THE IMPACT OF AGRICULTURAL INSTITUTIONS IN PRODUCTION RISK OF TURMERIC FARMING: A TWO-STAGE RISK FUNCTION ANALYSIS IN INDONESIA

Tutik Anggiyanti[1*], Anna Fariyanti[2], Nunung Kusnadi[2]

[1]Magister Program of Agribusiness, Faculty of Economics and Management, IPB University
Jl. Kamper, Campus of IPB Dramaga Bogor 16680, Indonesia
[2]Department of Agribusiness, Faculty of Economics and Management, IPB University
Jl. Kamper, Campus of IPB Dramaga Bogor 16680, Indonesia

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Abstract

Background: Turmeric has strong potential to drive economic growth; however, turmeric farming in Indonesia still faces various constraints affecting production and productivity, particularly high production risk occurring from the pre-production to post-harvest stages, which may significantly reduce yields. Strengthening agricultural institutions is considered a potential solution for mitigating these risks.
Purpose: This study aims to analyze the effects of various forms of institutional arrangement partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), private firms, cooperatives, farmer groups, assistance-providing institutions, and financial institutions on the production risk of turmeric farming.
Design/methodology/approach: This study uses secondary data from the 2013 Agricultural Census, comprising 1,311 respondents, because it is the most recent dataset with accessible detailed farm-level institutional information required. The analysis employs a two-stage risk function analysis model with a log-linear mean production function, as follows:
Finding/Result: The estimation results reveal that assistance-providing institutions significantly reduce production risk. Conversely, business partnerships (partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), and private firms) and farmer groups were positively associated with production risk. Partnerships with village unit cooperatives (KUD), other cooperatives, and financial institutions show no statistically significant effect on production risk.
Conclusion: Institutional roles vary in influencing production risks. Institutions directly involved in the production process are the most effective in reducing risks. Assistance-providing institutions are the most effective in mitigating production risk because they directly support and participate in the production process.
Originality/value (State of the art): This study examines multiple types of agricultural institutions and finds that not all institutions are effective in reducing production risks. Some institutional forms are identified as risk-increasing factors.

Keywords: agricultural institutions, production function, production risk, turmeric farming, two-stage risk function analysis

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[*] Corresponding author:
Email: tutikanggiyanti05@gmail.com

INTRODUCTION

Turmeric (*Curcuma longa*) is a strategic commodity that plays an important role in driving economic growth, both at the national and global levels. This commodity not only serves as a source of income for farmers but also contributes to value creation through the development of downstream industries based on biopharmaceuticals, food, and cosmetics products. In addition, turmeric contributes to increasing exports and generating foreign exchange earnings. In 2023, Indonesia's turmeric exports reached US$8.5 million, accounting for approximately 2.6% of total global turmeric exports (Global Export, 2023).

Indonesia ranks third among global turmeric producers, after India and Myanmar. In 2023, Indonesian turmeric production reached 205,656.08 tons, the largest in the biopharmaceutical crop category in Indonesia (BPS, 2023). This is due to a combination of these factors. Agro-ecologically, turmeric is highly suitable for cultivation in various regions of Indonesia, such as Java, Sumatra, and Sulawesi, because of its tropical climate and fertile soil.

Furthermore, the demand for turmeric continues to increase in both domestic and international markets owing to its multifunctional use as a raw material in the food, beverage, traditional herbal medicine, cosmetics, and pharmaceutical industries. According to the BSIP (2024), domestic turmeric demand increases by 10–25% annually. Demand is typically highest around major holidays, such as Eid. According to Umroh and Hidayah (2021), the high demand for turmeric is also linked to increasing public awareness of a healthy, herbal-based lifestyle (back to nature).

Although turmeric ranks first in terms of production, its production and productivity in Indonesia have fluctuated over the past decade. Turmeric productivity in Indonesia has shown a negative trend of -8.9% from 2018 to 2023. In 2023, the average productivity declined to 24.7 tons per hectare, down from 26.1 tons per hectare in the previous year. Over the last ten years, the average productivity has been 23.3 tons per hectare; however, this figure remains significantly below the optimal productivity level of 30 tons per hectare. These fluctuations in turmeric productivity indicate the presence of production risks.

In 2019, there was a sharp decline in turmeric production due to the effects of a drier and more intense dry season in 2019 (Syakriah, 2019). This resulted in lighter rhizomes, and many plants were affected by wilt and leaf spot diseases. Turmeric farming is also faced with rhizome rot, a disease feared by farmers because it can cause a production decrease of up to 80% (Vinayarani & Prakash, 2018)30 PGPR and 20 endophytic bacteria were identified based on biochemical assays and 16S rDNA sequence analysis. The isolates were screened for antagonistic activity against Pythium aphanidermatum (Edson. In addition, attacks by parasitic nematodes such as *Meloidogyne spp., Pratylenchus spp., and Rotylenchulus reniformis* can damage roots and rhizomes, causing stunted growth, yellowing of leaves, rotting of rhizomes, and even plant death, leading to decreased production and crop failure. These risk factors significantly affect turmeric production.

Production risk occurs when adverse events affect agricultural activities and yields. Production risk stems from internal and external factors. Internal factors include the use of inappropriate inputs, while external factors stem from factors beyond the farmer's control, such as weather, pest and disease attacks, natural disasters, and other related factors (Harwood et al., 1999). Production risks in turmeric farming can occur at various stages of the production process. Turmeric farming activities include land preparation, planting, maintenance, harvesting, and post-harvest operations, each of which carries potential risks that can impact yields. In the Just and Pope risk model, production risk is divided into two components: the mean production function and the variance production function, where the inputs used affect the production output and contribute to the farmer's production risk. Some inputs can increase production risk (risk-increasing factors), whereas others can reduce it (risk-reducing factors) (Robinson & Barry, 1987).

In this situation, farmers must develop risk prevention and mitigation measures. Based on this, farmer participation in institutions is an important aspect that needs to be studied because it is a solution to overcome various obstacles faced by farmers, especially in the production process. According to Meilani *et al.* (2023), agricultural institutions are an integral part of the agribusiness system because they are needed as a supporting system in every agribusiness subsystem. Agricultural institutions can take the form of partnerships, cooperatives, farmer groups, and

other institutions that can support and assist farmers in running their farming businesses better.

Several studies have discussed how agricultural inputs can influence production risk (Azhara et al., 2025; Febrian et al., 2023; Putra et al., 2020; Solehah & Fariyanti, 2024). Furthermore, several studies have explored the influence of institutional types, such as partnerships, on production risk. Studies examining the influence of partnerships on both production and production risk include Abarghouei et al. (2020), Basri et al. (2024), Rondhi et al. (2020), and Ruml and Qaim (2020). However, research analyzing the influence of various institutional types simultaneously to determine their respective effects on production risk is limited. Furthermore, research analyzing the factors influencing production risk using a two-stage risk function analysis is limited.

Based on this, the present study addresses this gap by simultaneously analyzing various forms of institutional arrangements, such as partnerships with private enterprises, cooperatives, farmer groups, financial institutions, and others, as well as production inputs that are presumed to influence the production risk of turmeric farming. This analysis employs the two-stage risk function analysis developed by Asche and Tveteras (1999). Through collaboration between farmers and other institutions, the production risks faced by farmers can be shared and managed more effectively. In this context, farmers no longer bear risks individually but instead receive institutional support to address various production uncertainties.

This study addresses this research gap by simultaneously examining various agricultural institutions, including business partnerships, cooperative partnerships, assistance-providing institutions, farmer groups, and financial institutions. This approach allows for the identification of institutional types that influence production risk reduction in turmeric farming in Indonesia while simultaneously measuring the extent of each institution's influence on production risk. The analysis was conducted using a two-stage risk function model developed by Asche and Tveteras (1999), utilizing farm-level data from the 2013 Agricultural Census to identify institutional factors influencing turmeric production risk.

Based on the explanation above, this study hypothesizes that partnerships with business entities such as state-owned enterprises (SOEs), regionally owned enterprises (ROEs), and private firms, partnerships with village unit cooperatives (KUD) and other cooperatives, assistance-providing institutions, farmer groups, and financial institutions have an effect on reducing the production risk of turmeric farming. Based on this description, this study aims to analyze the effect of partnerships with business entities such as state-owned enterprises (SOEs), regionally owned enterprises (ROEs), and private firms, partnerships with village unit cooperatives (KUD) and other cooperatives, assistance-providing institutions, farmer groups, and financial institutions on the production risk of turmeric farming in Indonesia.

METHODS

The data used in this study are secondary data sourced from the results of the 2013 Agricultural Census for turmeric commodities obtained from the Indonesian Central Statistics Agency (BPS). The data used were obtained from the results of the ST2013-SHR.S survey, which covers farmers engaged in turmeric farming during the dry season (February–September 2013 and/or February–May 2014) and the rainy season (October 2013–January 2014). Based on this, the type of data used in this study is *cross-sectional* data. The dataset was selected because it provides comprehensive farm-level information on agricultural institutions required for this study. Although the 2023 Agricultural Census has been completed, the corresponding detailed microdata are not yet available. Therefore, the 2013 Agricultural Census remains the most suitable data source for this analysis.

The research data were obtained from the Central Statistics Agency (BPS) in the form of microdata from the 2013 Agricultural Census (ST2013-SHR.S). A selection process was then conducted for farming households cultivating turmeric. The analysis focused on five central turmeric production provinces: East Java, Central Java, West Java, North Sumatra, and West Sulawesi, which together contribute more than 84% of the national turmeric production. These regions were selected to obtain a more representative sample of the main turmeric-producing regions in Indonesia.

The data were also filtered to include only farmers with land areas of less than 1 ha. This filtering was carried out because the number of farmers with land areas above 1 ha was relatively small, potentially resulting in extreme observations (outliers) that could affect the stability of the model estimates. Furthermore, this restriction aimed to obtain a sample with more homogeneous farming characteristics so that the estimation results would reflect the conditions of the majority of turmeric farmers in Indonesia. After the selection process, data completeness checks and adjustments to the research variables were carried out, and data that met the criteria were used as the basis for analysis using a two-stage risk function model.

The data analysis in this study uses a model developed by Asche and Tveteras (1999), namely, the two-stage risk production function analysis, which is an empirical implementation of the production risk model developed by Just and Pope (1979). This approach separates the estimation of the production function and the production risk function, allowing for a more focused analysis of the factors that influence production levels and risk. This separation of estimates is necessary because, in the Just and Pope model, the presence of production risk is reflected in the form of heteroscedasticity in the production function, which causes production variance to be inconsistent, thus creating complexity in this estimation approach. Therefore, a two-stage risk function approach is used to separate the production function estimation from the risk function. In this approach, heteroscedasticity is not considered a problem to be eliminated but rather utilized as information to measure production risk through the residuals of the production function.

The first step in the estimation is to estimate the production function to obtain residual values that reflect the deviation between actual and expected production. These residuals represent production variations that cannot be explained by the input variables in this model. The production function estimation used in this study uses an average production function. The second estimation, production risk, is measured using the squared residuals from the first stage, which are then transformed into natural logarithms as proxies for production risk. Squared residuals were used to capture the magnitude of production variation, whereas logarithmic transformation was used to stabilize the variance and facilitate interpretation. These risk variables were regressed against the independent variables to identify the factors influencing production risk. Mathematically, the equations for the average production and risk functions are defined as follows:

The production function is estimated to determine the relationship between the independent variables (production inputs) and dependent variable (output). The model used is the mean production function in the natural logarithmic (Ln) form.

$$LnY = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \theta_4 LnX_{4i} + D_6 D_{1i} + u_i$$

The production risk function is measured using the squared residuals from the first stage (the production function) as a proxy for production variance. To stabilize the variance, the squared residuals were transformed into natural logarithmic (ln) form.

$$Ln\,(u^2) = \theta_0 + \theta_1 LnX_{1i} + \theta_2 LnX_{2i} + \theta_3 LnX_{3i} + \theta_4 LnX_{4i} + \theta_5 LnX_{5i} + \theta_6 D_{1i} + \theta_7 D_{2i} + \theta_8 D_{3i} + \theta_9 D_{4i} + \theta_{10} D_{5i} + \theta_{11} D_{6i}$$

Where: Y (actual turmeric productivity (kg/ha)); U^2 (proxy for production risk (kg/ha)); X_1 (labor (man-days/ha)); X_2 (turmeric seed usage (kg/ha)); X_3 (organic fertilizer usage (kg/ha)); X_4 (inorganic fertilizer usage (kg/ha)); X_5 (harvested area (ha)); D_1(planting season dummy variable (1 = rainy season, 0 = dry season)); D_2(partnership dummy variable 1 (partnerships with state-owned enterprises, regionally owned enterprises, and private firms, where 1 = engaged in partnership, 0 = not engaged)); D_3(partnership dummy variable 2 (partnerships with cooperatives/KUD)); D_4(assistance receipt dummy variable (1 = received assistance, 0 = did not receive assistance)); D_5(farmer group participation dummy variable (1 = participates in a farmer group, 0 = does not participate)); D_6(financial institution dummy variable (1 = obtained financing, 0 = did not obtain financing)); u_i(error term); and β and θ (coefficients).

Based on production risk theory, institutional theory, and previous empirical studies, this study proposes the following hypothesis: Various institutional forms, namely partnerships with state-owned enterprises (BUMN), regionally owned enterprises (BUMD), private businesses, partnerships with cooperatives (KUD) and other cooperatives, aid agencies, farmer groups, and financial institutions, influence the reduction of production risk in turmeric farming in Indonesia.

Figure 1 illustrates the systemic flow of the research, explaining that the frequency and low productivity of turmeric reflect the existence of production risks influenced by internal factors, such as the use of production inputs, as well as external factors, such as climate conditions, pest and disease attacks, and natural disasters. One effort that can be made to reduce these risks is through farmer participation in various forms of agricultural institutions that play a role in providing access to production inputs, financing, extension, information, technology, and technical assistance. Based on this framework, this study analyzes the influence of various forms of agricultural institutions on the production risks of turmeric farming using the two-stage risk function model developed by Asche and Tveteras (1999) to identify the institutional forms that play the most important role in influencing the production risks of turmeric farming in Indonesia.

RESULTS

Overview of Turmeric Farming in Indonesia

Turmeric farming in Indonesia is generally conducted on a small to medium scale and is spread across various regions, particularly on the islands of Java, Sumatra, and Sulawesi. Based on this, this study focused on five central turmeric-producing provinces: East Java, Central Java, West Java, North Sumatra, and South Sulawesi. Turmeric farming involves a series of production activities, including land preparation, cultivation, planting, plant maintenance, fertilization, pest and plant-disturbing organism control, harvesting, and product transportation.

Based on the research results, turmeric farming is carried out in different seasonal conditions, namely the rainy and dry seasons, so farmers face different agro-climatic conditions during the production process. The production process in turmeric farming involves a combination of production factors such as land area, labor, seeds, and organic and inorganic fertilizers. In practice, turmeric farmers use production inputs in varying amounts and intensities, depending on the scale of the farm, agroecological conditions, and farmer involvement in agricultural institutions.

The results show that the average production of farmers involved in institutional arrangements is 2,594 kg, which is significantly higher than that of farmers not involved in such arrangements (1, 301 kg). A similar pattern is observed in productivity, where farmers participating in institutional arrangements achieved a productivity of 19,694.91 kg/ha, while those not participating recorded only 14,824 kg/ha. These findings indicate that involvement in institutional arrangements has the potential to improve farming performance in terms of production output and productivity.

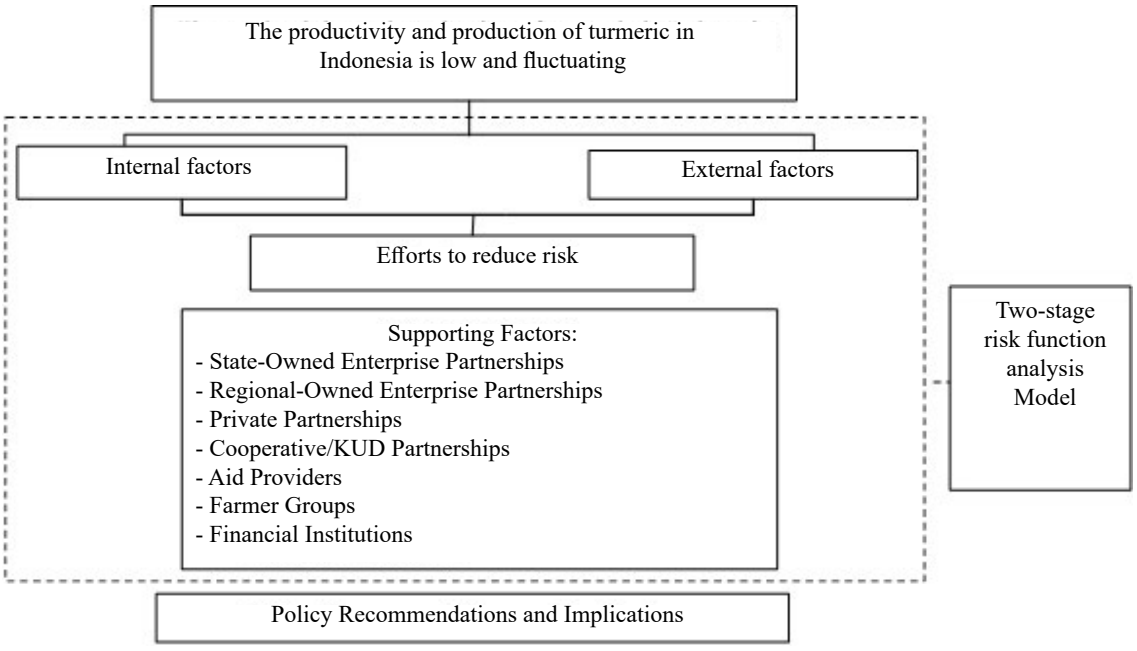

Figure 1. Research Framework

Turmeric farming in Indonesia follows a commercial pattern, where production is not only intended for household consumption but also to meet market demand. Turmeric is produced for sale through village unit cooperatives (KUD)/farmer cooperatives, collectors, markets, business partners, or other industries. Based on this, turmeric farming can be categorized as agribusiness or commercial farming.

As a commercially oriented agricultural enterprise, turmeric farming is inextricably linked to agricultural institutions. Farmer involvement in institutions, such as partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), private firms, cooperatives, assistance-providing institutions, farmer groups, and financial institutions, is crucial because it serves as a means to overcome the various limitations faced by individual farmers. Institutions provide access to both upstream and downstream resources, such as production inputs, financing, technical information, and a relatively broader and more structured marketing network than that of farmers operating independently.

The study found that all farmers participated in agricultural extension services. This indicates that access to information and technical assistance through extension services is relatively equitable among the farmers. High participation was also observed among aid-providing institutions, at 28.38% or 372 farmers. This suggests that farmers tend to be active in institutions that provide direct benefits in the form of input assistance, subsidies, or support for production facilities. At the next level, farmer participation in farmer groups and partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), and the private sector were relatively similar, at 14.72% and 14.95%, or 193 farmers and 196 farmers, respectively. Participation in farmer groups is generally driven by the need for coordination among farmers and access to government programs. Partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), and the private sector provide opportunities for market access, technology, and marketing guarantees, although not all farmers can participate because of certain requirements.

Participation in partnerships with cooperatives was recorded at 10,98%, (144 farmers). This indicates that cooperatives remain the primary institution supporting locally based institutional partnerships. According to Koib and Simamora (2022), cooperatives play a role in facilitating farmers access to inputs, providing capital, offering extension services, and serving as a marketing channel for agricultural products for their members. Meanwhile, the lowest level of participation was found in financial institutions, at 5.03% or 66 farmers. The low level of farmer participation in financial institutions is due to limited access to formal financial services, relatively strict administrative requirements, and farmers' concerns about credit risk and loan repayment obligations.

Overall, these results indicate that farmers tend to be more active in institutions that provide direct benefits, are easily accessible, and carry low risks, such as extension services and assistance agencies. Conversely, formal institutions with strict requirements or those involving financial risks tend to have lower participation rates.

Respondent Farmer Characteristics

The farmer characteristics in this study consisted of socio-demographic characteristics, including age, gender, and education level of the farmer. Farming characteristics included land area, ownership status, and type of seed used. The average age of turmeric farmers is 42 years, meaning that the majority are still within their productive farming age. The average number of turmeric farmers is 1,169 men, while only 143 are female. The educational level of turmeric farmers in Indonesia is still dominated by farmers with a primary school education, at 55% (717 farmers).

The land area used for turmeric farming by respondents is dominated by farmers with relatively small-scale holdings, namely, less than 0.5 hectares. Although the average landholding is relatively small, almost all farmers cultivate turmeric on their own land, totaling 1,167 farmers, while the remainder cultivate turmeric on rented land. In their farming practices, turmeric farmers generally use seeds derived from their own propagation or non-certified seeds, with only 29 farmers using certified or high-quality seeds. According to Ojdowska et al. (2025), certified seeds consistently provide higher productivity and more stable yields than non-certified seeds.

The Effect of Institutions on the Production Risk of Turmeric Farming

The production risk function model used in this study is a two-step production risk function. The first analysis examines the factors influencing turmeric farming production in Indonesia using the Cobb-Douglas production function (Table 1).

Based on the results of the study, the Return to Scale (RTS) value is 1,044 (> 1). This indicates that turmeric farming operates under increasing returns to scale. The prob > F value of 0.000 implies that the regression model is jointly significant at the 1% significance level. The R-squared value of 0.637 indicates that 63.7% of the variation in turmeric production can be explained by the independent variables included in the model, while the remaining 36.3% is explained by other factors outside the model, such as weather conditions, pest and disease attacks, and other external factors not included in the analysis.

The labor variable has a positive coefficient of 0.280 and is statistically significant at the 1% level. This indicates that an increase in labor use can enhance the effectiveness of crop management, thereby leading to higher yields. Turmeric cultivation is labor-intensive, making labor a crucial factor in the production process. Jusman et al. (2023) show that labor is a positive and significant production factor, as it plays an important role in determining the level of output. According to Leovita and Martadona (2021), labor can improve productivity when supported by adequate knowledge and technical skills, enabling farmers to apply these skills effectively in their farming practices.

Seed also had a positive and significant effect on turmeric production, with a coefficient of 0.335 at the 1% significance level. This indicates that seeds are the most responsive variable affecting turmeric production, as successful cultivation begins with the use of high-quality seeds in appropriate quantities. The use of high-quality seeds enhances plant growth and productivity, thereby directly contributing to increased output. According to Azhara et al. (2025) and Pohan et al. (2025), seeds are a highly responsive production factor and play a substantial role in increasing production when used appropriately.

The organic fertilizers used in this study included manure and compost. The use of organic fertilizer had a positive coefficient of 0.021 but did not significantly affect turmeric production. This indicates that the application of organic fertilizers has not yet made a substantial contribution to increasing production, which may be related to differences in dosage, quality, and application methods used by the farmers. According to Azhara et al. (2025), the use of organic fertilizers must be properly adjusted to meet crop requirements in terms of quantity and timing. The effect of organic fertilizers on production is not immediate but rather requires a relatively long period to optimally improve soil fertility (Boru, 2025). This contrasts with inorganic fertilizers, whose nutrients are more readily available and can be directly absorbed by the plants.

The inorganic fertilizer variable has a coefficient of 0.244 and is statistically significant at the 1% level. This finding indicates that nutrient fulfillment through inorganic fertilizers remains an important factor in supporting turmeric plant growth and yield. In this study, inorganic fertilizers included a combination of urea, triple superphosphate (TSP), ZA, KCl, and NPK. These fertilizers play a role in supplying essential macronutrients, such as nitrogen, phosphorus, potassium, and others, which are crucial for supporting vegetative growth, root formation, and rhizome development in turmeric. According to Saptana et al.(2016), inorganic fertilizers provide essential nutrients required for vegetative growth and rhizome development.

The planting season variable, where 1 represents the rainy season and 0 represents the dry season, had a positive and significant effect on turmeric production, with a coefficient of 0.177 at the 1% significance level. This indicates that turmeric production tends to be higher during the rainy season than during the dry season. This is because turmeric, as a rhizome crop, requires sufficient water during vegetative growth and rhizome formation. According to Simarmata (2025), rhizome crops require adequate water for optimal growth and development.

After analyzing the production function, the next step is to analyze the production risk function. This study aimed to examine the effects of various institutional groups, production inputs, and other factors on the production risk of turmeric farming in Indonesia. Table 2 presents the estimation results of the production risk function for turmeric farming in the study area.

Table 1. Estimated coefficients of the Cobb–Douglas production function for turmeric farming in Indonesia

Variables	Coefficient	Std. Error	t
Labor	0.285***	0.029	0.000
Seeds	0.334***	0.019	0.000
Organic Fertilizer	0.020	0.018	0.264
Inrganic Fertilizer	0.244***	0.021	0.000
Planting Season	0.160***	0.032	0.000

***) Signicant at α=1%

Table 2. Estimated coefficients of the production risk function for turmeric farming in Indonesia

Variable	Coefficient	Std. Error	z
Labor	0.392***	0.134	0.003
Seed	-0.594***	0.080	0.000
Organic fertilizer	0.375***	0.076	0.000
Inorganic fertilizer	-0.165*	0.092	0.074
Planting season	-0.812***	0.138	0.000
Land area	-0.136*	0.081	0.095
Partnership 1 (SOEs, ROEs, and private firms)	0.340*	0.183	0.071
Partnership 2 (cooperatives)	-0.168	0.210	0.424
Assistance institutions	-0.360	0.146	0.014
Farmer group membership	0.384	0.196	0.051
Financial institutions	0.372	0.317	0.240

***) Signicant at α=1%, **) Signicant at α=5%, *) Signicant at α=10%

Based on the estimation results, labor has a positive and significant effect on production risk, with a coefficient of 0.392 at the 1% significance level. This indicates that an increase in labor use tends to be associated with greater variability in production outcomes, which, in turn, increases the production risk faced by farmers (risk-inducing factor). This may be due to the relatively low education level of the workforce, often dominated by elementary school graduates, potentially impacting their ability to implement appropriate cultivation techniques. Furthermore, farmers often rely on family labor or unskilled workers to meet their labor needs. According to Mutisari and Meitasari (2019), labor utilization must be proportional; otherwise, excessive or inappropriate labor allocation can increase risks in agricultural activities.

The results of the production risk function analysis indicate that the seed variable has a significant effect at the 1% level, with a negative coefficient of −0.594. This finding suggests that seeds act as risk-reducing factors. The use of high-quality seeds that comply with recommended technical guidelines can promote the growth of plants that are more resistant to pests and diseases, thereby reducing production risks in agriculture. This result is consistent with the findings of Azhara et al. (2025) and Simarmata (2025), who stated that the use of appropriate and standardized seeds plays an important role in reducing production risk, particularly by ensuring optimal growth during the early stages of planting.

The organic fertilizer variable has a positive and significant effect on production risk, with a coefficient of 0,375 at the 1% significance level. This result indicates that an increase in the use of organic fertilizers tends to increase production variability (risk factor). On average, turmeric farmers applied organic fertilizers at a rate of 1.202 kg/ha, consisting of a combination of compost and manure. However, there are concerns that these fertilizers may adversely affect crops if applied directly. According to Basri et al. (2024), manure contains methane compounds that can cause plant wilting if applied directly. In addition, organic fertilizers have a slow-release nutrient characteristic, meaning that plant responses are not immediate, which may lead to uncertainty in production outcomes in the short term. This finding is in line with that of Febrian et al. (2023), who reported that organic fertilizers can increase production risk when applied excessively or not in accordance with standard operating procedures (SOP).

The inorganic fertilizer variable has a negative and statistically significant coefficient at the 10% level, with a value of −0.165. This result indicates that the use of inorganic fertilizers significantly reduces the production risk of turmeric farming in Indonesia. The average application of inorganic fertilizers in this study was 699 kg/ha. These findings are consistent with those of Mutisari and Meitasari (2019) and Solehah and Fariyanti (2024) (2024), who stated that inorganic fertilizers can reduce production risk (risk-reducing factors).

The planting season variable shows a negative and significant effect on production risk, with a coefficient of −0.812 at the 1% significance level. This result indicates that turmeric farming conducted during the rainy season (dummy = 1) tends to have a lower production risk than that in the dry season. This finding is consistent with the study's hypothesis. Turmeric plants require sufficient water during the planting period to support their growth and optimal rhizome development. Conversely, cultivation during the dry season can cause wilting or even crop failure, resulting in underdeveloped rhizomes and stunted plant growth. These findings are in line with those of Astuti et al. (2019) and Simarmata (2025), who reported that shallot and ginger cultivation during the dry season faces higher production risks than that during the rainy season.

The variable harvested land area shows a negative and statistically significant effect at the 10% level, with a coefficient of −0.136. This indicates that an increase in land area tends to reduce the production risk in turmeric cultivation (risk-reducing factor). Larger farm sizes allow production risk to be distributed across only a portion of the land, rather than affecting the entire crop. In addition, larger areas generally exhibit greater agroecological diversity, such as variations in soil type, moisture levels, and drainage conditions, so that not all parts of the land are equally affected by risks arising from weather disturbances or pests. This finding is supported by Parre et al. (2024), who showed that diversification can reduce production risks in agricultural activities.

Further production risk function estimation results indicate that partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), and private firms have a positive and statistically significant effect, with a coefficient of 0.340 at the 10% significance level. This implies that while these partnerships are expected to reduce risk by improving access to inputs and markets, they do not always reduce production risk. According to Bellemare et al. (2018), the impact of partnerships varies significantly depending on the type of partnership, commodity, and farmer conditions; therefore, the effects are context-specific and do not always directly impact the production process. This suggests that partnerships with business entities do not always focus on mitigating production risk, implying that production decisions and associated risks remain largely borne by the farmers themselves. Furthermore, Xena et al. (2021) note that risks in partnerships often arise from farmers non-compliance with established rules or agreements, as well as from inadequate input support provided by companies despite the imposition of high-quality standards for harvested outputs.

Institutions providing assistance to farmers show a negative and statistically significant effect at the 5% level, with a coefficient of −0.360. This result indicates that farmers who receive assistance tend to face lower production risk than those who do not, implying that such assistance acts as a risk-reducing factor in turmeric cultivation. A total of 372 farmers received assistance from government and non-government institutions in the form of production inputs (seeds, fertilizers, and pesticides), agricultural machinery and equipment, business financing, and extension services. This finding is supported by Liu et al. (2024), who reported that agricultural assistance reduces production risk and increases production efficiency.

Farmer group membership has a positive and statistically significant effect on turmeric production risk at the 10% significance level, with a coefficient value of 0.384. This finding indicates that the existence of farmer groups does not always reduce production risk; under certain conditions, it can be associated with increased production risk. Existing farmer groups do not focus on a single commodity, including turmeric, but rather encompass a wide range of farming activities. Consequently, information dissemination and technology implementation tend to be less specific and less optimal for each commodity. Furthermore, not all farmers can comply with the recommendations provided by farmer groups due to limited knowledge, skills, and available resources.

Financial institutions show a positive but statistically insignificant effect, with a coefficient of 0.372. This result suggests that access to credit from financial institutions tends to reduce production risk; however, the effect is not statistically significant. In this study, credit refers to loans from banks, cooperatives, other institutions, or individuals, all of which involve interest-bearing arrangements. This finding is consistent with Ndegwa et al. (2024), who stated that access to credit does not always significantly affect agricultural output or production risk. This is because agricultural output is inherently uncertain and is heavily influenced by external factors that cannot be controlled solely through financial access. Furthermore, credit does not directly determine success, as its effectiveness depends on how farmers utilize the loan funds.

Managerial Implications

The managerial implications of these findings suggest that agricultural institutions should play a more active role in managing and mitigating production risks, particularly during the production phase of turmeric cultivation. This can be achieved through improved access to inputs, capital support, the supply of production facilities and infrastructure, and the delivery of continuous technical guidance. Farmers should also be encouraged to participate more actively in institutional arrangements, adhere to operational standards, and effectively utilize the facilities provided to improve agricultural performance and mitigate production risks.

Policymakers should prioritize strengthening support institutions, as these institutions have been shown to significantly reduce production risks through their direct involvement in agricultural processes. Expanding technical assistance, extension services, production input support, and farmer training is expected to improve farmers' capacity to manage production risks. Conversely, the positive relationship between business partnerships, farmer groups, and production risks highlights the need to evaluate and improve the effectiveness of these institutional arrangements. Therefore, policymakers should focus on improving institutional performance and ensuring that agricultural support programs are effectively implemented to enhance turmeric farming sustainability and resilience.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The institutional arrangements that significantly reduce production risk in turmeric farming are those directly involved in the production process, particularly institutions that provide assistance to turmeric farmers. In contrast, institutional forms such as partnerships with state-owned enterprises (SOEs), regionally owned enterprises (ROEs), private firms, and farmer groups increase production risk. Meanwhile, partnerships with cooperatives and financial institutions do not have a statistically significant effect on the level of production risk in turmeric farming in Indonesia.

Recommendations

Based on the findings of this study, it is recommended that farmers use production inputs appropriately and in accordance with their actual needs. Farmers should also enhance their capacity and professionalism in managing their farming activities, particularly in the use of production inputs and risk management. Various institutions need to strengthen their roles in interacting with and supporting turmeric farmers, especially in terms of production. Institutions are expected to function as organizational platforms or marketing facilitators and actively support production activities through the provision of appropriate inputs, technical assistance, and the application of suitable technologies. Furthermore, institutions should play a role in managing the production risks faced by farmers by providing information, pest and disease control measures, and more adaptive cultivation practices in response to uncertainty. The government is expected to strengthen institutional roles through policies that support capacity building, particularly in production. In addition, the government should monitor and evaluate institutional performance to ensure its optimal function in supporting farming activities. Future research is recommended to develop more in-depth analyses of the role of institutions in farming, particularly by distinguishing institutional functions more specifically, such as in production, marketing, and financing, so that the most effective institutional forms in supporting farming activities and managing risk can be more clearly identified.

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