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The Impact of Using Certified Seeds on The Technical Efficiency of Garling Farming In Indonesia

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ABSTRACT

The use of certified seeds can increase productivity and technical efficiency of garlic farming. This study aimed to examine the effect of using certified seeds on the technical efficiency and productivity of garlic farming. This study uses secondary data in the form of cross-sections from the Horticultural Plant Household Survey (SHR, 2014) conducted by the Central Bureau of Statistics (BPS). The number of samples used is the same as the number of SHR 2014 samples. These data were analyzed using stochastic production frontier sample correction (SC-SPF) combined with propensity score matching (PSM) to eliminate observed and unobserved biases. The average treatment effect on the treated (ATET) used to directly calculate the effect of using certified seeds on productivity and technical efficiency. The average productivity of farmers using certified seeds was higher than that of farmers who did not use certified seeds. Meanwhile, the average technical efficiency (ET) of farmers who use certified seeds is lower than that of farmers who do not use certified seeds. This shows that the use of certified seeds has no effect on the technical efficiency of garlic farming. There are two alternative policies that can be taken, the first is advising farmers not to use certified seeds or the second alternative is improving the mechanism for distributing garlic seed assistance and developing the garlic seed industry.

Keywords: *Propensity score matching, sc-spf, technical efficiency*

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INTRODUCTION

Agricultural intensification and development is a prerequisite for production growth or farming efficiency (Pamuk, Bulte and Adekunle, 2014). An important component of many agricultural development strategies is using new agricultural innovations or technologies. With the existence of new technology, the use of the same input will shift the production function up or form a new production function so that it becomes more efficient (Udimal et al., 2017; Humaidi et al., 2019). Using new technology can be a way to increase the productivity or technical efficiency of garlic farming so that garlic self-sufficiency can be achieved. Policies that have so far relied on extensification in the form of area development or additional planting areas need to change their focus to intensification policies. This is because extensification is less relevant to the conditions of garlic farming in the field. The potential area for planting garlic is only 13,000 ha, while the planting area targeted to achieve self-sufficiency is 100,000 ha (Ministry of Agriculture, 2020).

Intensification of garlic farming in the form of using new technologies is increasingly important with the decrease in garlic productivity in the last five years. Indonesia's garlic productivity growth rate during the 2015-2019 period decreased by 3.48% (Ministry of Agriculture, 2020). One of the technologies that needs to be focused on to increase the productivity and efficiency of garlic farming is certified seeds. The use of certified seeds can provide various benefits such as:(Kabeakan 2017;Puspitasari 2017): (1) saves on the use of seeds, (2) is more responsive to fertilization and other agronomic treatments, (3) higher productivity, (4) guaranteed production quality, and (5) has resistance to pests and diseases. In addition, seeds have a significant influence in determining the technical efficiency and productivity of farming (Triyono et al., 2021).

The use of certified seeds is closely related to the socio-economic and institutional characteristics of farmers (Akudugu et al. 2012). These three categories can be further broken down into factors of education, age, gender, access to information, access to counseling, access to credit, net profit, and non-farming income (Udimal et al. 2017). Several studies have shown that these characteristics have a significant effect on the use of new technology (Noviyanti et al. 2020; Suprehatin 2019; Worku 2019; Ghimire et al. 2015; Burhansyah 2014). Thus, these characteristics need to be considered in the dissemination of new agricultural technologies.

Several previous studies regarding the effect of a program on technical efficiency (TE) still used the conventional approach formulated byAigner et al. (1977). Meanwhile, conventional methods produce two potential biases, namely observed and unobserved biases. Therefore, this study seeks to eliminate these two biases by combining the PSM and Sample Correction Stochastic Production Function (SC-SPF) methods so that the research results become more accurate. This research has never been done by other researchers. Several studies are similar to this study. For example, Baglan et al. (2020) examined the impact of using certified seeds on the technical efficiency of wheat farming in Kazakhstan; Mwangi, Ndirangu, and Isaboke (2020) examined the technical efficiency of small-scale tomato farming in Kenya; and Bravo-Ureta et al. (2020) examined the impact of irrigation projects on the technical efficiency of agriculture in the Philippines. This study established that the impact of using certified seeds on technical efficiency varied between commodities. Therefore, it is crucial to study how the utilization of certified seeds affects the technical effectiveness of garlic cultivation and at the same time eliminating the observed and unobserved biases so that the analysis results become more accurate.

RESEARCH METHODS

The data used in this study are secondary data in the form of cross-sections taken from the Central Bureau of Statistics' 2014 Horticultural Plant Household Survey (SHR 2014). Because the BPS will no longer conduct surveys in the next few years, this data is the most recently available. These data are widely used by academics and remain pertinent to the state of the world. A total of 251 garlic growers who planted their crops during the dry season comprised the sample of garlic growers. A total of 200 farmers elected not to use certified seeds, compared to 51 farmers who did. The number of samples is representative of the entire population because the number of samples is the same as the total population in SHR 2014.

By directly comparing the TE scores between the treatment and control groups, there is a chance of both observable and unobserved bias in the examination of the program's impact on technical efficiency (Bravo-Ureta et al., 2012; Greene, 2010). In this study, the observed bias was corrected using the propensity score matching (PSM) method, and the unobserved bias was corrected using the stochastic production frontier (SC-SPF) corrective sample model. The PSM approach can aid in minimizing the bias caused by the observed variables. Based on the similarity of the observed variables, each farmer in the treatment group in PSM had the best comparison with the control group (Khandker et al., 2010). The lowest difference in the propensity score (PS) demonstrated this similarity (Grotta and Bellocco, 2014; Khandker et al., 2010; Sianesi, 2001).

To calculate the propensity score (PS) for each farmer in this study, a probit binary choice model was used. Based on the observed variables, the PS value represents the likelihood that farmers use certified seeds (Khandker et al. 2010). Additionally, this work follows Baglan et al. (2020) and Harmini (2022), who created control groups with characteristics that are as comparable to the treatment group as possible using the "nearest neighbor matching" method estimated by the PSMATCH2-STATA package (Leuven and Sianesi, 2003). This method was employed because of its simplicity and clear interpretation (Rosenbaum and Rubin, 1983; Baglan et al., 2020). Using this method, each farmer in the treatment group was paired with a farmer in the control group, and farmers who did not fit the general support conditions were eliminated and excluded from the analysis. A matched sample is the outcome of this process and calculated using the PSMATCH2-STATA Package (Leuven and Sianesi, 2003). The average treatment effect on the treated (ATET) can be used to directly calculate the effect of using certified seeds on productivity and technical efficiency, presuming the bias associated with unobserved variables has been corrected (Villano et al. 2015;Bravo-Ureta et al. 2020; Harmini et al. 2022):

ATET = E(Y1 | D=1) – E(Y0 | D=0)……………………………………………………………..…………..(5)

Where Y1 and Y0 are the average values for the treatment and control groups. Meanwhile, D is a dummy variable where 1 is for the treatment group and 0 for the control group.

The SC-SPF Greene (2010) model is used to overcome unobserved bias in determining the production frontier of garlic farming. The Greene model is a nonlinear version of Heckman's (1979) model. In Greene's model, noise in the Stochastic Production Frontier is assumed linked to unobserved traits in the sample selection model. Greene (2010) takes into account the SPF framework's sample selection using these assumptions. The structure of the model is as follows:

sample selection:
di = 1[ά Zi + wi >0],wi N(0,1) …………………………………………………………..………… ….(6)

Stochastic frontier:
Yi = βXi + εiεi N(0,σ_ε^2), (Yi,Xi) is observed only when at = 1………………………….....………… ……(7)

Error structure:
εi = vi - ui…………………………………………………………………………..……………………..(8)

ui =σ_u | Ui | where is Ui N(0,1)
vi = Vi where Vi N(0,1)σ_v
(w_i, vi) N2 [(0,0), (1, ρσ_v,)]σ_v^2

Where Zi is the exogenous origin vector to explain the adoption of certified seeds, wi is the distributed term error N(0,), ά is the parameter vector to be observed, Yi is the farmer's garlic production (Kg), Xi is the input vector on the frontier production, β is the parameter vector to be estimated, and εi is error term.

Nevertheless, the Cobb-Douglas stochastic frontier production function was the type of function used in this investigation. This function was selected because it is frequently used in agricultural research, reduces the likelihood of multicollinearity, is homogeneous, has straightforward computations, and can be expressed as a linear function (Bravo-Ureta et al. 2020; Baglan et al. 2020; Ngango and Hong, 2021).The Cobb-Douglas model specifications are as follows (Ngango and Hong 2021;Harmini et al. 2022):

Ln(Yi) = β0 +$\sum \beta_j \ln X_{ij}$+ vi-ui ……………………………………………………………(9)

Where,
Yi : farmer's output to i
Xij : is input j from farmer to i
β : parameter to be estimated
ui and vi: elements of the composed error term.

The combined PSM and SPF processes were implemented using several variables. Table 1 provides the descriptions of these variables.

Table1. Description of variables used in PSM and SC-SPF

Variable	Notation	Definition/Unit
PSM Probit Model		
Gender dummy	Z1	Male farmers (1), female farmers (0)
Age	Z2	Year
Education	Z3	Did not finish elementary school (1), elementary school (2), junior high school (3), high school (4), D1/D2 (5), and D3 (6), D4/S1 (7)
Dummy participation of farmer groups	Z4	Participating in farmer groups (1), Not joining farmer groups (0)
OPT attack dummy	Z5	OPT attacks (1), No pest attacks (0)
Land type dummy	Z6	Paddy fields (1), non-paddy fields (0)
Dummy Planting Methods	Z7	Regular (1), irregular (0)
Climate change dummy	Z8	Extreme climate change (drought/flood) (1), No extreme climate change (0)
Dummy financing barriers	Z9	Difficulty obtaining financing (1), no difficulty obtaining financing (0)
Dummy marketing barriers	Z10	Difficulty in marketing results (1), no difficulty in marketing results (0).
Model SC-SPF		
Production	Y	Garlic production (Kg)
Seed	X1	Use of seeds (Kg)
Land area	X2	Garlic harvested area (m2)
Nitrogen Fertilizer (N)	X3	Fertilizer use N(Kg)
Phosphorus (P) Fertilizer	X4	Fertilizer use P(Kg)
Labor	X5	Employment of labor (HOK)

RESULT AND DISCUSSION

Farmers Descriptive Statistics . Matched data were corrected using PSM, and unmatched data were initial data that were not corrected. The number of farmers who used certified seeds before matching was 51 (unmatched data), whereas after matching it was 43 (matched data). Eight farmer samples were discarded because they did not meet general matching conditions (Bravo-Ureta, Higgins and Arslan, 2020). Most farmers who use certified and non-certified seeds are male. This is because women usually devote more time to working in the household than outside the home (Aida and Taridala, 2010). The average age of farmers who used certified seeds was 49 years, whereas farmers who did not use certified seeds were 50 years old (Table 2). This means that the average respondent farmer was old or approaching unproductive age. The older the farmer, the less physical and mental strength they have, as well as the desire to use certified seeds in garlic farming (Seran, Kapa and Pudjiastuti, 2020).

Table 2 Average characteristics of farmers using and not using certified garlic seeds

Variable	Unmatched samples			Matched samples		
	Certified	Not Certified	Diff	Certified	Not Certified	Diff
Gender	0.94	0.92	-0.03	0.98	0.92	-0.06
Age	49.57	50.38	0.81	49.55	50.38	0.82
Education	1.98	2.18	0.19	2.02	2.18	0.15
Participation of farmer group	0.29	0.45	0.15	0.27	0.45	0.18
OPT attack	0.45	0.50	0.05	0.49	0.50	0.01
Land type	0.73	0.25	-0.48	0.71	0.25	-0.46
Planting method	0.84	0.25	-0.60	0.84	0.25	-0.59
Climate change	0.37	0.54	0.18	0.35	0.54	1.91
Financing barriers	0.38	0.41	0.03	0.38	0.48	0.10
Marketing barriers	0.33	0.80	0.47	0.33	0.79	0.46
Seed (Kg)	52.72	30.01	-22.7	54.83	30.01	-24.8
Land area (m2)	1464.7	1505.31	40.6	1520.4	1505.31	-15.1
Fertilizer N (Kg)	31.72	16.92	-14.8	32.94	16.92	-16.0
Fertilizer P (Kg)	32.91	25.87	-7.04	34.07	25.87	-8.20
Labor (IDR000)	1846.2	1932.8	86.6	1897.5	1932.8	35.3
Number of observations	51	200		43	200	

Source: BPS 2014

The average education of farmers in the unmatched and matched data was also not different, namely for elementary school graduates (Table 2). This means that farmers' education is low enough to slow technology adoption (Sudjarmoko, 2016). Education is a key factor in the adoption of certified seeds (Baglan *et al.*, 2020). Meanwhile, Tadesse & Bahiigwa, (2015) stated that educational attainment facilitates technology adoption and causes farmers to become information sensitive.

Regarding production inputs, farmers who used certified seeds used more seeds than farmers who did not use certified seeds (Table 2). This is because farmers use regular planting methods such that their land use is optimal (Kuntariningsih and Mariyono, 2013). The land area of farmers who used certified seeds was not significantly different from that of farmers who did not use certified seeds. Farmers who use certified seeds use more fertilizer than farmers who do not use certified seeds. This cannot be attributed to farmers' decisions to use certified seeds because fertilizers are intended to fertilize plants with the nutrients they need (Baglan *et al.*, 2020). Labor costs incurred by farmers who use certified seeds are not significantly different from those incurred by farmers who do not use certified seeds. The average labor cost incurred by farmers is 1.8–1.9 million Rupiah.

Parameter Estimation of Sample Correction Stochastic Production Frontier (SC-SPF). In general, efficiency measurements use a stochastic production function (SPF) model. However, a weakness of this approach is its inability to explain the selection bias arising from unobserved sources. Therefore, this study used the SC-SPF Greene (2010) model to overcome unobserved bias in determining the garlic farming production frontier. However, the conventional SPF is still used to calculate technical efficiency in comparison with the calculation results using SC-SPF.

Table 4 parameter estimation for the conventional SPF and SC-SPF models

Variable	Conventional SPF						SC-SPF			
	Pooled		Certified		Not Certified		Certified		Not Certified	
	Coeef.	SE	Coeef.	SE	Coeef.	SE	Coeef.	SE	Coeef.	SE
Constant	2.45591***	0.34091	3.71807***	0.9293	2.43754***	0.3835	3.13740***	1.08772	2.17865***	0.39458
ln land	0.01798	0.04318	0.01689	0.06727	0.04004	0.05144	0.03608	0.08211	0.02508	0.05265
Ln Seed	0.53131***	0.03447	0.77612***	0.07689	0.46970***	0.04116	.74049***	0.1017	.48590***	0.04225
Ln Fertilizer N	0.00308	0.00367	0.01453	0.00932	0.0068	0.0049	0.01047	0.0106	0.005	0.00496
Ln Fertilizer P	0.00649*	0.00365	0.00882**	0.00403	0.00323	0.00514	0.00726**	0.00448	0.00484	0.00522
ln Labour	0.28167***	0.05347	-0.0276	0.1405	0.29374***	0.06129	0.10405	0.19193	.29827***	0.0626
Log-likelihood	-152.45		-15,446		-126.61		-73,231		-156.57	
Λ							1861		0.66604	
σ2	0.70219***	0.16211	0.44528	0.45046	0.9402***	0.17557				
σ(u)	0.08254		0.01985		0.13854		0.45128***	0.12154	0.28231	0.18444
σ(v)	0.16739		0.10008		0.15673		0.24250***	0.08935	.42387***	0.04695
ρ(w, v)							0.99310***	0.0798	0.09832	0.37237

Note: ***, **, and * are significant at the 1%, 5%, and 10% levels.

Table 3 presents the estimation results of the conventional SPF model using unmatched data or without the observed bias correction, and the SC-SPF model using matched data or with the observed bias correction. The log-likelihood estimation value shows that the SC-SPF model has better goodness of fit than the conventional SPF model. The inputs that have a significant effect on the amount of output produced by farmers who use or do not use certified seeds are phosphorus seeds and fertilizers. Both inputs had a significant effect on the level of garlic production in both conventional SPF and SC-SPF models.

Interestingly, the input of phosphorus fertilizer only had a significant effect on the garlic production level of farmers who used certified seeds in both the conventional SPF and SC-SPF models. These results are consistent with the findings of Baglan et al., (2020) that seeds and fertilizers are the main drivers of adoption. Harmini et al., (2022) showed that fertilizer input is an important factor in determining the increase in farm production. Certified seeds are more efficient at absorbing nutrients; therefore, the additional use of fertilizers increases production (Suharno, 2015). However, seeds that are not certified are less responsive to fertilization; therefore, the addition of fertilizer does not have a direct impact on increasing garlic production (Suharno, 2015).

In contrast, labor input only had a significant effect on the level of garlic production by farmers using certified seeds. Harmini et al., (2022) also showed that labor input has a significant effect on the production level of the control farmer group. The land area had no significant effect on garlic production. These results are consistent with other balancing factors that determine farmers' decisions to use certified seeds (Villano et al., 2015). This finding is inversely proportional to those of (Baglan et al., 2020; Ngango and Hong, 2021), which show that land area has a significant effect on the level of production.

The Effect of Using Certified Seeds on Productivity and Technical Efficiency. Table 4 presents a comparison of the average productivity of farmers who used certified seeds and those who did not. The results of the comparison using PSM show that there is a significant difference in the productivity of garlic farming among farmers who use and do not use certified seeds, both in the conventional SPF and SC-SPF models. The average garlic productivity of farmers using certified seeds was 9,358 kg/ha for the conventional SPF model and 9,355 kg/ha for SC-SPF. The average garlic productivity of farmers who did not use certified seeds was 7,758 kg/ha and 5, 518 kg/ha for the conventional SPF and SC-SPF models, respectively. Thus, there was a difference in garlic productivity between farmers who did and did not use certified seeds of 1,160 kg/ha and 3,836 kg/ha for conventional SPF and SC-SPF, respectively.

Table 4 TE frequency distribution and average productivity of farmers using and not using certified seeds in the Conventional SPF and SC-SPF models

TE score	SPF-Conventional				SC-SPF			
	Certified		Not-Certified		Certified		Not-Certified	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0 - < 0.5	0	0	3	1.5	5	11.63	0	0
0.5 - < 0.6	0	0	3	1.5	6	13.95	2	1
0.6 - < 0.7	0	0	42	21	7	16.28	3	1.5
0.7 - < 0.8	0	0	102	51	4	9.30	85	42.5
0.8 - < 0.9	31	60.78	49	24.5	18	41.86	109	54.5
0.9 – 1	20	39.22	1	0.5	3	6.98	1	0.5
Total	51	100	200	100	43	100	200	100
TE Score Min	0.815		0.325		0.364		0.539	
Max TE Score	0.932		0.906		0.923		0911	
Mean TE Score (ATET)	0.80		0.75		0.72		0.79	
Difference mean TE Score (ATET)			0.05***				-0.07***	
Average Productivity (kg/ha)	9358		7758		9355		5518	
Productivity Average Difference (kg/ha) (ATET)	1560***				3836***			

Note: ***, **, and * are significant at the 1%, 5%, and 10% levels

Bernard et al., (2016) stated that farmers using certified seeds tend to achieve higher yields (10–30%) because they use higher quality seeds. The underlying reason for this is that certified seeds have better quality and uniformity, resulting in higher production yields than seeds stored by farmers from their production. The results of this study are in line with those of Baglan et al., (2020), who found that farmers who used certified seeds produce 1661.7 kg/ha more than farmers who did not use certified seeds. Therefore, farmers who use certified seeds produce higher output. Likewise, several studies have shown that users of certified seeds have a higher total production (Villano et al., 2015; Baglan et al., 2020).

The average TE between farmers who use certified seeds and those who do not in the conventional SPF model is different from that in the SC-SPF model. In the conventional SPF, the average TE of farmers using certified seeds (80%) was greater and significantly different from that of farmers who did not use certified seeds (75%), with a difference of 5%. In contrast, in SC-SPF, the average TE of farmers using certified seeds (72%) was smaller and significantly different from that of farmers who did not use certified seeds (79%), with a difference of 7%. This demonstrates the potential bias in the conventional SPF model. This finding further proves the importance of bias correction using the SC-SPF model in combination with PSM (Ngango and Hong, 2021).

The average TE value of farmers who use certified seeds is smaller than that of farmers who do not use certified seeds in the SC-SPF model, indicating that the use of certified seeds has not been able to increase the technical efficiency of garlic farming. This result did not support the initial hypothesis that the use of certified seeds can increase the technical efficiency of garlic farming. Several factors were suspected to be the cause of this finding. First, the distribution of aid is not targeted. This is because the mechanism for distributing certified seed assistance is not accompanied by adequate supervision. The government fully surrendered the mechanism for distributing certified seed assistance to farmer groups and no further supervision was carried out (Heliaantoro and Juwana, 2018; Susilowati, 2018).

The distribution of seed assistance that is not within the target causes inefficient seed use. Farmers often use large amounts of seeds. Although the use of certified seeds should reduce the use of seeds, this is similar to the fertilizer subsidy policy, which encourages the excessive and inefficient use of fertilizers (overdose) (Elis, 2015). Aiding farmers with garlic seeds is necessary to encourage them to use certified seeds. However, assisting must be careful because assistance or subsidies tend to spoil farmers, and farmers will demand continuous assistance (Mayrowani, 2008).

A distribution that is not on a target can also cause fraud. The results of interviews with farmers and the agricultural service in West Nusa Tenggara, a garlic production center, show that some farmers resell government-assisted seeds. This is also due to the difficulty in obtaining certified garlic seeds and their relatively high price, which ranges from Rp. 53,000/kg – Rp. 55,000/kg; therefore, some farmers seek profit by reselling government-supported seeds (Suryana, Agustian and Yofa, 2016; Kiloes and Hardiyanto, 2019). This was also triggered by farmers who believed that production yields using their seeds were higher than those using certified seeds.

The second factor is related to the first because certified seeds purchased by farmers are of low quality or use imported seeds that are not suitable for planting in Indonesia. Farmers usually use imported garlic seeds from China because they are easier to find, the size of the bulbs is bigger, and the price is more affordable (Xena, Suminah and Wibowo, 2021). However, garlic seeds from China are unsuitable for cultivation in Indonesia. Garlic seeds imported from China will only produce small bulbs when planted in Indonesia, owing to unsuitable agro-climatic conditions.

Two options can be adopted by stakeholders based on the results of this study, which show that certified garlic seeds do not increase the technical efficiency of garlic farming. First, it advises farmers not to use certified seeds because the technical efficiency of using non-certified seeds is greater than that of using certified seeds. In addition, garlic seeds are relatively expensive, and it is difficult to obtain high-quality seeds; therefore, the production costs of using non-certified seeds are lower than those of certified seeds (Kiloes and Hardiyanto, 2019). Thus, government policies that have assisted certified garlic seeds are no longer relevant and should be replaced by other policies.

The first option was difficult to implement. Several studies have shown that the use of certified seeds can increase garlic farming productivity (Aldila et al., 2015; Kiloes et al., 2017; Raditya et al., 2015). This study also showed that the use of certified garlic seeds could increase the productivity of garlic farming. The second option is to improve the mechanism for distributing certified seed assistance and developing the seed industry (Heliaantoro and Juwana, 2018). Improvements in the mechanism for distributing and supervising certified garlic seed assistance must be carried out so that there are no frauds committed by farmer groups or farmers. The government needs to involve various parties in this case, namely field extension officers (PPL), local agricultural services, and other government components that can provide support for this policy. The government can adopt a mechanism for distributing subsidized fertilizer assistance, which has proven to be better.

The government also needs to develop the seed industry to make it easier for farmers to obtain certified seeds at affordable prices and with guaranteed quality (Kiloes and Hardiyanto, 2020). If the seed industry is inadequate, local garlic will not be able to compete with imported garlic, which is cheaper and of higher quality. This is fundamental because it is difficult for farmers to obtain certified garlic seeds at low prices. Even if there are certified garlic seeds at low prices, the quality of the seeds is very low, and the production results are not what farmers want. As long as the seed industry has not been developed and farmers still rely on certified seed assistance, the government needs to control the quality of certified garlic seeds distributed by farmers by fostering and fully supervising farmers who partner with the government in procuring certified garlic seeds. Moreover, all sample farmers use certified seeds that come from government assistance.

CONCLUSIONS

The average productivity of garlic farmers who use certified seeds is greater than that of farmers who do not use certified seeds. The average TE of farmers who use certified seeds is smaller than that of farmers who do not use certified seeds in the SC-SPF model. Thus, the use of certified seeds did not increase the technical efficiency of garlic farming. This was because the certified garlic seed assistance was not targeted because of the improper distribution mechanism of the seed assistance and the low quality of the seeds. There are two alternative policies that the government can implement: urging farmers not to use certified seeds, stopping assistance with certified garlic seeds, or improving the distribution and control mechanism for certified seeds accompanied by the development of the seed industry. Future research is expected to use the stochastic metafrontier method because there are technological differences between farmers who use and do not use certified seeds. By using this method, the research results will be more accurate. Further research is also recommended using the latest data.

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