4	7.5	24.3	15.1	6.2	44.2
Cost of machinery (Rl/ha)	804160	732900	608550	855350	464420	601970	999030

Source: Research findings



	IS	IL	BO	CB	KH	FA	KB
Efficiency growth	0.985	0.994	0.984	0.977	0.99	1	0.958
Technological growth	1.032	1.037	1.028	1.034	1.047	1.037	1.035
Productivity growth	1.017	1.031	1.011	1.01	1.037	1.037	0.991

Fig. 1: The average of productivity growth, technological growth and TFPG in provinces of south-west region of Iran during the period of 2000-2011, (Capital letters synonyms IS=Isfahan, IL=Ilam, BO=Boushehr, CB=Charmahal-e-Bakhtiari, KH=Khozestan, FA=Fars, KB=Kohgiluyeh-va-Boyerahmad)

work forces with the average of 44.2 man-days/hectare and Ilam uses the least number with the average of 6.2 man-days per hectare. About using machinery, data demonstrated that Isfahan, with 999 thousand Rials per hectare, paid the maximum amount for agricultural machinery, while this amount is 460 thousand Rials for Boushehr, which is the least one. Generally, using above inputs in more developed provinces, Isfahan, Fars, and Khuzestan, are more than this using in less developed provinces of Kohgiluyeh (KB), Charmahal, Ilam and Boushehr.

b) The average of product yield in irrigated wheat farming

Product yield is one of the important indexes in farm efficiency. In another words, this index is one of the criteria for evaluating partial efficiency, which is calculated based on the farm input. Table 3 is the product yield of the considered provinces in the period of 2000-2011. According to the analyzed statistics, it is determined that the maximum yield devoted to Fars with 4094 kg/ha and the minimum yield belonged to Boushehr, with the average of 2101 kg/ha.

c) Productivity growth in producing irrigated wheat

Using input-output data in irrigating wheat farms of Kohgiluyeh-va-Boyerahmad (KB) province and neighboring provinces, and using Malmquist index (MI), this research calculated Total Factor Productivity Growth (TFPG) for each years of 2000-2011. As it is stated in methodology, the figures of MI are so that if they are more than one, they would indicate growth and if they were not, they would indicate negative growth. Dividing total productivity growth into productivity growth and technological changes makes it possible to evaluate the share of productivity components (productivity growth and technological changes) in production changes of each cereals product. It is also possible to compare provinces considering productivity index in a certain region and determine the management of using inputs and acceptance and application of new technologies and invents in each province.

Figure 1 shows the average of productivity growth, technological growth and TFPG of KB province comparing to neighboring provinces. According to this figure, among neighboring provinces, Fars and Khuzestan provinces have the highest average amount of productivity growth, 1.037. In another words, productivity growth in these provinces, during the years of 2000 to 2011, has been 3.7%. For KB, this average was 0.991%, which shows a negative annual growth. During these years, it is recognized that the only province with negative growth was KB province.

According to the Malmquist index and dividing total productivity growth into its components, annual technology growth in this province was 1.035 and had a growth of 3.5%, while productivity growth with the average of 0.958 experienced a negative growth of 4.2% per year. Therefore, it can be concluded that in spite of positive technological changes and growth in this province, productivity growth is very low because of lacking proper management of sources.

In another part, the research compared the process of TFPG in provinces of south-west region of Iran during the period of 2000-

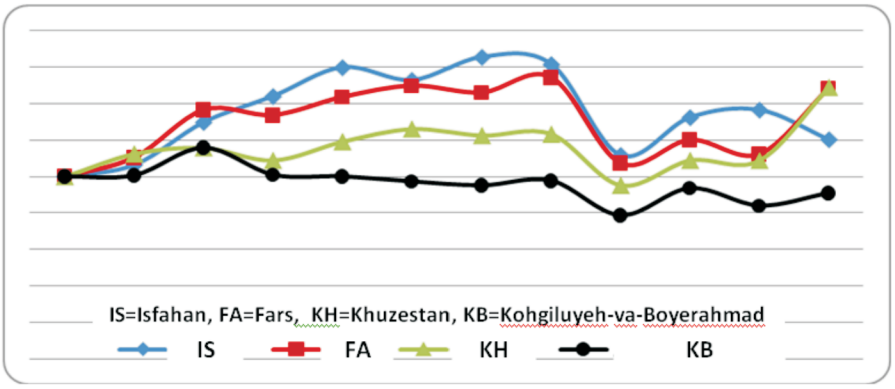


Fig. 2: Trend of TFPG for KB province comparing to neighboring developed provinces during the period of 2000-2011.

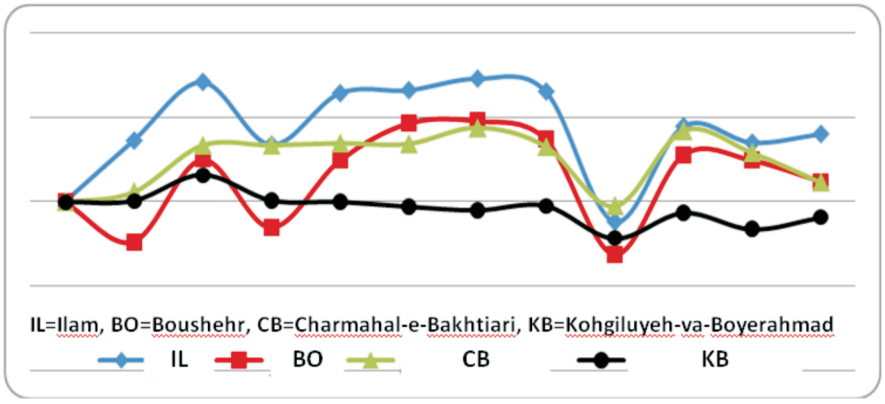


Fig. 3: Trend of TFPG for KB province comparing to neighboring less developed provinces during the period of 2000-2011

Table 3: Product yield average of irrigated wheat in provinces of south-west region during the period of 2000-2011

Province	Isfahan	Ilam	Boushehr	Charmahal	Khuzestan	Fars	Kohgiluyeh
Yield average (kg/ha)	4072	3160	2101	3380	3184	4094	3091

Source: Research findings

Table 4: Trend of TFPG and its constitutive components including productivity growth and technological changes in cereals farms of considered provinces

Provinces*	IS			IL			BO			CB			KB			FA			KH		
Indices**	P	E	T	P	E	T	P	E	T	P	E	T	P	E	T	P	E	T	P	E	T
Growth sign	+	-	+	+	-	+	+	-	+	+	-	+	+	-	+	+	0	+	-	-	+

*IS=Isfahan, IL=Ilam, BO=Boushehr, CB=Charmahal-e-Bakhtiari, KB=Kohgiluyeh-va-Boyerahmad, FA=Fars, KH=Khozestan
**Capital letters of P, E and T are respectively representative of TFPG, Efficiency growth, and Technological growth in agricultural products. Source: Research findings

2011. According to the development index, at first, considered provinces were divided into more developed and less developed provinces.

Then the province of KB was compared separately with these two groups. Figure 2 shows the process of TFPG in farming irrigated wheat in KB province comparing to neighboring provinces during the period of 2000-2011. According to the figure, this process, for the provinces of Isfahan, Fars and Khuzestan was ascending until 2008 when it experienced a sever decreasing, and then it continued its ascending growth again, while this process was descending for KB province. Among neighboring developed provinces of KB, Isfahan has the highest growth and Khuzestan the lowest productivity growth.

As it is shown in Figure 3, TFPG of Charmahal, Boushehr, and Ilam experienced an ascending growth until 2008 (with some few fluctuations), when a sever descending growth can be seen, and after that ascending flow continued, but it is not as severe as before. While this process was stable or descending for KB province.

The results of this research, in descriptive section, showed that, during the period of 2000-2011, the most yield of irrigated wheat belongs to Fars province with the average of 4094 kg/ha and the least one is Boushehr with the average of 2101 kg/ha.

In the case of using inputs like seeds, chemical fertilizer, pesticides, work forces and agricultural machinery, analysis showed that there is a significant difference between different provinces. For example, the most fertilizer using in farming irrigated wheat belongs to Isfahan with the average of 544 kg/ha and the least one belongs to Kohgiluyeh and Boushehr provinces with the average of 260 kg/ha. Using input-output data received from a 12 years period of 2000-2011 and applying MI, this research analyzed TFPG and its components in KB and its neighboring provinces. To summarize general results of this section into one table, it is possible as following (Table 4):

DISCUSSION

According to table 4, all provinces of south-west region of Iran, except KB province experienced positive productivity growth in farming irrigating wheat during the period of 2000-2011. These results are in accordance with the research conducted by Zare et al. [6]. On farming cotton in provinces of Kerman, Kermanshah and Golestan. According to a research by Coelli and Rao [17] about the positive productivity growth in agricultural section of Iran, it can be stated that this is true about all provinces in south-west except KB province. Therefore, based on received findings of this research, first hypothesis is confirmed, except about KB province[17].

Dividing TFPG into its constitutive components, the research

specified that all provinces in south-west region of Iran have a good technological growth in farming irrigated wheat during a 12 years period. Technological growth or changes result from investment and acceptance new technologies and invents by the farmers. Therefore, the second hypothesis is completely accepted. However, point to note is that the index of technical efficiency growth, which is the result of management improvement and optimal using of production factors in farm, is negative in all provinces of south-west region, except Fars, which was zero. Therefore, it can be stated that the share of technological changes is more than efficiency growth in TFPG of farming irrigated wheat. These results are in accordance with the research conducted by Wu *et al*. [8] on agricultural section of china but are in contrary to the researches of Zare *et al*. [6] on farming cotton and Rafiei *et al* [7] on farming corn in Fars province. Therefore, according to the findings, the third hypothesis of the research is completely confirmed.

CONCLUSION

The results of the research showed that except Kohgiloyeh-va-Boyerahmad province, the provinces studied had growth in productivity. The greatest growth in productivity in wheat farms is concerned with an average 7.3% per year in the provinces of Fars and Khuzestan. Average annual productivity in the provinces of Ilam, Isfahan, Boushehr, Charmahal, and Kohgilouyeh as 3.1, 1.7, 1.1, 1, and -0.9 measured, respectively. Decomposition of productivity growth into its component factors in irrigated wheat fields showed that the major contribution to productivity growth, resulting from technological change (i.e., the application of modern technologies in the farms) and the change in technical efficiency (i.e., managing the use of inputs) in all provinces south-west region of the country is in recession. The investment to improve education and promotion programs appropriate for better management of the wheat fields is proposed.

SUGGESTIONS

1- The results of TFPG of farming irrigated wheat show serious differences in total productivity growth, efficiency growth and technological changes in different provinces of the region. Therefore, it can be stated that there is divergence in TFPG of farming irrigated wheat and it should be planned for improving productivity situation, depending on the regional and provincial conditions. There should not be a general program for all regions of the country.

2- Dividing TFPG into its components in irrigated wheat farms showed this fact that although technological changes growth during the period of 2000-2011 was relatively good and acceptable but these provinces, regarding to technical efficiency growth or applying inputs management in irrigated wheat farms, experienced a bad situation. Therefore it is proposed to improve educational and promotional programs for optimal management of these farms.

ACKNOWLEDGEMENT

This paper is part of the research project with financially supported by a research grant No. 2-56-30-90016 from Kohgiloyeh & Boyerahmad Agricultural Research and Natural Resource and Education Center, Agricultural Research, Education and Extension Organization (AREEO), Yasouj, Iran.

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