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Investigating the Effect of Insurance on the Total Productivity of Agricultural production Factors: Analysis Based on Index Number Approach

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ABSTRACT

According to the new economic theories and endogenous growth models, productivity factors of production are expressed as a key variable for achieving high and continuous growth. Therefore, identifying the factors affecting the productivity of production factors is very important. In this study, due to the significance of the agricultural sector in the Iranian economy and its role in supplying food needs, we specified a behavioral model for productivity factors of agricultural production by focusing on the impact of insurance variable as an indicator for risk management. For this purpose, the total productivity factors of production was estimated using *Törnqvist-Theil* Index and the theoretical model of behavioral regression was evaluated by using cointegration methodology and based on time series data during 1984- 2017. The results show that insurance can positively influence productivity by providing security in crop production and increasing computing power and farmer planning. In addition, the real exchange rate, training costs, and technical efficiency indicators had a positive effect, while cost of capital had a negative effect on productivity. The information provided in this study can be used to implement insurance protection policies in the agricultural sector effectively to increase productivity.

1. Introduction

Most of the economic evidence suggest that new investments alone are not able to satisfy the demand and supply side needs, and the better use of available capital and facilities seems to be more important than increasing

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investment, which is known as promoting productivity and defining more production for a certain amount of inputs. Therefore, promoting productivity and gaining competitive advantage are considered as one of the most important approaches for sustainable growth and development due to the scarcity of resources since a significant part of the economic growth of developed countries is related to productivity growth. In Iranian economy, productivity growth has been one of the most important goals during the five-year development plan since the revolution, with one-third of expected and targeted economic growth since the Fourth Development Plan on average has been related to productivity growth. Further, the agricultural sector has a special place in the Iranian economy due to its potential production and employment capacity as well as less need for foreign exchange and the main source of rural income. This sector accounts for about 7% of GDP, among which 18% is related to total employment. Thus, the quantitative and qualitative improvement of agricultural production in the form of a lower-priced food basket has a positive effect on household welfare, especially for the poor. Also, reducing the price of agricultural products increases the purchasing power, which contributes to the greater presence of the agricultural sector in global competitive markets (Branson et al., 2012).

In addition to providing food, the agriculture sector supplies the raw materials for the industrial sector, providing additional foreign exchange resources and generating productive employment. However, in developing countries such as Iran, agricultural production falls below the production possibility curve due to the existing structural problems, poor policies and the inappropriate use of technology facilities. Therefore, to meet the food needs, it should increase agricultural production, which will be impossible in the long run due to land constraints and water crisis. Thus, trying to improve agricultural productivity should be considered as the key step. Therefore, to improve the performance of this section, much emphasis is held on improving irrigation activities and application of fertilizers, training, and transferring new technology.

However, agricultural activity is regarded as one of the riskiest economic activities. Because this sector is always exposed to the uncontrollable risks of the disease, natural hazards such as climate change, as well as social and economic risks like price fluctuations and instability of production factors, so it is generally considered as a fragile sector. Therefore, increasing investment and production security is regarded as one of the most rational expectations of producers, and playing the role of the agricultural sector in the economy requires macroeconomic tools and policies to manage the risks involved. Agricultural insurance is considered as one of the tools noted today to reduce the risks listed above and increase the incentives for investment and production in the agricultural sector because farmers' efforts to reduce risk are usually insufficient and the use of agricultural insurance is inevitable. Agricultural Insurance, in addition to helping stabilize farmers' income, reduces agricultural arrears. In addition, manufacturers' incentives to use new technologies increase, leading to an increase in production throughout the economy. Therefore, agricultural insurance, as one of the tools for risk coverage, can affect productivity and production in the agricultural sector.

Therefore, considering the effective role of productivity in economic growth as well as the high importance of agriculture sector in Iranian economy, the present study aimed to identify the factors affecting agricultural productivity and see whether agricultural insurance has a positive or negative effect on agricultural productivity of Iranian economy.

2. Literature review

2.1. Productivity and agricultural insurance

The term productivity was first coined by Quizen (1776), a mathematician and economist at the Physiocracy, who argued that the authority of any state is subjected to increased agricultural productivity. Adam Smith and Karl Marx then referred to the issue of productivity in economic activity but its concept was widely used after the economic crises of the 1930s. In the dictionary of economic sciences (Farhang, 2009), productivity is defined as the ratio between a given quantity of product and a certain amount of one or more factors of production or relative efficiency. In the field of management, productivity is regarded as the sum of efficiency (the ability to do things well) and effectiveness (doing the right thing). Therefore, in this field, productivity is generally defined as doing the right thing in the right way. But, in the field of economics, especially agricultural economics, the productivity is derived from the ratio of real output to real inputs, that its improvement is consistent with the upward shift of the production curve. However, it is worth noting that increasing production and efficiency do not necessarily mean increase in productivity productivity because productivity growth has three components in economy: technical efficiency changes, technology changes, and scale effects. However, early research on productivity growth was found in the studies of Koopmans (1951) and Solow (1957). Other studies such as Nishimizo and Page (1982) and Cave et al. (1982) investigated the factors affecting productivity growth.

Huffman and Evenson (1993) argued that the part of production growth which is not caused by the quantitative growth of inputs can be related to productivity growth. Thus, the change in agricultural productivity is related to human capital. Hall and Jones (1999) emphasized the importance of capital and social infrastructure. also, Acemoglu (2008) highlighted the role of quality of inputs in productivity and economic growth. North (1990) argues that value-added growth is driven by real economic mechanisms and institutional factors leading to relative price changes.

Endogenous growth theories have focused on the role of non-price variables such as human capital and research and development on productivity changes. Lucas (1988) and Romer (1990) emphasized the role of education and human capital accumulation. Grossman and Helpman (1991) reported the role of research and development and believed that new investment and technology advancement can be achieved by expanding research and development, leading to an improvement in the productivity of all factors of production. Coe and Helpman (1995) argue that productivity growth and subsequently economic growth depend not only on domestic resources but also on the research and development activities of trade partners.

In addition to the above studies, there are many newer theoretical literature and empirical evidence which confirm the results of the previous results and show that the main cause of agricultural productivity growth through technical and efficiency improvement is related to the appropriate policy structures (Nin

Pratt et al., 2009, Mamatzakis, 2002), Research and Development (Fare et al., 2008; Coe et al., 2009), infrastructure development and tax discount (Chen et al., 2008), human capital (Luh et al., 2008), the quality of the land under cultivation, modern irrigation techniques and advanced machinery (Candemir et al., 2011; Pfeiffer & Philson, 2004), expanding non-oil exports (Fryges & Wagner, 2007, Aki Nello, 2006). Also, Akinlo (2006) considered inflation and foreign direct investment as the factors affecting the productivity.

As shown in the theoretical literature on productivity, a wide range of economic and non-economic factors weres introduced by economists influencing the productivity of production factors. However, insurance is considered as one of the variables affecting productivity in economic sectors, which is effective in agriculture, which, in its simplest sense, is a method of risk transfer. The instability of nature and the unpredictable natural events (climate risks) and market uncertainty, institutions and policies (non-climate risks) have created special conditions for the agricultural sector, leading to the uncertainty of agricultural output and its future. Therefore, farmers consider risk management to reduce the existing risks and control agricultural uncertainty as a second goal. The mean of risk management is to use different methods to reduce the negative effects of unforeseen risks (Hardaker et al., 2004). In this regard, tools such as variety of agricultural products, contracts, guaranteed prices, financial reserves and flexibility in inputs are used (Nikooyi & Torkamani, 2004; Anderson & Dylan, 1992). However, although these methods may reduce farmers' income fluctuations and the negative effects of potential risks, they are not usually effective during serious natural hazards. Thus, agricultural insurance is regarded as one of the tools considered by policy makers and producers during the recent decades (Meuwissen, 2000). Agricultural insurance raises producers' risk-taking, which increase production, improve farmers' income and social welfare by more appropriate allocation of resources and a positive impact on investment in riskier and more productive activities (Ehsan et al., 1982; Williams et al., 1993; Turkman, 2001). Hence, by integrating risks of risk-averter underwriter and paying compensation, agricultural insurance try to create optimal Pareto position, which results in increasing the motivation of risk-averter individuals to be engaged in risky activities, because risk-averter manufacturers prefer those activities which are less risky. Also, they use fewer new technologies and tend to be more traditional (Nikooyi & Torkamani, 2002). Therefore, agricultural insurance is a new technology which is used to reduce the risk aversion of farmers and increase the efficiency and productivity of production factors and ultimately new investment. Insurance encourages the policyholders to use the factors of production more effectively by dividing the risk between insurers and underwriters (Ehsan et al., 1982).

Thus, the functions of agricultural insurance can be summarized as follows:

- Providing security for production in the agricultural sector
- Increasing computing power and planning
- Reducing government grants to farmers due to big damages
- Benefiting from the constant supervision of insurance experts
- Securing private investment in agriculture
- Eliminating non-economic agricultural products

Theoretically, agricultural Insurance is a type of risk sharing system, but practically, it is a costly tool for transferring risk from farmers to insurers. However, there is no universal experience in insuring all crops, horticulture and, livestock, so the choice of insurance coverage products is based on importance in the economy and food security. Usually, agricultural insurance is divided into two main types in terms of scope. In its limited form, agricultural insurance covers only insurance of products from the time of planting to harvest and, in its comprehensive form, covers the full range and scope of horizontal (forward and backward) agricultural activities including initial investments, agricultural equipment and related materials. the first form is the most commonly used type in Iran.

Premium costs are usually divided between producers and the government in certain proportions, part of which is paid by the policyholders (producer) and another by the government as a premium subsidy. Insurance largely depends on government financial support as a large share of the premium is provided by subsidies (Mahol & Estelle, 2010). The subsidy is based on the theory by which agricultural insurance has features related to public goods.

Therefore, the market cannot offer it at the optimal social level (Gholizade & Salami, 2012). On the other hand, the mismatch between incoming and payments to active insurers in agriculture has led governments to pay and inject subsidies to active insurers in the framework of their agricultural protection policies called the agricultural premium subsidy. Also, it is considered as one of the most common mechanisms for public sector participation in agricultural insurance markets. Due to the unwillingness of insurance companies to operate insurance and provide services to farmers for several reasons, the role of government and its support for agricultural insurance is evident all over the world.

2.2. Review of Related Studies

A review of the studies on the productivity of production factors in agriculture indicates, which has always attracted a lot of attention. However, some studies have addressed the impact of agricultural insurance through econometric models.

Darijani (1986) investigated the factors affecting the acceptance of agricultural insurance by using the questionnaire and logit econometric model and indicated that education, loans, crop history, and agricultural risk background positively affected insurance acceptance, while income variability, land ownership, and production variety negatively influenced insurance acceptance.

Gholizadeh and Salami (2013), following optimization conditions, proposed an insurance subsidy allocation model for promoting grain productivity. Optimal subsidy allocation was affected by factors such as product performance, premium, price elasticity of insurance demand, and current insurance level. Optimal subsidy allocation led to the redistribution of funds to different grain-producing regions, leading to increase in the productivity and efficiency.

Turkmani (2009) reported the effects of agricultural insurance on risk reduction and income inequality of farmers in Fars province. He represented that insurance plays a positive effect on reducing inequality of farmers.

Torkmani and Mousavi (2011) studied the effects of crop insurance on agricultural production efficiency in Fars province and indicated that insurance has a positive but insignificant effect on performance.

Sabaghi (2015) investigated the impact of agricultural insurance on production efficiency in Dezful, Iran, and found a positive but insignificant effect on efficiency.

Siham (2017) examined the impact of agricultural insurance market development on agricultural productivity growth among 23 countries during 2000-2015.

The results of the panel model indicated the positive effect of this variable on agricultural productivity. Further, the study used other important variables such as the penetration rate of agricultural insurance, credit, and education.

Muller et al. (2017) investigated the adverse consequences of climate insurance in agriculture and reported that agricultural insurance plans make land-use decision-making priorities. If insurance is a good tool to deal with the effects of climate change, it should be carefully developed with regard to specific local social and ecological conditions and risk strategies. Otherwise, it can produce undesirable long-term results.

Pasaribu and Sudiyanto (2016) examined the risk management of climate change and its effects on food production, especially rice, as the staple food of the majority of Indonesians. Agricultural insurance was introduced to manage natural hazards and disasters. The results indicated that rice crop insurance has received a positive response from farmers in several production areas.

Siham (2015) evaluated the relationship between crop insurance and productivity factors in this sector by using seasonal data during 2000- 2012 in the United States. The results of Granger causality suggested that there is a one-way relationship between agricultural insurance and productivity factors.

Olubiyo et al. (2009) examined the effect of agricultural insurance on farmers' performance and productivity. By estimating the Cobb-Douglas production function they indicated unexpectedly that farmers who did not use agricultural insurance had higher production and productivity.

Haiss and Sümegi (2008) investigated the impact of insurance on economic growth in European countries by using panel data and indicated a positive relationship between these two variables.

By considering the above-mentioned studies, although some research focused on the factors affecting agricultural productivity, it is still necessary to use insurance variables along with other macroeconomic variables because the coefficients are estimated bias when the model is improperly defined.

3. Theoretical Model and Methodology

Based on the theoretical foundations of the research, a generalized model using in Siham (2015) was used to investigate the effect of insurance on the total productivity of agricultural production factors, as shown in the following equation:

Eq. (1) $$TFP_t = \beta_0 + \beta_1 insurance_t + \beta_2 x_t + u_t$$

where TFP shows the total productivity of the factors of production in agriculture, insurance indicates agricultural premium, and x is considered as the vector of variables affecting productivity. The vector variables x as follows:

Real Exchange Rate: This variable can be considered as a key variable in the Iranian economy which affects almost all economic sectors. The impact of the exchange rate on productivity in the economic literature was gradually evaluated in the form of endogenous growth models. This variable, as an indicator of competitiveness in the global economy, affects the productivity of the factors of production and was considered from various aspects in the form of theoretical studies, although different and sometimes contradictory results were obtained. Kafaei and Bagherzadeh (2016), Cheraghi (2015) and Dialo (2010) emphasized the positive effect of the real exchange rate on productivity, while Jeanneney and Hua (2011) reported the negative effect.

Interest rate (or cost of capital): This variable, as a variable affecting production costs including borrowing and capital utilization, affects the productivity of the factors of production. For example, reducing this rate means lowering the price of the loans, which can be spent on short-term operating expenses such as fertilizer and seed and long-term investment such as machinery and land. Dritsakis (2003) and Cheraghi (2015) investigated the relationship between these two variables. However, we use the cost of capital, which is a more comprehensive variable than the interest rate, and was mentioned in the form of theories.

Agricultural Training Costs: Training has been considered as one of the ways to develop human resources in endogenous growth models to enhance productivity, leading to increased productivity by affecting human capital as well as its optimal allocation among economic sectors. Some studies reported this issue (e.g., Asadullah & Rahman, 2009; Reimers &Klasen, 2013; Annabi, 2017; Yao,2019).

Ratio of Output Current Value to Investment: The ratio of current value to output investment in the agricultural sector is another variable used in the theoretical model of research to explain productivity. Based on similar studies, this ratio is considered as an alternative variable for the technical efficiency index. Shahabadi et al. (2012) and Boyd and Pang (2000) evaluated the relationship between efficiency and productivity in agriculture and energy, respectively.

Given the above issues, the theoretical model of research is as follows:

Eq. (2) $$TFP_t = \beta_0 + \beta_1 INSUR_t + \beta_2 EFR_t + \beta_3 UCA_t + \beta_4 EDU_t + \beta_5 EI_t + u_t$$

where INSUR indicates the premium paid, EDU shows agricultural training costs, EFR represents Exchange Real rate, UCA is regarded as the cost of capital in agricultural sector, and EI is the ratio of value to investment or technical efficiency index.

4. Measurement methods and data

In this study, the data needed to estimate the model were collected from the central bank time series database (TSD), annuity budget rules, ministry of Agriculture-Jahad Databases, Agricultural Insurance Fund and Statistical Center of Iran. However, some variables were not officially published and each was extracted in accordance with theoretical principles with the help of other information.

4.1. Total Productivity of Agricultural Production Factors

Two major parametric (econometric) and non-parametric approaches were used to measure total factor productivity. Based on the non-parametric approach, index number, growth accounting method, and distance function method were used. In this paper, Tornqvist-Theil Index was used as one of the most important numerical indices.

This index is used to aggregate the quantitative indices of different inputs and outputs to calculate the total factor productivity index. According to the economic method, this index is consistent with flexible functions, it can provide a quadratic estimation of a two-time derivative homogeneous linear function (Yazdani et al., 2016). Also, a value greater than one and less than one indicates appropriate and inappropriate productivity, respectively, compared with the average of other units in the industry. The possibility to include the changes in the price of inputs and outputs during the period under review is considered as one advantage of this index compared with other indices. Further, this index is a discontinuous approximation of the divisia index and is consistent with the translog function. Therefore, the constant return assumption is eliminated. This index is calculated as follows:

Eq. (3): $$TFP_t = \frac{\sum_{i=1}^{n} \left(\frac{q_i^t}{q_i^0}\right)^{0.5\left(R_i^t + R_i^0\right)}}{\sum_{i=1}^{n} \left(\frac{x_i^t}{x_i^0}\right)^{0.5\left(s_i^t + s_i^0\right)}}$$

where q_i^t and x_i^t are output and input values at time t, R_i^t is the revenue share of the product i at time t, s_i^t is the cost share of input in the total cost of production, q_i^0 و x_i^0 are output and input in the base year, R_i^0 the revenue share of product i in the base year, s_i^0 shows share of the cost of input i of the total cost of producing product i in the base year.

4.2. Cost of capital in agricultural sector

The cost of capital in agriculture is considered as one of the important variables used in this paper, which is based on the Jorgenson (1963) as follows:

$$\text{Eq. (4)} \quad UCA = \frac{PIA}{PA}[\,\alpha(R + 0.05) + (1 - \alpha)(RZA) + \delta\,]$$

where PIA indicates the price of capital goods in the agricultural sector, PA represents the price index of agricultural production, α and α-1 are respectively considered as the share of investment financed by investor and bank.

R is the interest rate on long-term bank deposits, R + 0.05 is the opportunity cost of the investor, RZA is the interest rate on agricultural loans, and δ is the rate of depreciation on fixed capital in the agricultural sector.

5. Results

The model was estimated by Eviews software based on the integration and ARDL method. Before estimating, it is necessary to first examine the stationary of the variables used. For this purpose, the Augmented Dickey-Fuller test is used, the results of which are reported for the logarithm of the variables as shown in Table 1. Function state information is provided by the letters (C, T, P), where C is the constant term, T is the trend, and P is the number of lags. According to the Dickey-Fuller test results, all model variables except the logarithm of technical efficiency index are I(1).

Table 1. Examing the stationary variables

Variable	Function mode	Test statistics	Critical Quantity	Result
LOG(TPF)	(C, T, 2)	-1.485	-3.574	I(1)
DLOG(TFP)	(C, T, 1)	-9.3386	-3.574	
LOG(INSUR)	(-, -, 0)	1.888	-1.952	I(1)
DLOG(INSUR)	(-, -, 0)	-3.825	-1.952	
LOG(EFR)	(-, -, 0)	-1.225	-1.952	I(1)
DLOG(EFR)	(-, -, 0)	-4.401	-1.952	
LOG(UCA)	(-, -, 0)	-1.523	-1.952	I(1)
DLOG(UCA)	(-, -, 0)	-5.146	-1.952	
LOG(EDU)	(C, T, 1)	-2.901	-3.562	I(1)
DLOG(EDU)	(-, -, 0)	-4.696	-1.952	
LOG(EI)	(-, -, 0)	-2.277	-1.952	I(0)

After ensuring the order of integration of the variables, the dynamic, long-term and short-term models are estimated. The Schwartz-Bayesian index is used to determine the number of optimal lags in Table 2, which saves the number of lags and is therefore suitable for less observable samples. Before extracting a long-term relationship, it is necessary to ensure that there is a long-term equilibrium relationship between the variables. For this purpose, we used Banerjee Doladu and Master test. The results indicated that there is a integration and long-term equilibrium relationship between the variables. Further, the results of the diagnostic tests indicated the proof of all classical assumptions. The dummy variable D7174 was used to behave error term which are defined as one for years 71 to 74 and for other years as zero.

Dynamic Relationship of ARDL Productivity Function (1, 0, 0, 0, 0, 0)

Table 2. The dynamic relationship of the theoretical model

Variable	Coefficient	Std. Error	P-Value.
LOG(TFP(-1))	0.196	0.084	0.028
LOG(INSUR)	0.111	0.042	0.015
LOG(EFR)	0.557	0.103	0.000
LOG(UCA)	-0.392	0.077	0.000
LOG(EDU)	0.192	0.062	0.004
LOG(EI)	0.680	0.066	0.000
D7174	0.178	0.052	0.002
CONSTANT	-10.71	1.46	0.000
R^2 **= 0.93** ***Serial Correlation*** **= 1.36 (0.275)**			

Long-term relationship of productivity function

Table 3. The long-term relationship of the theoretical model

Variable	Coefficient	Std. Error	P-Value.
LOG(INSUR)	0.138	0.058	0.025
LOG(EFR)	0.694	0.141	0.000
LOG(UCA)	-0.488	0.097	0.000
LOG(EDU)	0.240	0.076	0.004
LOG(EI)	0.846	0.111	0.000
D7174	0.221	0.071	0.004
CONSTANT	-13.33	2.170	0.000

Short-term relationship of productivity function

Table 4. Short-term relationship of the theoretical model

Variable	Coefficient	Std. Error	P-Value.
DLOG(INSUR)	0.111	0.042	0.015
0.557DLOG(EFR)	0.557	0.103	0.000
DLOG(UCA)	-0.392	0.077	0.000
DLOG(EDU)	0.192	0.062	0.000
DLOG(EI)	0.680	0.066	0.000
DD7174	0.178	0.052	0.002
ECMTFP(-1)	-0.803	0.084	0.000

Based on the long-term relationship outputs in Table 3, all variables are significant. As shown, the main variable of the model, namely the premium paid (INSUR), has a positive effect on the productivity of agricultural production factors. By paying premiums for risk management, farmers and governments increase the degree of risk-taking, along with productivity by allocating resources more appropriately and investing in riskier and more productive activities. Thus, insurance, along with the reduction of government costs in compensating for the severe damages caused by natural disasters leads to an increase in farmers' ability to plan and motivate to produce more economical products by increasing the security of agricultural products. The real exchange rate as an index of global competitiveness leads to increase exports and production, and accordingly better use of the factors of production. Because external competition encourages local firms to increase their efficiency in staying on the market, it leads to the redistribution of resources from firms and sectors which are not very productive to firms and sectors which are more productive. Also, by increasing the cost of capital in the agricultural sector including increase borrowing and capital price, the use of fertilizers and other essential inputs may decrease leading to the reduction of productivity factors.

Increasing training costs in the agricultural sector as an indicator of human capital development in this sector leads to improved labor performance with new and more effective technologies and inputs which can directly increase the productivity of production factors. The ratio of the current value of output to investment as an alternative of technical efficiency index indicates the economical or non-economy of scale. Further, using advanced methods and techniques in the long term leads to an increase in the ratio, i.e. an increase in production for a certain amount of inputs, which can positively influence productivity.

As shown in Table 4, the coefficient of error correction is -0.803 in the short-term equation so that in each period 80% of the previous equilibrium error is eliminated.

6. Conclusion

Nutrition needs are considered as one of the most important needs of man, which has made food security as one of the main goals and concerns of politicians. Therefore, the agricultural sector can be considered as one of the most important economic sectors of any country. In this regard, increasing agricultural production due to increased productivity is very important. Therefore, the present study aimed to investigate the factors affecting productivity of production factors by emphasizing agricultural insurance during 1986-2017 by using integration methodology.

Agricultural insurance as a way of covering and managing risk changes the behavior of farmers, especially risk-avertor producers. It is expected that farmers will pass through the livelihood stage and gradually enter the commercial production stage by changing their allocation of resources. The results indicated that the premium by the aggregate of premium paid by the farmer and the government increases the productivity of the factors by increasing the degree of risk-taking, increasing the computational power, and planning of the farmer. Therefore, given the special importance and role of the agricultural sector in the Iranian economy, paying more attention to the insurance industry in agricultural products and the use of new tools can help strengthen this sector and greatly reduce the degree of agricultural degradation caused by the oil sector.

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