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Research article

Role and impact of contract farming under various pricing standards: A case of Guyana's rice sector

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Abstract: Rice cultivation has played a pivotal role in Guyana's agricultural history, contributing significantly to both sustenance and economic prosperity for over two centuries. Accounting for 3.3% of the country's gross domestic product (GDP) and a substantial 20.5% of the agricultural GDP, the rice industry has faced challenges influenced by various global and domestic factors, impacting the productivity and profitability of rice farmers. One key influencing factor is contract farming, involving agreements between farmers and firms that outline production and marketing conditions for agricultural products. In Guyana's rice industry, contract farming is prevalent, but challenges such as unequal bargaining power and discrepancies in weights and prices persist. Notably, using two pricing standards, high-price and low-price, further complicates the understanding of contract farming's impact on rice cultivation. We delved into the role and impact of contract farming on rice cultivation in Guyana, with a specific focus on the Mahaica-Berbice and Essequibo Islands-West Demerara regions. In this study, conducted with 121 farmers using systematic sampling, we used profitability assessment, frequency distribution, and binary logistic regression analyses. The findings revealed that high-price contracts contributed to greater farmer profitability compared to low-price contracts. Despite this, low-price contracts persisted due to factors such as risk-sharing, access to credit, and fertilizers. Moreover, pricing standards influenced farmer behavior, with low-price contracts prompting crop diversification to supplement income. These insights underscored the significance of pricing standards in determining the effectiveness of contract farming and its impact on farmers'

livelihoods. Policymakers and stakeholders can leverage these findings to design more effective contract farming models, enhancing farmers' profitability and contributing to sustainable agricultural development. Furthermore, future research may explore the impact of farmers' organization membership on contract farming productivity, providing additional depth to our understanding of this crucial agricultural practice.

Keywords: contract farming; pricing standard; profitability; Guyana; rice farming

1. Introduction

For more than two centuries, rice cultivation has been a fundamental aspect of Guyana's agricultural landscape, acting as a primary staple and a substantial contributor to the nation's economy. Notably, the rice industry accounts for 3.3% of Guyana's gross domestic product (GDP) and a substantial 20.5% of the agricultural GDP [1,2]. Nevertheless, the industry's performance has been volatile, influenced by a combination of global and domestic factors that have limited the productivity and profitability of rice farmers [2].

One of the key factors affecting the rice industry's performance is contract farming. Contract farming involves verbal or written agreements between farmers and other firms, outlining specific production and marketing conditions for agricultural products [3]. In Guyana's rice industry, contract farming is widely practiced, but it faces several challenges, including unequal bargaining power and discrepancies in the weights and prices offered to farmers[4]. Additionally, the use of two pricing standards, high-price and low-price, further complicates the understanding of contract farming's impact on rice farming.

Despite the evident challenges, rice farmers persist in participating in contract farming, underscoring its crucial role in Guyana's rice sector. Therefore, a comprehensive investigation of the impact of contract farming is essential to clarify its significance and implications.

Extensive literature has thoroughly examined contract farming, indicating that adopting contract farming is well-documented in the value chains of high-value products within export contexts [5]. However, in grain value chains, the uptake of contractual arrangements is less common. This is attributed to the limited demand for high-quality grain products, hindering the emergence of a premium pricing structure [6]. Additionally, the extended shelf life of grains contributes to the practice of side selling, further impacting the feasibility of contract farming in the grain sector [7].

Furthermore, many studies have discussed the role and impact of contract farming. Empirical studies in developing countries offer diverse analyses regarding contract farming participation and its impact. Several authors found that contract farming participation improves farmers' income [8–10], while others document various challenges affecting its performance, such as high default rates, biased terms, delayed payments, cheating, and lack of compensation for crop failure [11].

Researchers [12–15] have explored its role as a risk-sharing mechanism and a source of secured markets [16]. Additionally, contracts have been recognized as a means to manage farmers' production and marketing risks [17,18].

Furthermore, contract farming has been acknowledged for reducing the insecurity of earnings from farming businesses, particularly benefiting risk-averse subsistence farmers [19–21]. Additionally, the literature indicates that contract farming plays a role in reducing post-harvest losses and easing

liquidity constraints [22,23].

The impact of contract farming, both positive and negative, has been widely explored. Positive impacts include improved income, access to modern inputs, and entry into remote markets [24–26]. Negative impacts, such as exploitative power dynamics and negative effects on farmers' income, have also been highlighted in specific contexts [19,27].

However, the general conclusion from the literature is that contract farming improves income. Even those who are critical of contract farming schemes generally agree that participation improves household income [27]. Furthermore, contract farming has been linked to reduced post-harvest losses, improved access to production inputs and credit, and enhanced farm-to-market linkages [18,19,24].

Despite the extensive research, a critical gap exists in the literature. While many studies have focused on the role of contract farming and its impact on profitability, little attention has been given to how contract terms, specifically pricing standards, affect the role and impact of contract farming. Pricing standards, representing the payment conditions farmers accept for their products [28], introduce different risks and rewards for farmers [29]. Examining farmers' decisions to participate in contract farming under varying pricing standards can show how their roles and impacts may differ.

This research seeks to bridge this gap by offering insights into the dynamics of contract farming under different pricing standards. It will conduct a comparative analysis of contract farming under low-price and high-price standards, with a specific focus on understanding the roles and impacts. By examining disparities in contract farming's profitability, role, and behavioral impact, this study seeks to address the two fundamental questions: How does contract farming's role differ under varying pricing standards? How does contract farming's impact differ under varying pricing standards?

The acquired insights will enrich academic knowledge and hold practical implications for enhancing smallholders' acceptance of contracts. Aligning contract terms and provisions with farmers' preferences [30] will be crucial for designing more effective and equitable contract arrangements, ultimately contributing to sustainable agricultural development.

1.1 Characteristics (attributes) of contract farming in Guyana's rice sector

Contract farming is a widespread practice in Guyana's rice industry, where the miller supplies fertilizer to the farmer without offering any managerial assistance or supervision. The contracts are typically informal oral agreements lasting for one growing season, which spans three to four months [4].

In Guyana, two pricing standards exist: The low-price and high-price standards. The miller decides which pricing standard to use and sets the selling prices of the farmer's paddies. Each mill utilizes only one pricing standard, leading to variations in the final price of paddies supplied by farmers.

Under the low-price standard, the selling price of paddy is determined by the percentage of "good paddies" after subtracting estimated foreign materials like straw, weed seeds, and empty grains from the total weight of paddies supplied. Although paddies are graded as Extra A (Premium), A, B, or C based on quality parameters, the grading has a limited impact on the selling price (Figure 1).

Conversely, under the high-price standard, the final price is solely based on the percentage of good paddies, with no consideration for the grading of paddies.

Contractual agreements are established before planting, where farmers and millers agree on the type, quantity, delivery date, method of delivery, and prices of fertilizers. Discussions also include aspects such as the planting area and expected harvest time. Depending on factors like farm size and their relationship with the mill, millers may provide loans to farmers.

While contract farmers are expected to supply all their paddies to the miller, they do retain the freedom to sell to multiple millers. Nevertheless, they are obligated to cover the cost of the fertilizer they receive and make the payment for the fertilizer after harvest [31]. Failure to meet this cost obligation may lead to the mill refusing to engage in future contracts with the farmer.

The harvested paddy is typically sold immediately after harvesting. This prompt sale is primarily due to the absence of storage facilities among rice farmers, making it impossible for them to keep their paddies for prolonged periods. Additionally, the selling price is determined by the miller. The price may be adjusted based on the percentage of "good paddies" or both the percentage and grade of paddies supplied, depending on the pricing standard.

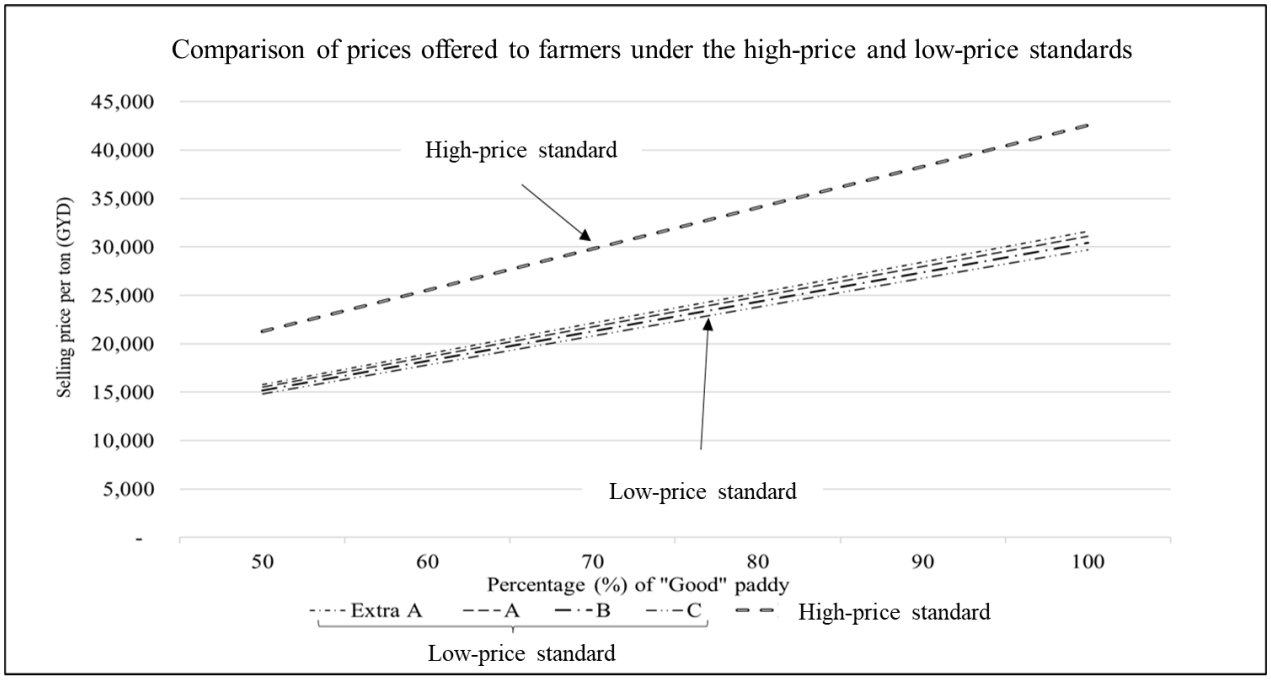

Figure 1. Comparison of the prices offered to farmers under the low-price and high-price standards.

Before determining the final payment, the miller deducts the cost of fertilizer and other services provided from the value of the "good" paddies supplied by the contract farmer. The payment for the paddy is usually made later.

It is essential to note that the selling price of farmers' paddy is published at the end of the growing season and is influenced by the miller's export price. This characteristic limits the ability of contract farming to serve as a hedge against market price fluctuations and effectively manage price risk for farmers.

Despite this limitation, contract farming offers distinct benefits to both rice farmers and millers. For farmers, it provides a means to share production risks with the miller, exempting them from reimbursing the miller for supplied fertilizer if natural disasters or pests compromise the crop. On the other hand, millers derive an advantage from a consistent paddy supply destined for sale to their buyers. This advantage arises because they are responsible for furnishing only the fertilizer than covering the cost of paddy production themselves.

2. Materials and methods

2.1. Study area

The study area, as illustrated in Figure 2, shows Guyana, which is positioned along the northern coast of South America. Its borders include Venezuela to the west, Suriname to the east, Brazil to the south, and the Atlantic Ocean to the north. The research focuses on specific regions within Guyana, particularly Mahaica-Berbice and Essequibo Islands-West Demerara, depicted in the map on the far right and second from the right, respectively.

Guyana boasts a tropical climate with modest temperature variations. The year is divided into two wet seasons: December to early February and late April to mid-August, featuring temperatures ranging from 16 °C to 34 °C. The conducive climate, characterized by warm temperatures and abundant rainfall, establishes an ideal environment for rice cultivation.

Covering a total land area of 214,999 km^2, Guyana has a population of 792,925 people. Rice farmland occupies 150,224 km^2 of the country's total land area, primarily on the thin strip of land along the low-lying coast bordering the Atlantic Ocean below sea level (2m). This land is relatively similar throughout, consisting almost entirely of heavy clay soil and depends on tidal flow for drainage. Approximately 15,933 farmers in cultivation. In 2016, Guyana's total paddy production reached 822,229 metric tons (mt), yielding about 5.5 tons per acre.

Guyana is the largest rice producer in the Caribbean Community (CARICOM) and one of the Caribbean's two rice-exporting countries. Over the years, rice exports have steadily increased, with the value rising from US $212,007,466 in 2016 to US $259,088,535 in 2020, reinforcing the importance of Guyana's rice industry in the national economy.

The key stakeholders in Guyana's rice supply chain include farmers, millers, and exporters, supported by various services from banks, microfinancing institutions, agricultural supply stores, and shipping companies. Government agencies like the Guyana Rice Development Board (GRDB) and the Guyana Rice Producers Association (GRPA) play crucial roles in providing seed distribution, quality assurance, extension, and monitoring services.

There are no active rice farmers' cooperatives, village-level farmers' groups, spot markets, or middlemen for farmers to market their paddy. Therefore, rice farmers must sell their paddy directly to mills, all of which are located in rural areas.

Building upon this backdrop, we focus on two historically significant regions—Mahaica-Berbice and Essequibo Islands-West Demerara—(Figure 2) renowned for their rich history of rice production. These areas have a long-standing tradition of rice cultivation, dating back to the early colonial era when rice was cultivated on sugar plantations to supplement the dietary needs of African slaves. Table 1 provides an overview of the rice industry in Guyana.

Mahaica-Berbice covers a land area of 4190 square kilometers and has a population of 49,723. Rice farming is the main economic activity of this region, followed by sugar and coconut farming and beef and dairy cattle ranching [32]. The region's rice farmland spans 49,196 hectares, cultivated by 1770 farmers. In 2016, Mahaica-Berbice contributed 201,980 tons to Guyana's total rice production, accounting for approximately 25% of the country's rice volume, with an average yield of around 5.3 tons per acre.

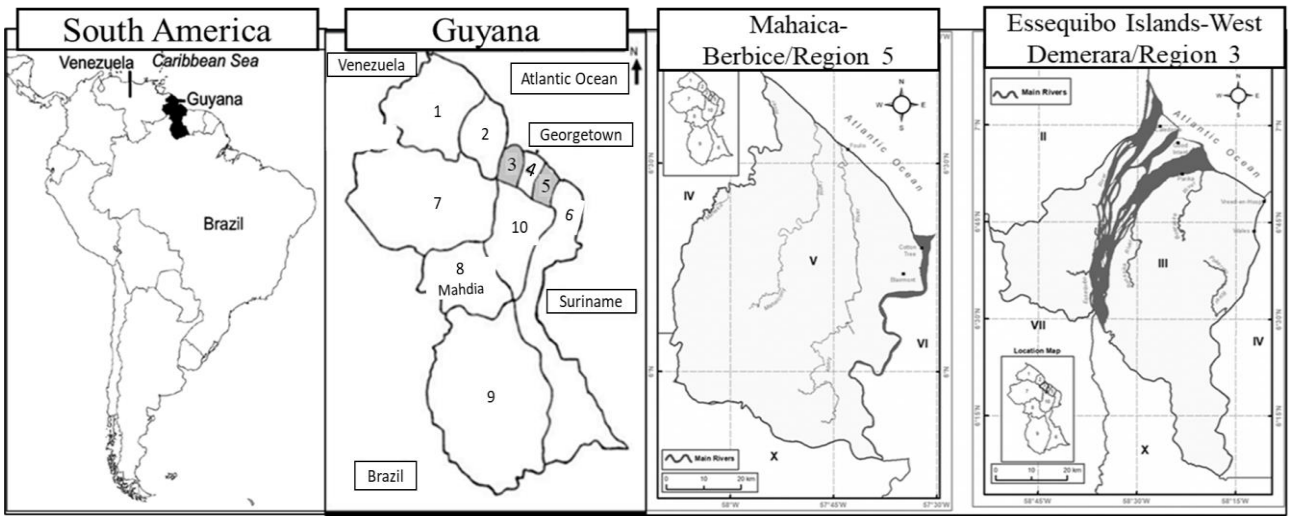

Figure 2. Map of the study area: South America, Guyana, Mahaica-Berbice, and Essequibo Islands-West Demerara.

Essequibo Islands-West Demerara encompasses a land area of 3770 square kilometers and is home to a population of 91,328. Essequibo Islands-West Demerara is traditionally a rice farming area with small amounts of sugar and coconut cultivation [31]. The region's rice farmland covers 16,465 hectares and involves 973 farmers. In 2016, Essequibo Islands-West Demerara contributed 60,319 tons to Guyana's total rice production, representing approximately 7% of the country's rice volume, with an average yield of about 4.7 tons per acre.

By focusing on these key rice-producing areas, the study aims to gain valuable insights into the dynamics of contract farming under low-price and high-price standards in Guyana's rice industry.

Table 1. Characteristics of the rice industry in Guyana, Mahaica-Berbice, and Essequibo Islands-West Demerara.

Description	Guyana	Mahaica-Berbice (High-price standard)	Essequibo Islands-West Demerara (Low-price standard)
Total land area (sq. km)	214,999	4190	3770
Total population	792,925	49,723	91,328
Total rice farmland (ha)	150,224	49,196	16,465
Number of rice farmers	15,933	1770	973
Total paddy production (tons)	822,229	201,980	60,319
% of Guyana's total volume of rice produced	-	25%	7%
Yield per acre (tons/ha)	~5.5	~5.3	~4.7

Note: ~: approximately. Source: The author collected.

2.2. Data collection

To gather primary data for this study, eight data collectors, who were trained agriculture extension officers attached to the Guyana Rice Development Board's research station, were employed. The data

collectors used the KoboToolbox online survey tool to collect information. The questionnaire, prepared by researchers in KoboToolbox, was designed to collect data on various aspects, including socioeconomic aspects, production costs, contract farming participation, and other relevant factors specific to the year 2021.

The systematic sampling method was employed to determine the number of farmers interviewed from each village within the study areas. This process involved a three-step process. Step 1 involved calculating the sample size, which was determined as 15% of the total number of farmers in Mahaica-Berbice and Essequibo Islands-West Demerara. In Step 2, the number of farmers in each village was converted into ratios relative to the total number of farmers in the respective study area. Last, in Step 3, the ratios calculated in Step 2 were applied to the sample size from Step 1. This final step determined the specific number of samples to be collected from each village, ensuring representation from various locations.

A total of 121 farmers were interviewed from 37 villages, with 91 farmers from Mahaica-Berbice and 30 farmers from Essequibo Islands-West Demerara.

2.3. Data analysis

Our aim of this study is to compare contract farming under the low-price and high-price standards to identify differences in profitability, role, and behavioral impact.

First, we conducted a comparison of the socio-economic characteristics of contract farmers under the low-price and high-price standards. This step was essential to identify potential differences between the two categories of contract farmers, as these differences could influence contract farming's profitability, role, and behavior.

Next, we performed a profitability analysis to assess the impact of pricing standards on contract farming. The gross margin was calculated using Equation 1, which subtracted the cost from the revenue.

$$\text{Revenue} - \text{Cost} = \text{Gross margin} \tag{1}$$

Revenue was determined using Equation 2, which considers the yield of paddy per acre and the selling price per ton.

$$\text{Yield (tons/acre)} \times \text{Selling price (GYD/ton)} = \text{Revenue (GYD/acre)} \tag{2}$$

The direct costs of paddy production, including direct labor, material, and transportation costs, were considered as the "cost." Fixed costs, such as depreciation, were treated as a separate line item in the income statement and not included in the cost analysis.

Following that, we conducted a frequency distribution analysis to understand the reasons for participating in contract farming and assess its role under different pricing standards.

Last, a binary logistic regression model was used to determine the impact of pricing standards on contract farmers' behavior, specifically their decision to engage in non-rice farm activities. This model, represented by Equation 3, allowed us to analyze binary dependent variables, where farmers were categorized as either "rice-only" farmers or those involved in non-rice farm activities.

$$Z_i = \ln\left[\frac{P(Y_i=1)}{1-P(Y_i=1)}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu \tag{3}$$

In this research, we model farmers' decisions to engage in non-rice farm activities using a utility function:

$$Z_i = \ln\left[\frac{P(Y_i=1)}{1-P(Y_i=1)}\right] \tag{4}$$

here, Z_i represents the natural logarithm of the odds ratio, indicating the likelihood of a farmer carrying out non-rice farm activities. The odds ratio is a measurement of association that compares the odds of an event of those exposed to the odds of an event in those unexposed. It serves to determine the relation between exposure and outcome [33]. The odds ratio is expressed as:

$$\frac{P(Y_i=1)}{1-P(Y_i=1)} \tag{5}$$

By applying the natural logarithm to both sides and incorporating the logistic function, we arrive at:

$$P(Y_i = 1) = \frac{e^{Z_i}}{(1+e^{Z_i})} \tag{6}$$

Substituting this back into the odds ratio expression simplifies it to. Consequently, the utility function becomes:

$$Z_i = \ln\left(e^{Z_i}\right) \tag{7}$$

Which further simplifies to:

$$Z_i = Z_i \tag{8}$$

This equation is then represented empirically as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu \tag{9}$$

here, Z_i is the natural logarithm of the odds ratio, β_0 ,β_1 ,β_2 ,β_3 ,β_4 ,β_5 and ,β_6 are regression coefficients of the independent variables X_1 ,X_2 ,X_3 ,X_4 ,X_5 and ,X_6 , respectively, capturing the factors influencing farmers' decisions and μ is the error term.

This empirical equation provides insights into the relationship between the odds of farmers engaging in non-rice farm activities and the specified independent variables.

The independent variables used in the regression analysis were pricing standards, years of experience, total land, number (no.) of family members, distance from the main town, and the percentage (%) of earnings from off-farm activities.

Pricing standard was used because different pricing standards may involve different risks and rewards for farmers, which can impact their behavior [29]. It has been demonstrated that experience play a significant role in explaining diversification that is, less experienced farmers are more specialized [34]. The likelihood of product diversification rises with farm size [35]. Additionally, farmers' family provides them with access to labor are more likely to diversify their operations [34]. The availability of markets for farmers' various products may be impacted by distance from the main town, affecting their choice to diversify production by engaging in non-rice farm activities [36]. Finally, farmers' willingness to diversify their farms may be influenced by off-farm income [37].

By employing these analytical methods and considering the relevant variables, we aim to gain a comprehensive understanding of contract farming under different pricing standards and its implications for farmers' profitability, role, and behavior in Guyana's rice industry. This will contribute to the existing literature on contract farming and provide valuable insights for policy formulation and agricultural development in the region [38,39].

3. Results

3.1. Socioeconomic characteristics of contract farmers

Table 2 presents a comparison of the socioeconomic characteristics of contract farmers operating under low-price and high-price standards. The analysis revealed significant differences between low-price and high-price standard contract farmers in various aspects. Low-price standard contract farmers tend to have more experience, with a mean of 30.43 years compared to 21.55 years for high-price standard contract farmers. Additionally, low-price standard contract farmers own smaller farms, with a mean of 34.10 acres, while high-price standard contract farmers operate larger farms, with a mean of 97.84 acres.

Table 2. Characteristics of the rice industry in Guyana, Mahaica-Berbice, and Essequibo Islands-West Demerara.

Variables	Contract farmers						
	Low-price standard n = 30			High-price standard n = 91			Sig
	Min	Max	Mean (Sd)	Min	Max	Mean	
Age (years)	25	74	47.4 (13.54)	21	69	46.12 (9.75)	
Years of education	7	17	11.43 (3.08)	1	19	12.47 (3.93)	
Years of experience	5	70	30.43 (16.98)	1	55	21.55 (11.44)	**
Total land (acre)	1	110	34.1 (31.51)	2	422	97.84 (78.75)	***
No. Tractor	0	3	0.63 (0.72)	0	5	1.34 (1.15)	***
No. of family members	0	5	2.33 (1.3)	0	10	1.41 (1.35)	***
No. of family laborers (persons)	0	2	0.5 (0.63)	0	4	0.57 (0.93)	
No. of Hired laborers (persons)	1	12	6.13 (2.42)	0	25	6.93 (5.14)	
Distance from the main town (miles)	2	75	64.23 (17.25)	1	115	42.39 (35.21)	***
Distance from the mill (miles)	1	5	1.53 (1.01)	1	14	4.56 (2.51)	***
Acre of vegetables	0	2	0.07 (0.37)	0	2	0.03 (0.23)	
Acre of fruits	0	5	0.2 (0.93)	0	0	0 (0)	
No. of poultry	0	140	18.07 (34.09)	0	4,000	52.2 (421.49)	
Heads of cattle	0	60	14.73 (18.55)	0	350	13.32 (52.87)	
% of earnings from off-farm activities	0	70	13.83 (20.12)	0	75	2.97 (12.89)	***
% of earnings from other crops	0	50	6.57 (11.72)	0	30	0.68 (3.82)	**
% of earnings from livestock	0	45	12.2 (12.92)	0	30	1.81 (5.2)	***
% of earnings from rice	5	100	67.63 (24.96)	28	100	96.35 (10.19)	***

Note: 1) ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively. 2) Total earnings = Earnings from off-farm activities + (Earnings from other crops + Earning from livestock + Earnings from rice). Source: The author collected.

Furthermore, low-price standard contract farmers own fewer tractors (mean of 0.63) compared to high-price standard contract farmers (mean of 1.34). Family size also differs, with low-price standard contract farmers having more family members (mean of 2.33) than high-price standard contract farmers (mean of 1.41).

Geographical factors also play a role, with low-price standard contract farmers living further from the main town (mean distance of 64.23 miles) compared to high-price standard contract farmers (mean

distance of 42.39 miles). However, low-price standard contract farmers live closer to the mill they supply (mean distance of 1.53 miles) than high-price standard contract farmers (mean distance of 4.56 miles).

Moreover, low-price standard contract farmers rely more on off-farm activities, other crops, and livestock for their household income. They earned 13.83% from off-farm activities, 6.57% from other crops, and 12.20% from livestock. In contrast, high-price standard contract farmers earned only 2.97% from off-farm activities, 0.68% from other crops, and 1.81% from livestock.

Last, low-price standard contract farmers earned significantly less from rice cultivation, with an average of 67.63% of their household earnings coming from rice compared to 96.35% for high-price standard contract farmers.

3.2. Comparison of contract farming profitability under low-price and high-price standards

To compare contract farming's profitability under the low-price and high-price price standards on, a profitability analysis was conducted, as shown in Table 3. The results indicate that low-price standard contract farmers were significantly less profitable than their high-price standard counterparts. The mean gross margin per acre for low-price standard contract farmers was GYD/ACRE 8,275, significantly lower than the GYD/ACRE 43,137 earned by high-price standard contract farmers.

Table 3. Characteristics of the rice industry in Guyana, Mahaica-Berbice, and Essequibo Islands-West Demerara.

Variables (GYD/ACRE/Acre)	Contract farmers		
	Low-price standard Mean (Sd)	High-price standard Mean (Sd)	Sig
Revenue	79,14 (21,100)	123,569 (17,382)	***
Total cost	70,86 (10,810)	80,432 (21,415)	**
Land preparation	1,818 (4,09)	13,827 (7,200)	***
Hired laborers	8,04 (1.595)	18,425 (9,401)	***
Seed	499 (224)	5,847 (3,294)	**
Fertilizer	13,500 (2.581)	23,538 (8,208)	***
Herbicide and pesticide	3,333 (307)	339 (1,293)	***
Harvest and transportation	15,330 (3,617)	8,224 (2,431)	***
Rent	7,127 (7,705)	8,445 (5,997)	
Other	350 (1,917)	786 (4,012)	**
Gross margin	8,275 (19,359)	3,137 (24,056)	***
Selling price per ton	29,940 (3,977)	41,886 (2,078)	***
Yield (ton/acre)	2.7 (0.7)	3 (0.4)	**

Note: 1) ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively. 2) GYD denotes the Guyanese Dollar. 1 GYD is equal to 0.0048 United States dollars. Source: The author collected.

This difference in profitability is attributed to lower revenue for low-price standard contract farmers. They earned a mean revenue of GYD/ACRE 79,137, significantly lower than high-price standard contract farmers' mean revenue of GYD/ACRE 123,569. This discrepancy is primarily due to the lower mean selling price and yield of low-price standard contract farmers.

The analysis further reveals that low-price standard contract farmers sold their paddies at a mean

price of GYD/ACRE 29,940, while high-price standard contract farmers sold them at a mean price of GYD/ACRE 41,886. Consequently, low-price standard contract farmers spent less on rice inputs, resulting in lower total cost per acre (mean of GYD/ACRE 70,862) compared to high-price standard contract farmers (mean of GYD/ACRE 80,432).

However, the lower yield of low-price standard contract farmers led to lower profitability. Additionally, specific costs, such as land preparation, harvest, transportation, herbicide, and pesticide costs, were significantly higher for low-price standard contract farmers compared to their high-price standard counterparts.

3.3. Role of contract farming under the high-price standard and low-price standard.

To understand the role of contract farming, interviews with farmers were conducted, and the reasons for participating in contract farming were analyzed (Table 4). Access to credit was a crucial factor for all contract farmers, with 100% of low-price standard contract farmers and 83.5% of high-price standard contract farmers indicating it as their reason for participating in contract farming.

High-price standard contract farmers also participated in contract farming to gain access to stable markets for their paddies (48.4%) and obtain loans (35.2%). Contract farming provides them with a guaranteed market for their paddies, reducing the risk of spoilage due to prolonged storage. Additionally, they can secure loans from their contract mill to invest in machinery and increase productivity.

Table 4. Comparison of the reasons for contracting under the high-price and low-price standards.

Reasons	High-price standard		Low-price standard	
	Frequency	%	Frequency	%
Access to credit	76	83.5	30	100.0
Access to stable markets	44	48.4	0	0.0
Access to loans	32	35.2	0	0.0
A good relationship with the mill	9	9.9	3	10.0
Advance payment for paddy	6	6.6	0	0.0
Assistance with Harvesting	5	5.5	0	0.0
Recommended by other farmers	5	5.5	4	13.3
Access to better varieties	1	1.1	0	0.0
Access to machinery and equipment	1	1.1	1	3.3
Assistance with transportation	1	1.1	0	0.0
Higher paddy prices	1	1.1	0	0.0
Contract organization is nearby	0	0.0	5	16.7

Note:1) High-price standard: 91 farmers = 100%, Low-price standard: 30 farmers = 100%; 2) Farmers are allowed to give multiple responses. Source: The author collected.

3.4. Behavioral impact

The behavioral patterns observed among contract farmers extend beyond traditional economic considerations, delving into diversification, machinery ownership, and overall profitability.

Table 1 presents a stark contrast between low-price and high-price standard contract farmers

regarding the percentage of household earnings derived from rice cultivation. Low-price standard contract farmers earned a significantly lower percentage (67.63%) than their high-price standard counterparts (96.35%). This discrepancy suggests a behavioral tendency among low-price standard contract farmers to diversify their production and engage in non-rice farm activities, possibly as a strategic response to economic constraints.

Furthermore, the frequency distribution in Table 5 sheds light on the prevalence of diversification practices. An overwhelming 96.7% of low-price standard contract farmers actively engage in non-rice farm activities, highlighting a deliberate effort to broaden their agricultural portfolio. In contrast, only 22% of high-price standard contract farmers follow a similar approach, emphasizing the distinct behavioral choices influenced by pricing standards.

The decision of low-price standard contract farmers to diversify their production is multi-faceted. This strategic behavior involves cultivating other crops (53.3%) and rearing livestock (93.3%) alongside rice cultivation. Adopting such diversified production practices reflects an adaptive response to economic conditions, providing these farmers with additional income streams and mitigating the impact of lower profitability associated with low-price contracts.

In the context of machinery ownership, it is essential to note that while economies of scale generally lead to specialization [40], the observed diversification among low-price standard contract farmers might be influenced by other factors, such as limited scale due to resource constraints. Future research may delve deeper into the interplay between machinery ownership, scale of operations, and diversification patterns.

The profitability comparison between low-price and high-price standard contracts unveils the economic rationale behind these behavioral choices. Low-price standard contract farmers, facing lower revenues and profitability, strategically embrace diversification to bolster their overall income. In contrast, high-price standard contracts, offering better economic returns, exhibit a lower prevalence of diversification.

In unraveling the intricate behavioral impact of contract farming, the study underscores the need for nuanced analyses considering the unique circumstances of each farming context. This comprehensive understanding provides valuable insights for policymakers aiming to design effective and targeted interventions that consider the behavioral dynamics of contract farmers.

Table 5. Frequency distribution of contract farmers under the Low-price and high-price standards.

Farm activity	Contract farmers				Total sample n=121	
	Low-price standard		High-price standard			
	Frequency	%	Frequency	%	Frequency	%
Non-rice-farm-activity	29	96.7	20	22.0	49	40.5
Cultivate other crops	16	53.3	6	6.6	22	18.2
Rear livestock	28	93.3	17	18.7	45	37.2

Note: 1) Contract farmers – 30 farmers = 100%; 2) Independent farmers – 102 farmers = 100%. Source: Author collected.

Table 6. Binary logistic regression of the factors influencing farmers' decision to carry out non-rice farm activities.

Independent variables	B Coefficient	SE	Odds Ratio	p. value
Constant	−4.555	1.199	0.011	***
Pricing standard (0: High-price standard, 1: Low-price standard)	3.945	1.155	51.661	***
Years of experience	0.013	0.025	1.013	
Total land (acre)	0.002	0.004	1.002	
No. of family members	0.381	0.244	1.464	
Distance from main town (miles)	0.041	0.013	1.042	***
% of earnings from off-farm activities	0.022	0.018	1.022	
Model predictive accuracy	83.90%			

Note: 1) Dependent variable: non-rice farm activity; 2) ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively; 3) Model predictive accuracy: 84.7%; 4) Standard Error. Source: Author collected.

A binary logistic regression analysis was performed to identify factors influencing farmers' decisions to engage in non-rice farm activities, as outlined in Table 6. Two independent variables significantly impact this decision: Pricing standard and Distance from the main town (miles), with associated Odds Ratios of 51.661 and 1.022, respectively.

The Odds Ratio of 51.661 for the Pricing standard highlights its substantial influence on farmers' choices. Farmers under the low-price standard are approximately 51.661 times more likely to engage in non-rice farm activities than those under the high-price standard. This underscores the motivating factor of lower gross margins from rice, stemming from reduced selling prices and yields under the low-price standard, compelling farmers to diversify their activities.

Furthermore, these results prompt an exploration of potential endogeneity in the "pricing standard" variable. Could lower pricing standards result from the inherent characteristics of farmers than influencing their behavior?

In Essequibo Islands-West Demerara, where the low-price standard prevails, unique regional characteristics play a role. This region, traditionally focused on rice farming with smaller sugar and coconut cultivation, involves diversification. Some farmers may inherently engage in non-rice activities, impacting average yields or perceived rice quality, leading to lower pricing standards. However, this is not the sole driver, as the binary logistic regression considers multiple variables, and the statistically significant Odds Ratio for the pricing standard persists.

Similarly, the Odds Ratio of 1.022 for Distance from the main town suggests a modest yet noteworthy impact. Farmers are approximately 1.022 times more likely to engage in non-rice farm activities for each additional mile away from the main town. This indicates that farmers facing greater distances from the main town encounter challenges in accessing inputs and incur higher costs for rice cultivation, prompting alternative farming activities.

In conclusion, the statistically significant Odds Ratios in Table 6 underscore the pivotal role of contract farming, particularly the pricing standard, in shaping farmers' decisions, profitability, and diversification strategies within Guyana's rice industry. This analysis provides essential insights into the nuanced dynamics of agricultural practices under different pricing standards, emphasizing the multifaceted impact of contract terms on farmers' choices and economic outcomes.

4. Discussion

The literature on contract farming underscores its widespread adoption in high-value product value chains within export contexts, with its application in grain value chains being less common. Previous research attributes this rarity in grain value chains, particularly rice, to factors such as the limited demand for high-quality grain products and challenges associated with side selling [5,6]. We delve into the multifaceted dynamics of contract farming in Guyana's rice industry, shedding light on its distinctive role in addressing challenges unique to the local context.

Contrary to conventional expectations, contract farming in Guyana's rice sector plays a pivotal role despite the absence of a premium pricing structure for high-quality grain products. This deviation is attributed to the specific challenges rice farmers face in the region, notably the lack of storage facilities for their paddies and the absence of spot markets for selling paddy independently. Rice farmers in Guyana encounter logistical constraints, with no provision for storing their harvested paddies. This limitation necessitates an immediate market for their produce, aligning with findings by Soullier and Moustier [6] and Swinnen et al. [7], emphasizing the influence of storage-related challenges on the prevalence of contract farming.

Furthermore, the absence of spot markets for selling paddy in Guyana accentuates the significance of contract farming as a structured marketing channel. With no alternative market mechanisms, rice farmers must sell their produce exclusively to the rice mills. This lack of spot markets underscores the critical role of contract farming in providing farmers with a guaranteed market and stable pricing, consistent with the insights of Barrett et al. [8]. The unique circumstances in Guyana contribute to the understanding of why contract farming becomes an essential arrangement in the absence of conventional market structures.

The nuanced dynamics of contract farming in Guyana's rice industry extend beyond traditional explanations, necessitating an in-depth analysis of its impact on socioeconomic characteristics, profitability, and behavioral patterns of contract farmers. By considering the contextual challenges and constraints faced by rice farmers in Guyana, this study aims to enrich the existing literature on contract farming and offer valuable insights for policymakers and stakeholders seeking to enhance the sustainability and effectiveness of agricultural practices in the region.

We employed a comprehensive methodology, comparing low-price and high-price standard contract farmers across various parameters. Socioeconomic characteristics, profitability, and behavioral aspects were meticulously analyzed through quantitative methods, shedding light on the intricate relationships within the contractual arrangements.

The findings reveal substantial differences between low-price and high-price standard contract farmers. Despite having more experience, low-price standard contract farmers operate smaller farms, own fewer tractors and reside farther from the main town. Their income diversification strategies, reliance on off-farm activities, and the proportion of earnings from rice cultivation differ significantly from their high-price standard counterparts. Moreover, profitability analysis demonstrates that low-price standard contract farmers are significantly less profitable than their counterparts due to lower revenues, primarily attributed to reduced selling prices and yields.

As we delve into the intricacies of contract farming in Guyana's rice industry, our results illuminate novel insights that elucidate the multifaceted dynamics of pricing standards, revenue disparities, and the nuanced behavior of contract farmers. These findings significantly contribute to the existing literature on agricultural contracts and farm management. Now, transitioning from the

results section to the discussion, we further analyze the implications of these insights and their relevance to the broader context of contract farming.

The study's novel contribution lies in its revelation of the substantial impact of pricing standards on contract farming profitability. High-price standard contracts prove more advantageous, resulting in higher profitability. This aligns with existing literature emphasizing the importance of contract terms in shaping economic outcomes [38,41].

The revenue dynamics under low-price standards require a comprehensive examination, considering the contractual obligations of contract farmers. Farmers are obliged to cover the cost of the fertilizer received, with payment due after harvest. Failing to fulfill this cost obligation has immediate financial implications for the farmers and may jeopardize their ability to engage in contracts with the mill. This intricacy adds another layer to the revenue analysis, emphasizing the interconnectedness of contractual commitments and financial outcomes for farmers. While we primarily focus on reported revenue figures within the contract terms, it is crucial to recognize that these figures may only partially capture instances where farmers, under financial pressures, might breach contractual agreements to explore alternative, potentially higher-paying markets. Enforcing contracts in agriculture poses challenges [17,21], and the nature of agricultural contracts, along with risk preferences, may lead to deviations [17]. On the other hand, research suggests that contract farming can mitigate such risks [38]. Addressing the possibility of contract violations is crucial in Guyana, and future research with direct assessments of contract compliance can provide a more nuanced understanding of revenue dynamics under low-price standards.

Our results challenge the traditional notion that contract farming in grains, particularly rice, faces hindrances such as side selling and the extended shelf life of grains [7]. Instead, our results illuminate the high-price standard's unique role as a robust risk mitigation strategy. This pricing standard provides a structured framework for farmers to navigate the complexities of market volatility, price fluctuations, and uncertainties stemming from weather-related factors [12]. In adopting high-price standards, farmers gain a sense of security, effectively addressing challenges that may impede grain production and ensuring a stable environment for farmers and mill operators.

The findings emphasize the pivotal role of contracts in elevating product quality and facilitating market access. Particularly noteworthy is the impact of low-price standard contract farming, which results in a consistent and high-quality paddy supply. This aligns with the insights provided by Bellemare [38], highlighting the welfare impacts of contract farming through product quality enhancement. Adherence to specific standards in low-price contracts benefits farmers by incentivizing them to meet these criteria and contributes to overall product quality within the rice industry.

Our study contributes significantly to the literature by delving into the behavioral aspects influenced by pricing standards, explicitly focusing on farmers' decisions to engage in non-rice farm activities. Notably, low-price standard contract farmers are more inclined toward diversifying their production efforts. This aligns with the findings of Masakure and Henson [12], which underscore the tendency of small-scale producers to participate in contract farming to supplement income through diversification. The adaptability and resilience observed among low-price standard contract farmers reflect the dynamic nature of agricultural practices and the multifaceted impact of contract terms on farmers' choices and economic outcomes.

Given the substantial differences in profitability between low-price and high-price standard contracts, policymakers should encourage the adoption of high-price standard contracts as the primary pricing model for rice mills. This strategic shift will likely result in higher farm yields, making more

paddy available for the mills and increasing farmers' profitability [4].

Acknowledging the continued prevalence of low-price standard contracts, particularly in areas where they are predominant, it is essential to establish crop insurance schemes. These schemes aim to safeguard farmers in the event of crop losses due to natural disasters or pests, providing them with financial protection and stability [12].

Recognizing the critical role of credit in agricultural productivity, especially for investing in machinery and equipment, the government should facilitate the establishment of credit schemes. These schemes can enhance farmers' access to credit, particularly those operating under high-price standard contracts, contributing to increased productivity [2,18].

Addressing the lack of storage facilities for rice paddies is crucial to giving farmers more flexibility in marketing their produce. Investments in the development of storage infrastructure can enable farmers to store their harvests strategically, taking advantage of market conditions and potentially reducing their reliance on immediate sales to rice mills [6].

Future research and policy initiatives should explore the influence of farmers' organization membership on contract farming productivity under different pricing standards. Encouraging the formation of strong farmers' organizations can empower farmers, enhance their bargaining power, and contribute to more favorable contract terms [8].

Policymakers should extend their focus beyond economic outcomes and explore broader sustainability, environmental, and social dimensions of contract farming. This includes assessing the environmental impact, social welfare of farmers, and the overall sustainability of agricultural practices under different pricing standards [37].

Recognizing the absence of spot markets for selling paddy, policymakers should explore mechanisms to develop and facilitate spot markets. This can provide farmers with alternative avenues to sell their produce, promoting market competition and potentially improving pricing dynamics [8].

By incorporating these policy recommendations, policymakers can contribute to the enhanced resilience, profitability, and sustainability of Guyana's rice industry, aligning with the broader objectives of promoting agricultural development and improving the livelihoods of contract farmers.

We identify the absence of an assessment of the impact of farmers' organization membership as a limitation, suggesting future research avenues. Additionally, our insights have broader implications for sustainable agricultural development in Guyana. Policymakers can utilize these findings to design more effective and equitable contract farming models that enhance farmers' livelihoods and contribute to the growth of the agricultural sector.

In conclusion, this study contributes novel findings to the existing literature on contract farming and provides actionable insights for policymakers and stakeholders in Guyana's rice industry. The nuanced understanding of the impact of pricing standards on farmers' profitability, risk mitigation, and behavioral patterns enhances our comprehension of contract farming dynamics in the context of grain value chains. These insights are crucial for developing targeted and effective policies that promote sustainable agricultural development and improved livelihoods for contract farmers.

5. Conclusions

In conclusion, our comprehensive exploration of contract farming in Guyana's rice industry has yielded valuable insights into the intricate dynamics that govern profitability, behavior, and the role of farmers. While contract farming serves as a vital risk-sharing mechanism, offering stability through access to markets, credit, and fertilizers, our findings emphasize pricing standards' critical influence

on farmers' outcomes.

High-price standard contracts emerge as a more advantageous model, demonstrating higher profitability for farmers. In contrast, low-price standard contracts present challenges, with significantly lower selling prices and reduced capacity to acquire essential inputs, impacting overall yield and financial returns. Despite these challenges, farmers continue to engage in low-price standard contracts driven by the appeal of risk-sharing mechanisms, access to credit, and fertilizers.

The behavioral patterns observed among contract farmers underscore the adaptability and resilience inherent in their response to varying contract conditions. Low-price standard contracts incentivize farmers to diversify their production efforts, engaging in additional crops and livestock farming alongside rice cultivation. This strategic diversification is a testament to farmers' ability to navigate and adapt to different contract conditions.

Our study contributes novel findings to the existing literature, particularly in highlighting the substantial impact of pricing standards on contract farming profitability. The high-price standard emerges as a robust risk mitigation strategy, providing a structured framework for farmers to navigate market complexities, price fluctuations, and uncertainties arising from weather-related factors. This nuanced understanding enhances our comprehension of contract farming dynamics within grain value chains.

For policymakers and stakeholders in Guyana's rice industry, our recommendations prioritize adopting high-price standard contracts as the primary model for mills. This strategic shift is poised to enhance farm yields, increase paddy availability, and improve farmers' profitability. However, acknowledging the persistence of low-price standard contracts, particularly in certain regions, our recommendations extend to establishing crop insurance schemes and facilitating government-backed credit initiatives. These measures aim to provide financial protection, stability, and improved access to credit for farmers in areas where low-price contracts prevail.

While our study contributes significantly to the literature, it has limitations. The influence of farmers' organization membership on contract farming productivity under different pricing systems remains unexplored. Future research avenues should delve into this aspect, offering a more comprehensive understanding of the role of farmers' organizations in shaping contract farming outcomes.

In essence, this study underscores the importance of considering pricing standards and contextual factors in contract farming to maximize benefits for farmers and promote sustainable agricultural development. Armed with these nuanced insights, policymakers and stakeholders can design and implement more effective contract farming models, fostering the growth of the agricultural sector and enhancing the livelihoods of contract farmers in Guyana.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Author contributions

Conceptualization, R.G.; methodology, R.G.; analysis, R.G.; investigation, R.G.; writing review and editing, Raulston Gillette and Godfrid Erasme Ibikoule; and supervision, Norio Sakai. All authors have read and agreed to the published version of the manuscript.

Data availability statement

The data gathered in this study have been obtained in collaboration with the Ministry of Agriculture, Guyana, with their authorized permission. Due to the imperative requirement of maintaining strict confidentiality, the data cannot be disclosed openly.

Conflict of interest

The authors declare no conflicts of interest.

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