Studies in Agricultural Economics 122 (2020) 44-50 https://doi.org/10.7896/j.2004

Short communication

Mohammad KAVOOSI-KALASHAMI* and Mohammad Karim MOTAMED*

Productivity analysis of sericulture in Northern Iran

Increasing productivity is the best and most efficient way for achieving economic growth in the agriculture sector. Guilan province in northern Iran is a leading region in sericulture production in Iran. The production of sericulture has been very volatile and in recent years as a significant proportion of the producers was out of production. This study investigates Total Factor Productivity (TFP) changes and its components in the sericulture system of Guilan province, Northern Iran, during 2007-2016. For this purpose, non-parametric Malmquist index and panel data of 15 counties over 11 years were used. Results show that only Talesh and Rudsar counties achieved productivity growth during the period analysed. Moreover, three counties of Astana-Ashrafieh, Lahijan and Masal & Shandermann experienced negative changes in efficiency and technology, which resulted in a significant negative change in TFP. Among understudy counties, only Sowme'ehSara County had year-to-year increase in productivity over the period 2007 to 2016. Furthermore, the counties of Roodsar and the Sowme'ehSara had the highest and lowest fluctuations of year-to-year TFP, respectively. The average of TFP change for all counties was negative. Overall, findings show that with the exception of the years 2011, 2014 and 2016, the major changes in TFP all occurred due to technology change.

Keywords: Malmquist index, efficiency change, technology change, scale change, distance function

JEL classification: D24

* Department of Agricultural Economics, Faculty of Agricultural Sciences, University of Guilan, Rasht, Iran. Corresponding author: mkavoosi@guilan.ac.ir
Received: 22 January 2020, Revised: 24 February 2020, Accepted: 28 February 2020.

Introduction

Productivity is one of the most important areas of economic research (Bayyurt and Yılmaz, 2012). It is most often defined as the ability of production factors to produce (Latruffe, 2010). OECD (2001) defined productivity as a ratio of a volume measure of output to a volume measure of input use. Also, Pfeiffer (2003) stated productivity as an essential source of growth that encompasses the output gains attributable to technical change. Fabricant (1959) claimed that the broader the coverage of inputs, the better the measure of productivity, defining the best measure of productivity as one that compares output with the combined use of all inputs. As a result, productivity growth in many studies was estimated using a total factor productivity (TFP) approach. Researchers and policy makers alike have recognized the importance of enhancing productivity to increase agricultural output. Economic growth in different sectors is achieved through two strategies. The first approach is to increase production using more inputs, while the other is using new technologies and to utilise production factors more effectively. In most developing countries, including Iran, limited access to inputs and their scarcity in the agriculture sector have made the application of the former strategy impossible. Therefore, policymakers in these countries have used the second strategy of increasing production based on improving productivity. In Iran, the necessity of improving the productivity of the agriculture sector is mentioned in many laws and documents (Note 35 of the Iran's second development plan (1995-2000); Article 5 of the Iran's fourth development plan (2005-2010); Articles 128, 130 and 133 of Iran's fifth development plan (2011-2016)).

Investigation of the agriculture sector situation in developing countries showed that insufficient knowledge of production facilities and resources and low productivity and efficiency of production caused these countries failed to achieve their agricultural development goals (Chizari and Sadeghi, 2001). Productivity increase is the best and most effective way of achieving economic growth and enhancing the ability of Iran's agricultural sector to compete with other sectors. The study of the research centre of Iran's Islamic Consultative Assembly (IICA) showed that TFP growth of the agricultural sector during the implemented development plans after the Iran's revolution (1979) has been declining. During the early years of the first development plan (1991-1993), the second development plan (1995-2000), the third development plan (2000-2005) and the fourth development plan (2005-2010), the average TFP growth in Iran's agriculture sector were equal to 2.87, 0.16, 0.17 and -0.43, respectively. An initial estimate by the research centre of IICA showed that TFP change for Iran's agriculture sector during the fifth development plan (2011-2016) was overall negative (-0.26%). This situation highlights the need to pay more attention to the issue of productivity and evaluate changes in productivity levels in the various activities of Iran's agriculture sector.

Agriculture is a major economic activity in Iran's rural, deprived and remote areas. Planning for improving agricultural productivity is a key to achieving sustainable development in rural areas. Improvement of productivity indices in this sector have a significant role in removing and reducing economic, social and cultural anomalies in deprived areas of Iran. In this regard, awareness of productivity and its growth in different areas and activities can increase the effectiveness of the proposed policies for regional economic growth and welfare. Measurement is an integral part of productivity analysis. The measurement of productivity provides information on how to move from the present situation to the desired goals.

Demand increase for sericulture products, low costs of breeding, low environmental pollution in production process, the possibility of breeding in most parts of Iran (due to the existence of mulberry tree), market capacity and a short period of production operations (45 days) are among the causes that have brought attention to this ancient activity and its revival in Iran. To the best of our knowledge, there are no studies investigating productivity changes in sericulture production in Iran. Guilan province is considered as the main hub of sericulture production in Iran. The present study investigates the TFP changes of sericulture production system in this province during 2007-2016.

The next section provides a review of some pertinent literature. The data and sources, and models used to estimate TFP change are described under section 3 as methodology. Section 4 captures the results and discusses the reported estimations. The final section concludes.

Literature Review

The study of productivity change goes back to the early works of Koopmans (1951) and Solow (1957). The Malmquist Index was first introduced in 1953 to analyse input consumption and then in 1982 was used to calculate TFP change and its components over two time periods (Färe *et al*., 1992). Caves *et al*. (1982) presented the Malmquist productivity index based on the distance function of inputs. Färe *et al*. (1992) combined two idea of Farrell (1957) and Caves *et al*. (1982) and created the Malmquist Productivity Index directly from inputs and outputs using Data Envelopment Analysis (DEA). Measuring and evaluating productivity changes in different economic sectors, especially in the agriculture sector, has a long history.

Kijek *et al*. (2019) showed that convergence occurred in agricultural productivity almost in all EU member states (except Belgium and the United Kingdom). Also, in new EU member states, the process of making up differences in the productivity of agriculture was stronger than in old EU member states. Djokoto and Pomeyie (2018) explored the productivity comparison further through the evaluation of a common production technology used in 74 countries around the world, over the period 2005 to 2014. The findings relating to production function approach revealed conventional agriculture to be more productive than organic agriculture and the productivity of conventional agriculture was shown to be exponentially rising, whereas that of organic is declining, although it has a quadratic growth path. Du and Lin (2017) have constructed a Malmquist energy productivity index based on the Shephard energy distance function to measure total-factor energy productivity change. The model was applied to compare energy productivity growth across the world's 123 economies. The findings showed that on average, the world witnessed a 34.6% growth of energy productivity between 1990 and 2010, which was mainly driven by technological progress. Moreover, developed countries achieved higher growth in energy productivity than the developing countries and the developed countries took the lead in achieving technological progress, while the developing countries performed better in efficiency improvement.

Nowak and Kijek (2016) determined the relationship between total, average and marginal human factor productivity and the level of education of a farm manager in Poland. The study involved the Cobb-Douglas production function method. Results showed that human capital approximated by the level of education had a positive effect on the average and marginal productivity of the analysed farms. Rizov *et al*. (2013) used a structural semi-parametric estimation algorithm directly incorporating the effect of subsidies into a model of unobserved productivity for the Farm Accountancy Data Network (FADN) samples of the EU-15 countries. Results showed that subsidies impact negatively on farm productivity in the period before the decoupling reform was implemented. However, after decoupling, the effect of subsidies on productivity was more nuanced and in several countries it turned to be positive. Singh and Singh (2012) analysed the rate of TFP growth and technical progress of Indian Agriculture between the periods 1971-2004, using Malmquist productivity index and a Data Envelopment Analysis (DEA). It was observed that productivity growth of Indian agriculture was negative, confirming that the entire output growth was generated by input growth. The decomposition of productivity growth into efficiency change and technical progress reveals that the efficiency change is positively contributing towards the growth of productivity, whereas the negative growth of technology restrict the potential productivity growth in Indian agriculture. Furthermore, it was also observed that efficiency change was insignificant, while technical change was Hicks non-neutral in Indian agriculture. Latruffe *et al*. (2011) showed that higher subsidy and labour dependence was significantly associated with higher productivity across Denmark, France, Germany, Ireland, Spain, Netherland and the United Kingdom. Similarly, the authors stated that the Common Agricultural Policy (CAP) regime introducing fully decoupled payments reduced productivity in all countries considered except Denmark. Linh (2009) also applied the Malmquist productivity index method to measure TFP growth in Vietnamese agriculture using a panel data from 60 provinces in Vietnam during the period 1985-2000. This study indicated that most of the early growth in Vietnamese agriculture (1985-1990) was due to TFP growth, in response to incentive reforms. During the period 1990-1995, the growth rate of TFP fell and Vietnam's agricultural growth was mainly caused by drastic investment in capital. In the last period (1995-2000), TFP growth increased again, though the figure for this period was still much lower than in the period 1985-1990. Overall, the TFP growth rate for the whole period was estimated to be 1.96 percent, contributing to 38% of Vietnam's agricultural growth.

In Iran, the first attempts to measure and evaluate productivity changes in the agriculture sector using non-parametric approaches has begun from the 1990s. Heydari (1999) studied TFP in wheat production of Markazi province using the Törnqvist index. Mojaverian (2003) used the Malmquist index to study the TFP change of strategic crops production system (wheat, barley, cotton, rice and sugar beet) in Iran's agriculture sector over the period 1990-1998. Kavoosi-Kalashami and Khaligh-Khiyavi (2017) studied the TFP change of Iran's crop production subsector using Malmquist approach between 1990 and 2008. For the first time in Iran, this study analysed the TFP changes of 23 major crops during 18 crop years. Results showed that sugar beet production had the highest and rainfed barley and chickpea production had the lowest productivity growth in the studied period. In Iran, few studies have examined productivity in the livestock sub-sector and its related activities. ZandiBaghcheban-Maryam *et al*. (2009) studied the TFP of 36 goat herds in Kurdistan Province using the Törnqvist-Thiel index. Daneshvar-Ameri and Akhondan (2013) investigated the effect of technology change on growth of shrimp production in Bushehr province. The data used were from 48 shrimp farms during the years 2000-2003. Dashti *et al*. (2015) used the Törnqvist-Thiel index for calculating TFP of red meat production in Iran during 1992-2012, while Abedi-Parijani *et al*. (2017) investigated TFP of 240 sericulturists in Mazandaran Province using Cobb-Douglas production function.

Methodology

This study applies the nonparametric Malmquist method based on a panel data of 16 counties in Guilan Province, Northern Iran, during the time period 2007-2016. The TFP estimated by the Malmquist index does not need observed prices and allow the decomposition of TFP growth into efficiency change and technical change (Linh, 2009). Färe *et al*. (1994) showed that the Malmquist productivity index could be calculated without any price data. In their approach, the output distance function is defined as (Färe *et al*, 1992):

$$D(i,o) = \min\{\delta : (o/\delta) \in P(i)\}, \tag{1}$$

The output distance function $D(i,o)$ will take a value larger than zero and less than or equal to one if the output vector o is an element of the feasible production set. If o is located on the boundary of the feasible production set, the output distance function will take a value of unity.

The output-oriented Malmquist TFP index measures the TFP change between two periods by calculating the distance functions of each data point to the relevant technology. Following Färe *et al*. (1994), the Malmquist (output-oriented) TFP change index between period s (the base period) and period e under constant return to scale (CRS) is defined as:

$$M_s^e(o_s, i_s, o_e, i_e) = \sqrt{\left[\frac{D_e^s(o_e, i_e)}{D_s^s(o_s, i_s)}\right] \times \left[\frac{D_e^e(o_e, i_e)}{D_s^e(o_s, i_s)}\right]}, \tag{2}$$

In which, D_e^s, D_e^e, D_s^s and D_s^e are distance functions under CRS. Also, o and i are the output and input vectors. The TFP change index in (2) is actually the geometric mean of two TFP change measure. The first is relative to period s, and the second is relative to period e. On the whole, a Malmquist index greater than unity indicates a TFP increase from s to e, while a Malmquist index less than unity indicates a TFP decrease.

Equation (2) can be arranged to show that the TFP change index is equivalent to the product of a technical efficiency change index and an index of technology change:

$$M_s^e(o_s, i_s, o_e, i_e) = \frac{D_e^e(o_e, i_e)}{D_s^s(o_s, i_s)} \times \\ \times \sqrt{\left[\frac{D_e^s(o_e, i_e)}{D_e^e(o_e, i_e)}\right] \times \left[\frac{D_s^s(o_s, i_s)}{D_s^e(o_s, i_s)}\right]}, \tag{3}$$

In the above equation, the first part shows technical efficiency change index between time periods s and e (EC_s^e) and the second part indicates technology change index between time periods s and e (TC_s^e):

$$EC_s^e = \frac{D_e^e(o_e, i_e)}{D_s^s(o_s, i_s)}, \tag{4}$$

$$TC_s^e = \sqrt{\left[\frac{D_e^s(o_e, i_e)}{D_e^e(o_e, i_e)}\right] \times \left[\frac{D_s^s(o_s, i_s)}{D_s^e(o_s, i_s)}\right]}, \tag{5}$$

The efficiency change index (EC_s^e) can be further decomposed into pure efficiency change or efficiency change between time periods s and e under variable return to scale (PEC_s^e) and scale efficiency change in the same time period (SEC_s^e).

$$PEC_s^e = \frac{D_{e\_VRS}^e(o_e, i_e)}{D_{s\ VRS}^s(o_s, i_s)}, \tag{6}$$

$$SEC_s^e = \frac{D_e^e(o_e, i_e) / D_{e\_VRS}^e(o_e, i_e)}{D_s^s(o_s, i_s) / D_{s\_VRS}^e(o_s, i_s)}, \tag{7}$$

The distance functions are estimated by a Linear Programming (LP) problem under constant return to scale (CRS). For example for $\hat{D}_s^e(o_s, i_s)$ we have:

$$\begin{aligned} &\left[\hat{D}_s^e(o_s, i_s)\right]^{-1} = Max_{\theta,\lambda}\hat{\theta} \\ &\text{Subject to:} \\ &-\theta o_{is} + O_e\lambda \geq 0, \\ &i_{is} + X_e\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned} \tag{8}$$

For the distance functions under Variable Return to Scale (VRS), the convexity constraint added to the above LP problem.

Panel data used related to 15 counties of Guilan province include Astana-Ashrafieh, Amlash, Bandar-Anzali, Talesh, Rasht, Rezvanshahr, Roodbar, Roodsar, Siahkal, Shaft, Sowme'ehSara, Fouman, Lahijan, Langrood and Masal&Shanderman during 2007-2016. Inputs for each county include mulberry garden size (hectare), number of distributed mulberry sapling, number of sericulturists and number of distributed silkworm cocoons eggs (basket). Production of silk cocoon (kg) considered as an output in productivity analysis. The requested data set was obtained from Iran's Sericulture Development Centre (ISDC).

Results

As evident from Table 1, the results of the Malmquist index shows that only Talesh and Roodsar counties (13.33% of total counties) experienced productivity growth during the study period and TFP decreased in all other counties. In Talesh and Roodsar counties, efficiency and technology growth contributed to TFP, and the share of technology growth in TFP growth of these two counties were 85% and 75%, respectively. The three counties of Astana-Ashrafieh, Lahijan and Masal & Shanderman had a negative change in efficiency and technology that led to a significant negative change in TFP. Negative technology change has a major role to play and its share of negative TFP change for these three counties were 99.4%, 99.7% and 65.1%, respectively. In the three counties of Amlash, Bandar-Anzali and Rasht, all the negative change in TFP was due to the negative change in silk cocoon production technology. During the study period, the counties of Rezvanshahr, Roodbar, Siahkal, Shaft, Sowme'ehSara, Fouman and Langrood had poor efficiency growth (less than 1%) in the silk cocoon production system, but a negative change in technology led to a negative change in TFP for all these counties. The average efficiency growth in these seven counties was 0.39%, but the average negative change in technology was -28.76%. Decomposing the values of the efficiency changes into two components of efficiency pure change and scale change showed that in 78% of the counties experiencing efficiency growth (Talesh, Rezvanshahr, Roodbar, Siahkal, Shaft, Fouman and Langrood) was solely due to the scale change of the production system.

Only in the Roodsar and Sowme'ehSara counties (22% of the studied counties), the efficiency growth was driven by a positive efficiency pure change, so that in Roodsar county, 100% of efficiency growth was due to the growth of this component. The negative contribution of the scale change component (-0.3%) in the Sowme'ehSara county reduced the positive effect of the pure efficiency change component on efficiency (from 1.2% to 0.9%) of the sericulture production system.

Astana-Ashrafieh, Lahijan and Masal&Shanderman counties also had negative efficiency changes. The negative efficiency change in the counties of Lahijan and Masal&Shanderman was all caused by a negative scale change. The shares of pure efficiency and scale changes in negative efficiency change of Astana-Ashrafieh County were 67% and 33%, respectively. In the three counties of Amlash, Bandar-Anzali and Rasht, there were no changes in the components of pure efficiency and scale.

As observable in Table 2, descriptive statistics of year-to-year TFP change of silk cocoon production in Guilan province indicated that only the median of year-to-year TFP change for Sowme'ehSara County was positive. Roodsar and Sowme'ehSara counties had the highest and lowest fluctuations of year-to-year TFP, respectively. Among the studied counties, only Astana-Ashrafieh had negative median in year-to-year pure efficiency change. The counties of Siahkal, Sowme'ehSara and Fouman had a negative median in year-to-year scale efficiency change over the period analysed.

During 2007-2016, the average value of TFP change for all studied counties was negative, indicating that if an increase in the amount of silk cocoon production in Guilan province occurred, it was entirely caused by increase in inputs consumption (Table 3). The share of efficiency and technology in the average TFP change during this period was 2.9% and 97.1%, respectively, indicating a decline in production technology of this product.

The highest year-to-year TFP growth can be seen in 2011-2012, while the lowest TFP change belonged to 2009-2010. With the exception of 2011, 2014, and 2016, the major year-to-year TFP changes in the silk cocoon production system of Guilan province occurred due to technology change. It was only in 2013-2014 when the simultaneous growth of effi-

Table 1: Average changes in TFP of sericulture in Guilan province, 2007-2016 (%).

County	Efficiency change	Technology change	Pure change in efficiency	Scale change	TFP change
Astana-Ashrafieh	-0.3	-34.7	-0.2	-0.1	-34.9
Amlash	0.0	-11.8	0.0	0.0	-11.8
Bandar-Anzali	0.0	-27.2	0.0	0.0	-27.2
Talesh	0.4	2.3	0.0	0.4	2.7
Rasht	0.0	-40.2	0.0	0.0	-40.2
Rezvanshahr	0.1	-19.8	0.0	0.1	-19.7
Roodbar	0.7	-9.1	0.0	0.7	-8.4
Roodsar	0.2	0.6	0.2	0.0	0.8
Siahkal	0.2	-36.3	0.0	0.2	-36.1
Shaft	0.3	-38.8	0.0	0.3	-38.5
Sowme'ehSara	0.9	-33.1	1.2	-0.3	-32.2
Fouman	0.4	-38.7	0.0	0.4	-38.3
Lahijan	-0.1	-42.2	0.0	-0.1	-42.3
Langrud	0.1	-25.5	0.0	0.1	-25.4
Masal& Shanderman	-14.1	-26.3	0.0	-14.1	-40.4
Max	Sowme'ehSara	Talesh	Sowme'ehSara	Roodbar	Talesh
Min	Masal&Shanderman	Lahijan	Astana-Ashrafieh	Masal&Shanderman	Lahijan
Average	-0.8	-26.7	0.1	-0.9	-27.5

Source: own calculations based on ISDC (2016) data ciency and technology occurred. Efficiency growth caused 66.4% of TFP growth, while the share of scale growth in TFP growth of 2013-2014 was 61%.

2009, 2010 and 2013 were the years when negative changes in technology efficiency occurred. Although low efficiency growth occurred in these years, this was not able to offset the negative impact of technology change on TFP. In 2008, 2010, 2011, 2015 and 2016, there was a negative change in efficiency and technology growth compared to the previous year. With the exception of 2010 and 2016, technology growth offset the negative impact of efficiency and led to the growth of TFP in the silk cocoon production system of the Guilan province.

The efficiency change decomposition showed that except for the years of 2010, 2013 and 2014, the scale change was negative compared to the previous year. Scale growth was associated with pure efficiency growth over the period 2013-2014, while no change in pure efficiency over 2009-2010 and 2012-2013 occurred. Compared to the previous year, pure efficiency change and scale change were in opposite

Table 2: Descriptive statistics of year-to-year TFP change of sericulture in Guilan province, 2007-2016 (%).

County	Descriptive statistics	Efficiency change	Technology change	Pure change in efficiency	Scale change	TFP change
Astana-Ashrafieh	Median	-1.90	-4.60	-0.10	0.00	-2.00
	S.D.	9.09	35.54	7.62	4.94	33.93
Amlash	Median	0.00	-24.00	0.00	0.00	-24.00
	S.D.	3.63	58.40	3.33	0.25	63.73
Bandar-Anzali	Median	0.00	1.40	0.00	0.00	-1.10
	S.D.	6.21	35.82	5.19	2.43	35.52
Talesh	Median	2.40	-3.20	0.00	2.40	-8.70
	S.D.	11.70	189.70	0.00	11.7	217.46
Rasht	Median	0.00	-4.60	0.00	0.00	-1.00
	S.D.	9.37	37.33	9.12	1.47	34.38
Rezvanshahr	Median	-0.50	5.30	0.00	0.00	-3.90
	S.D.	11.14	31.93	6.72	6.36	34.87
Roodbar	Median	0.00	-6.70	0.00	0.00	-2.70
	S.D.	12.15	336.25	5.08	12.35	307.01
Roodsar	Median	0.00	4.30	0.00	0.00	-7.20
	S.D.	9.17	1,040.96	6.32	6.44	1,190.09
Siahkal	Median	-1.70	-5.80	0.00	-1.70	-5.20
	S.D.	7.95	46.89	0.10	7.99	46.59
Shaft	Median	0.00	4.10	0.00	0.00	-1.60
	S.D.	9.02	34.32	0.00	9.02	34.97
Sowme'ehSara	Median	-0.40	-3.30	0.00	-0.40	2.70
	S.D.	12.06	36.14	8.15	4.63	33.69
Fouman	Median	-0.10	-3.30	0.00	-0.50	-1.30
	S.D.	9.78	35.97	7.95	5.89	35.36
Lahijan	Median	0.00	-7.00	0.00	0.00	-5.70
	S.D.	5.79	35.3	0.00	5.79	34.93
Langrood	Median	0.00	-2.90	0.00	0.00	-2.50
	S.D.	6.86	34.48	0.00	6.86	34.78
Masal&Shanderman	Median	0.00	8.50	0.00	0.00	-6.40
	S.D.	25.81	42.07	1.67	26.2	41.71

Source: own calculations based on ISDC (2016) data

Table 3: Average changes in year-to-year TFP of sericulture in Guilan province, 2007-2016 (%).

Year	Efficiency change	Technology change	Pure change in efficiency	Scale change	TFP change
2007-2008	-2.8	4.0	-1.1	-1.7	1.2
2008-2009	1.4	-27.4	1.9	-0.5	-26.0
2009-2010	3.8	-96.1	0.0	3.8	-92.3
2010-2011	-6.8	6.0	-2.3	-4.5	-0.8
2011-2012	-2.9	107.8	-1.6	-1.3	104.9
2012-2013	0.1	-17.8	0.0	0.1	-17.7
2013-2014	9.7	4.9	3.8	5.9	14.6
2014-2015	-2.8	9.0	-1.2	-1.6	6.2
2015-2016	-6.1	0.1	1.3	-7.4	-6.0
Max	2014	2012	2014	2014	2012
Min	2011	2010	2011	2016	2010
Average	-0.8	-26.7	0.1	-0.9	-27.5

Source: own calculations based on ISDC (2016) data directions for 2009 and 2016, which in the first case of pure efficiency growth, eliminated the negative effect of scale change and caused TFP growth, but in the second case, this did not happen.

Discussion and Conclusions

Productivity plays an effective role in production growth and increasing competitiveness of Guilan province silk cocoon production system. Therefore, improving productivity and technology upgrades should be on the agenda of the ISDC, which has been in charge of the sericulture industry in Iran since 2014. Optimal policies adapted by the government, including the timely determination, announcement, and provision of a reliable cocoon guarantee price as a support tool (such that the sericulturists would be aware of price ranges when they need to purchase silkworm cocoons eggs) could help boost producers' motivation as well as help optimise the sericulturists's decisions as to the amount or volume of silkworm breeding operations they undertake. Optimal combination of inputs and operation volume determination play an important role in improving TFP.

Identifying the agents of sericulture industry so as to assess the status of silkworm breeding, cocoon production and silk production accurately and consistently as well as provide desirable technical-educational services, and in particular organise and facilitate the marketing process of silk products, is an indispensable prerequisite for observing productivity changes. According to the Iran's National Productivity Centre (INPC) stated goal to increase TFP by 4.4% (YadollahzadeTabari and Khoshabi, 2012), it can be concluded that there is a considerable gap between the productivity of sericulture system in Guilan Province and the level considered desirable. The first step is to develop a comprehensive program to improve hard and soft factors of productivity in the silk cocoon production system of Guilan Province.

An important factor in motivating producers to improve the TFP is incentives. Undoubtedly, sericulture producers' investment in technology and efficiency improvement (hard factors of TFP growth), which ultimately leads to TFP growth, needs financial incentives. Implementation of a step-by-step policy to balance domestic prices of silk products with world prices and shift to equilibrium prices, establishing appropriate customs tariffs and regulating the import of cocoon and silk to support domestic production, providing comprehensive training to sericulturists in the form of technical recommendations for the separation of high-quality cocoons from expanding ones (cocoons grading and sorting) and launching a quality assessment system for silk produced from the cocoon of sericulturist in order to justify and proper pricing of their products could be considered as four important policies for Iran's sericulture industry.

The purpose of this study was to monitor the performance of the sericulture section in Guilan Province, Northern Iran in order to make performance comparisons across this province's counties, and finally to assist policymakers to design optimal policies to improve productivity. In particular, productivity growth can be largely attributed to public research and development (R&D) expenditure so that productivity measurement is a first step to establish whether the investments made in sericulture research represent an appropriate use of public funds. Negative TFP change during the study period showed that research of public centres (like public universities and research centres) in sericulture section did not have contributions to productivity growth. Increasing productivity in sericulture has a number of important effects. First, it releases resources that can be used by other sericulturists in different counties, thereby creating economic growth. Second, higher levels of productivity result in lower prices of sericulture products that increase consumers' welfare. Third, productivity growth in sericulture improves the competitive position of the agriculture sector in Guilan Province.

References

Abedi-Parijani, A., Motamed, M.K. and Kavoosi-Kalashami, M. (2017): Investigating total factor productivity and factors affecting it in sericulture of Mazandaran province. Animal Production Research, **5** (1), 89–96.

Bayyurt, N. and Yılmaz, S. (2012): The impacts of governance and education on agricultural efficiency: An international analysis. Procedia-Social and Behavioral Sciences, **58**, 1158–1165. http://dx.doi.org/10.1016/j.sbspro.2012.09.1097

Caves, D.W., Christensen, L.R. and Dievert, W.E. (1982): The economic theory of index number and the measurement of input, output and productivity. Econometrica, **50**, 1393–1414.

Chizari, A. and Sadeghi, A. (2001): Economic impact of drainage system on productivity of Date Production, Case Study of Bushehr Province. Iranian Journal of Agricultural Economics and Development **30**, 76–92. (In Persian)

Daneshvar-Ameri, ZH. and Akhondan, N. (2013): The effect of technology change on growth of shrimp production in Bushehr province. Iranian Journal of Agricultural Economics and Development Research **43** (2), 193–200. (In Persian)

Dashti, GH., JagjoTazekand, E. and Ghahremanzadeh, M. (2015): The Impact of Government Support Policies on total factor productivity changes of meat production in Iran. Animal Science Research, **25** (3), 33–45. (In Persian)

Djokoto, J.G. and Pomeyie, P. (2018): Productivity of organic and conventional agriculture – a common technology analysis. Studies in Agricultural Economics, **120** (3), 150–156. https://doi.org/10.7896/j.1808

Du, K. and Lin, B. (2017): International comparison of total-factor energy productivity growth: A parametric Malmquist index approach. Energy, **118**, 481–488. https://doi.org/10.1016/j.energy.2016.10.052

Fabricant, S. (1959): Basic Facts on Productivity Change. Occasional Paper No. 63, National Bureau of Economic Research, Washington DC., USA.

Färe, R., Grosskopf, S., Lindgren, B. and Roos, P. (1992): Productivity changes in Swedish pharmacies 1980-1989: A non-parametric Malmquist approach. Journal of Productivity Analysis, **3**, 85–101. https://doi.org/10.1007/BF00158770

Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994): Productivity growth, technical progress, and efficiency change in industrialized countries. American Economic Review, **84** (1), 66–83.

Heydari, K.H. (1999): Total factor productivity of wheat production in Markazi Province. Iranian Journal of Agricultural Economics and Development **28**, 137–157. (In Persian)

Kavoosi-Kalashami, M. and Khaligh-Khiyavi, P. (2017): Total factor productivity analysis in Iran's crop subsector. Iranian Journal of Agricultural Economics Research, **8** (2), 157–172. (In Persian)

Kijek, A., Kijek, T., Nowak, A. and Skrzypek, A. (2019): Productivity and its convergence in agriculture in new and old European Union member states. Agricultural Economics-Czech, **65,** 1–9. https://doi.org/10.17221/262/2017-AGRICECON

Koopmans, T.C. (1951): An analysis of production as an efficient combination of activities, In: T.C. Koopmans (ed.), Activity Analysis of Production and Allocation. Cowles Commission for Research in Economics. Monograph No. 13, New York: Wiley.

Latruffe, L. (2010): Competitiveness, Productivity and efficiency in the agricultural and agri-food sectors. OECD Food, Agriculture and Fisheries Papers, No. 30. Paris: OECD publishing.

Latruffe, L., Bravo-Ureta, B.E., Moreira, V.H., Desjeux, Y. and Dupraz, P. (2011): Productivity and Subsidies in European Union Countries: An Analysis for Dairy Farms Using Input Distance Frontiers. Paper prepared for presentation at the EAAE 2011 Congress Change and Uncertainty, Challenges for Agriculture, Food and Natural Resources, August 30 to September 2, 2011, ETH Zurich, Zurich, Switzerland.

Linh, V.H. (2009): Vietnam agricultural productivity: a Malmquist index approach. Vietnam Development Forum, Working Paper No. 0903. Retrieved from: http://www.vdf.org.vn/workingpapers/vdfwp0903 (Accessed in October 2019)

Mojaverian, M. (2003): Estimation of Malmquist Productivity Index for Iran's Strategic Products over the Period of 1991-2000. Iranian Journal of Agricultural Economics, **43-44,** 143–162. (In Persian)

Nowak, A. and Kijek, T. (2016): The effect of human capital on labour productivity of farms in Poland. Studies in Agricultural Economics, **118** (1), 16–21. http://dx.doi.org/10.7896/j.1606

OECD (2001): Measuring Productivity – OECD Manual: Measurement of Aggregate and Industry-level Productivity Growth. OECD, Paris, France.

Pfeiffer, L.M. (2003): Agricultural Productivity Growth in the Andean Community. American Journal of Agricultural Economics, **85** (5), 1335–1341. https://doi.org/10.1111/j.0092-5853.2003.00553.x

Research Centre of Iran's Islamic Consultative Assembly (2014): Report on performance evaluation and agricultural sector goals in development plans. (In Persian)

Rizov, M., Pokrivcak, J. and Ciaian, P. (2013): CAP subsidies and productivity of the EU farms. Journal of Agricultural Economics, **64** (3), 537–557. https://doi.org/10.1111/1477-9552.12030

Singh, P. and Singh, A. (2012): Decomposition of technical change and productivity growth in Indian agriculture using non-parametric Malmquist index. Eurasian Journal of Business and Economics, **5** (9), 187–202.

Solow, R. (1957): Technical change and the aggregate production function. Review of Economics and Statistics, **39**, 312–320.

ZandiBaghcheban-Maryam, M., MoradiShahrBabak, M., MirayiAshtiani, S.R. and Kavoosi-Kalashami, M. (2009): Comparison of total factor productivity of Markhoz goat herds in Kurdistan Province. Animal Science Journal, **83**, 74–82. (In Persian)