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Production risk assessment: evidence from cauliflower growers of Mymensingh district in Bangladesh

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ABSTRACT

Risk and inefficiency are crucial elements that affect farmers' decisions about farm management, investment and production. A total of 80 farmers were selected from Mymensingh district of Bangladesh using purposive random sampling method. This study uses a stochastic frontier model with a risk and an inefficiency function to evaluate the production risk and inefficiency of cauliflower farmers in Bangladesh. Study showed that significant production risk exists in Cauliflower farming. The results also reveal that seed and irrigation cost have positive and significant effect on cauliflower farming. Furthermore, using more seed and fertilizer increase the risk, although the size of the farm has the opposite impact. Education and training have a positive impact and boosts farm efficiency. It is advised that more technical skill on the best inputs usage, education and training be provided to the farmers in order to reduce risk and boost efficiency.

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1. Introduction

Inherently agriculture is risky and agricultural businesses run in a risky condition (Tama *et al.* 2021). The price and yield variability of agricultural products, numerous natural disasters, defective input/output economies, the lack of financial facilities and a constrained layout of risk management instruments, such as insurance and credit are the main causes of increased agricultural risks (Adnan *et al.* 2020). Production risk is one of the main risk's farmers encounters (Adnan *et al.* 2021). Sadly, farmers have neglected the production related risks that occurred in an affluent income variation (Woo *et al.* 2020). Management practices adoption and variation in input use by the farmers may cause risk (FAOSTAT 2019). Consequently, risk management and input management techniques are crucial for ensuring the best possible output. Inefficient utilization of inputs might result from production factors which are linked to risk. Due to inefficiency, the need for management expertise, institutional infrastructure, and production heterogeneity, there is a significant opportunity for more effective use of farming inputs and efficiency gains, which are essential in a country with limited resources like Bangladesh. In Bangladesh, cauliflower (Brassicaoleracea L. var. botrytis) is the most extensively grown vegetable, occupying 56426 acres of land and producing 342306 metric tons in total (BBS 2022). It is a high-value, 60–70 day-short rabi crop that yields an early return. In Bangladesh, cauliflower production is rising steadily. Cauliflower accounts for a significant portion of the overall planted area and production among all the vegetables grown in the country (Sharmin *et al.* 2018). "It has high nutritional value because of its low-calorie content and high content of fatty acids, fiber, and vitamins such as B, C, E, and A nutrients including Mg, P, Mn and" Fe (Kapusta-Duch *et al.* 2019, Ibraheem *et al.* 2022). This vegetable also includes numerous beneficial and healthful plant metabolites including as flavonoids, S-methylcysteine sulfoxide, coumarins, terpenes, sulfur-containing glucosinolates and other small molecules. These substances from cauliflower and other Brassica vegetables have been found to be powerful cancer-fighting agents (Miah *et al.*, 2018) which enhanced the need for its consumption and in more recent years, has sparked the interest and expansion of its production among many farmers and amateurs around the country (Ibraheem *et al.* 2022). A very small number of researches examined the production of vegetables and cauliflower in Bangladesh and overseas.

In particular, Begum *et al.* (2023) evaluated the occurrence of significant production risk of bean farming in Bangladesh. Dahal *et al.* (2019) measured the technical efficiency of cauliflower production in Nepal. Hoque *et al.* (2019) conducted the sources of inefficiency and technical efficiency of brinjal and bottle gourd cultivation in Bangladesh. According to Yuliawati *et al.* (2018), semi-organic vegetable growing in Indonesia carries a higher risk than conventional vegetable production. A study on the efficiency and profitability of cabbage growing in Nigeria was undertaken by Abdulrahman *et al.* (2018).

The technical efficiency of tomato farming in Pakistan, was measured by Wahid *et al.* (2017). Rajendran *et al.* (2015) experimented the technical efficiency of the traditional vegetable cultivation in Tanzania. Rajendran (2014) conducted research on the technical efficiency of India's fruit and vegetable production. These research' findings were not consistent and they demonstrated that irrigation, labor, seed and fertilizer all had an impact on the technical efficiency of vegetable cultivation. Additionally, socioeconomic factors like farmer's age, level of education, farm size, variety of seedlings, and training services had a great impact on inefficiency. Despite the importance of measuring risk and inefficiency, no research has been conducted in Bangladesh to evaluate the production risk and inefficiency of cauliflower farming. Therefore, the primary goal of this research is to evaluate the production risk and the inefficiency of cauliflower farming in Bangladesh, which will highlight the influence of significant farm household features on such risk-related concerns from which policy makers can benefit and design excellent policies for growers dealing with the constantly changing environment (Huq *et al.* 2020).

2. Methodology

2.1. Study area, sampling technique and data collection

As study area, Mymensingh district was deliberately chosen, situated in the northern part of Bangladesh due to its abundance in cauliflower production along with other vegetables (Islam *et al.* 2020a). Randomly two cauliflower producing area, namely Mymensingh Sadar and Trishal upazila

Fig. 1. Location of the research area

was selected for farmer selection. With a thorough discussion of key informants and, Upazilla Agriculture Officer (UAO), 80 farmers were chosen using purposive random sampling techniques. Employing a well-structured interview schedule this study collected primary data in between January to April 2019 on different aspects of cauliflower farmers.

2.2. Analytical Methodology

2.2.1. Analysis of Production risk and inefficiency

Utilizing the stochastic frontier production (SFP) function, the productivity of cauliflower was measured. The SFP specification can be written as follows:

$$y_i = f(x_i; a) + v_i - u_i \quad \text{.............................} (1)$$

Where, yi indicate the output of the ith farm (i = 1, …, N), xi are the inputs applied by the ith farm (i = 1, …, N), α is the parameter that intimate the variations in output due to the change in inputs, vi illustrate the error term, and ui represent the inefficiency of the ith farm. The error term vi has a normal distribution and independent by the input level. Nevertheless, Just and Pope (1978) assert that this is a production risk if the error term is not distributed uniformly. A specification of production and a variance function were suggested by Just and Pope (1978). The Just and Pope model makes it possible to calculate how inputs will affect output and production risk.

The following are the production and variance functions:

$$y_i = f(x_i; a) + h(x_i - \beta)v_i \quad \text{.............................} (2)$$

where f (.) and h (.) are the respective symbols for the production function and variance function. Risk and a production function are coupled in equation (2). However, Kumbhakar (2002) stated that equation (2) might include inefficiency function to evaluate technical efficiency by taking into account probable effects of risk on efficiency estimates. Consequently, equation (2) was extended by adding an inefficiency function q (.) to equation (3):

$$y_i = f(x_i; a) + h(x_i - \beta)v_i - q(z; \gamma)u_i \quad \text{..............} (3)$$

where, q (z; γ) denotes how socioeconomic factors affect technical efficiency.

In consequence, model equation (3) necessitates the estimation of three functions: the mean, variance, and inefficiency functions. Mean and variance functions are evaluated with the Cobb-Douglas production function, but the inefficiency function is determined with the linear production function. Given the study's smaller sample size, the Cobb-Douglas production function rather than the translog production function is more suitable. Moreover, this model is still widely utilized due to its advantages in terms of analysis and interpretation (Begum *et al.* 2023).

The following is the empirical model for the mean production function:

$In\ [f(x; a)] = a_0 + \Sigma^{5i} = 1a_i\ ln\ X_i + \mu$ .... (4)

Where y is the harvested cauliflower yield, X_i is the production inputs, and is a half-normally distributed residual.

As described below, the variance function is:

$In\ [h(x; \beta)] = \beta_0 + \Sigma^{5i} = 1\beta_i\ ln\ X_i + \varepsilon$............. (5)

Finally, the following is how the inefficiency function q (z; γ) can be expressed:

$In\ [q\ (z; \gamma) = \gamma_0 + \Sigma^{5i} = 1\gamma_i\ ln\ X_i + v$................(6)

3. Results and Discussions

3.1 Summary statistics

Socioeconomic factors like education, age, training, and experience have a considerable impact on how productive, profitable, and diverse the production of vegetables is as well as how risky farming is for farmers (Modeste *et al.* 2018). The summary statistics table presents data from 80 Cauliflower farmers (Table 1).

Table 1. Summary statistics of cauliflower farmers

Variables	Mean	Standard deviation	Min	Max
Age (Years)	43.56	11.55	23	70
Male (Number)	3.21	1.08	2	7
Female (Number)	2.55	1.11	1	6
Earning Member (Number)	1.31	0.54	1	3
Education (Schooling years)	4.38	3.62	0	12
Family size (Number)	5.74	1.47	3	12
Farm size (Hectare)	0.23	0.23	0.04	2.02
Training (Days)	0.57	0.74	0	3
Experience (Years)	20.36	10.15	4	45
Extension service (Days)	1.35	1.49	0	5
Labor (Man-days)	144.40	51.57	53.33	284.05
Seed cost (Tk.)	15203.89	5430.02	1235	28068.18
Fertilizer (Kg)	.30	.10	0.02	0.56
Irrigation (Times)	18	9	3	44
Total output (Kg)	28877.47	7003.73	7410	40418.18
Annual return (Tk.)	300932.5	71751.39	134727.3	474240

On average, households consist of approximately 3.2 males and 2.6 females, with a total household size of around 5.7 members and there are typically 1.3 earning members per household. The average age of respondents is 43.6 years, and they have about 4.4 years of formal education. These farmers have been growing vegetables for an average of 20.4 years. The average farm size is small, at roughly 0.23 hectares. Labor input averages about 144 man- days, while irrigation events average 18.6 times. Training attendance is limited, with only 41.3% having received training and an average of 0.58 days attended.

In terms of production, the average total vegetable output is around 2,983 kgs. Costs associated with production include average labor costs of about 54,948 Taka (Bangladeshi currency), seed costs of 15,204 Taka, while the average return is significantly higher at 300,933 Taka annually, indicating overall profitability despite variation among households.

3.2 Measurement of production risk and technical inefficiency in cauliflower farming

The estimated production function of cauliflower is demonstrated in Table 2 and the associated coefficients along with the mean production function was also calculated. Calculated estimation of both the output as well as the exogenous variables involved in Cobb-Douglas production function are found to be mean-corrected and have been normalized by applying individual sample mean. Among the productive variables, the coefficients of farm size, seed and irrigation cost influence the production significantly.

According to model estimates, the associated coefficient of seed is appeared to be positive and found to be significant implying the fact that using more seed significantly increases the production. Since seed is considered to be one of the primary inputs of crop production, the potentiality of production also relies on the seed quality to a large extent. Moreover, using improved quality seed can enhance the production of small farm holders and contribute to reduce the malnutrition problem of poor countries (Rahman *et al.* 2022). Irrigation cost is found to be positive and has a significant effect on production which indicates more investment on irrigation significantly increases the production of cauliflower. Incorporating new and modern irrigation technology in agriculture can increase crop yield, income and also contribute in attaining food security (Adebayo *et al.* 2018). Bidzakin *et al.* (2018) in another study found out that farmers who spend more on irrigation technology are more productive and can earn more profit through increasing their yield. Additionally, farm size of production indicates negative and also statistically significant impact on the cultivation which implies that comparing the large farms; smaller farms are more productive. This is because small farm is easy to manage compared to large farm.

Table 2. Parameter of mean function and associated risk function for cauliflower

Variables of production function	Estimated coefficient	Standard error of estimate	P- value
Mean production function, f (x, z)			
In cost of labour	-0.0004	0.001	0.97
In required seed	0.464***	0.014	0.00
In fertilizer cost	0.015	0.020	0.43
In irrigation charge	0.086***	0.009	0.00
In cauliflower farming area	-0.049***	0.005	0.00
Constant	9.926***	0.101	0.00
Risk function estimation, h (x, z)			
In cost of labor	0.562	0.595	0.35
In required Seed	5.406***	1.300	0.00
In fertilizer cost	13.280***	4.364	0.00
In irrigation charge	-2.879	2.050	0.16
In cauliflower farming area	-15.986***	3.289	0.00
Constant	-115.834***	31.55	0.00
No. of Observation		80	

*** 1% significant, **5% significant, *10% significant.

Moreover, it is easy for the small farmers to implement new technological and institutional innovation in their farms which increase their productivity. Additionally, it is also found that as size of the farm increases; the output level per unit area of land declines (Noack & Larsen, 2019). In general, the analysis of mean indicates that using current technology, it is possible for the respondent farmers to increase their Cauliflower production by applying less resource more efficiently. In risk function estimation, the findings reveal that production variability is naturally affected through the variation in input use by the respondent farmers. The estimation finds that seed is among the risk increasing inputs used in cauliflower production. Unfortunately, this is happening because farmers stock more seeds to get more production and reluctant to maintain the authorized scientific density of seeds that's why, plants can't absorb the proper nutrients from the soil and didn't get proper space to grow which reduce the productivity and also responsible for increasing the production risk. Although the use of good quality seeds can reduce the risk of seed use to a large extent; many farmers around the world especially smallholders do not have access to good quality seeds (Kansiime *et al.* 2021). The results from Table 2 show that at 1% level of significant, fertilizer possesses risk-increasing consequences. That's because producers apply more fertilizers to get more return from their production and do not maintain the prescribed scientific amount of fertilizer. This unprescribed application of fertilizer may burn the plants which cause them to look dried out and unhealthy that not only declines the productivity but also enhance the production risk. When farmers over-fertilize or under-fertilize their crops because of their attitude to risk on fertilizer use; their production process is hampered severely (Begho *et al.* 2022).

Results also suggest that farm size has statistically risk-reducing effect as large farms are commercially operated and can use sufficient inputs during the production period whereas small farms cannot do the same due to capital constraint or liquidity problem. On the other hand, commercial banks have loans facilities but do not have access for the small-scale producers. Furthermore, liquidity problem is another issue for cauliflower farmers. Commercial farms are well managed also. Production variation is observed due to variation of farm size among the producers. Wu *et al.* (2021) revealed that more chemical fertilizers and also insecticides are applied by the small producers in the hope of more production than large farmers which is risky not only for their production but also for the environment.

Table 3 reports the estimated parameters of inefficiency function of cauliflower farm. We found expected sign for all variables but only age, education and training have significant effects on inefficiency. Technical Inefficiency (TIE) increasing effect of age is positive which indicates that if age increases then the inefficiency also increases because the young farmers are energetic and have the ability to cope with the situation than the older. Seok *et al.* (2018) found that in Korea farm efficiency. Continually decrease with the age of the farmers. Moreover, age also declines the learning capacity of farmers of new production methods (Liu *et al.* 2021). Additionally, education is a very important element which can reduce the related technical inefficiency of producers in the respective area to a large extent. Farmers who receive education have more knowledge and ability to reduce inefficiency. Furthermore, farmers who have lower education level, also have lower capability to adopt the new innovations of agricultural sector (Oduro-ofori, 2015). Hence, naturally a certain positive correlation prevails between education level and earning of farmers as expected, providing training

Table 3. Parameters of associated inefficiency function for cauliflower farms

Variable item	Coefficient of estimate	Standard error	P-value
Age of respondents	0.066*	0.040	0.10
Education level	-0.287**	0.150	0.05
Experience of respondents	-0.057	0.043	0.18
Training facilities	-2.610**	1.130	0.02
Extension Service	-0.845	1.117	0.44
Constant	-8.899***	2.459	0.00
Value of mean technical efficiency	0.97		

*** 1% significant, **5% significant, *10% significant (Ashraf & Qasim, 2019).

facility to farmers statistically has a significant impact on reducing the technical inefficiency of cauliflower production.

Naturally, farmers who receive more training on cauliflower farming indicating possession of adequate information about vegetable farming compared to non-receiver of training and also able to handle any difficult situation with the experience gained from the training program. Through training program farmers can develop their work quality, increase farm products and income. Wonde *et al.* (2022) found the positive effect of training facility on the productivity and income of the cauliflower producers.

4. Conclusion

With increasing demand; cauliflower production is gaining popularity in Bangladesh. This respective study estimates the risk and inefficiency associated with cauliflower production which will help the cauliflower farmers to take appropriate measures to avoid those risks and increase production. However, the cauliflower production increases with increasing irrigation cost and using more seeds in the farm. On the other hand, large farm size decreases the production of cauliflower as it is difficult to manage by the farmers. In case of risk function estimation, it is found that using seeds and fertilizers have risk increasing effect on production as they have to be used in prescribed and scientific way to get the maximum cauliflower production but the farm size has risk decreasing effect. This study also found that the absence of proper education and adequate training among the farmers of cauliflower make them inefficient. So, it is mandatory to impart them training and at least basic education about agriculture to increase their productivity. Additionally, quality seeds and fertilizers should be supplied by the government and other agencies in time and at reasonable price to encourage the farmers to produce cauliflower. As most of the farmers do not know about modern technology and face many risks in the production process, agriculture extension workers should be more cooperative in case of providing advice to cauliflower producers to reduce the risk and inefficiency. Since majority of the farmers do not keep any record of their agriculture production, data collected for the research were mainly based on their memorization. So, policy makers may consider this limitation before making future implications of this study.

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Author's contribution

Ratna Begum: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. Tamanna Yesmine:

Writing – original draft, Investigation, Review and editing. Sultana Parvin Mukta: review & editing.

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