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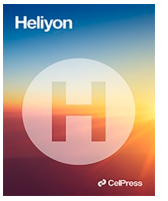

Research article

Private sector led multi-stakeholder platforms positively influence certified common bean seed supply in Malawi

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ABSTRACT

Common bean yields in Malawi remain low, primarily due to the use of low-yielding, recycled local seeds by most smallholder farmers. The low uptake of certified bean seed is attributed to limited incentives from the private sector. This study hypothesizes that the sustainable adoption of market-preferred varieties can be achieved by synchronizing and linking seed production to the grain market through committed value chain actors in a private sector-led multi-stakeholder platform. This paper examines the role of private sector-led multi-stakeholder platforms in the supply of certified common bean seed in Malawi. The research draws on both qualitative and quantitative primary data collected through a semi-structured questionnaire and interviews with key informants. Data were analyzed using an Ordinary Least Squares (OLS) regression model. The results indicate that several variables representing membership in multi-stakeholder platforms (MSPs) significantly affect the supply of certified common bean seed. Participation in MSPs, contractual arrangements, market structure, extension services, and seed demonstrations positively influenced seed supply. The findings underscore the need for a well-coordinated multi-stakeholder platform to enhance the supply of certified common bean seed, supported by effective policies and incentives from policymakers.

1. Introduction

The government of Malawi (GOM) and Non-State actors like the National Smallholders Farmers' Association of Malawi (NASFAM) have invested in promoting smallholder commercial farming of legumes such as groundnuts, pigeon peas, and soya beans. These initiatives were introduced to diversify the agricultural economy, given the challenges faced by tobacco, the main cash crop and

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foreign currency earner of Malawi, including price fluctuations and anti-smoking campaign. Among the legumes, this study is centered on the common bean seed supply. Despite not being a priority crop, common beans are highly beneficial to Malawians, serving as a primary protein source, particulary for less privileged households, due to their affordability and availability compared to animal protein sources [1]. On average, Malawians consume 5g of common beans per day, compared to the global average of 7–8g of animal protein per day [2].

Malawi's development framework emphasizes the agriculture sector, with investments aimed at enhancing national food security, nourishment, agro-processing, value addition, rural development, manufacturing, and trade. The National agricultural policy (2020) highlights the government's goal to improve agricultural productivity through frequent agricultural extension and rural consultative services, including private sector-led multi-stakeholder platforms. These platforms promote studies on agricultural innovation systems, technology generation, and distribution. Common beans were introduced to Malawi from the eastern coast of Africa over 304 years ago through globalization by traders [3]. By the 1990s, common beans had become the most-grown legume nationwide [4]. However, smallholder farmers faced significant challenges that reduced bean productivity, with national average yields about ten times below their potential (Verdoodt et al., 2004). This underscored the need for high-yielding, improved common bean seed varieties resistant to drought, pests, and diseases.

Common beans are crucial source of protein, vitamins, carbohydrates, iron, zinc, potassium, and magnesium for a significant population of Malawi [5]. They contribute to agricultural export earnings, provide income to smallholder farmer households, improve nutrition, and aid in soil nitrogen fixation [6]. The main common bean include Dedza, Ntcheu, Lilongwe, Chitipa, and Thyolo, which together produce over 70 % of Malawi's common bean [6]. Despite their importance, common bean seed production faces several challenges. Private stakeholders in Malawi tend to focus on specific fragments of the value chain, often failing to disseminate crucial information about the bean grain trade [1,7]. This leads to incoordination and inefficiencies in production, supply, and adoption of new common bean varieties [8].

Multi-stakeholder platform (MSPs) aim to coordinate the entire common bean seed production pipeline by bringing together various actors to address coordination failures and enhance the efficiency of production, distribution, and consumption [8]. Sustainable adoption of market-preferred varieties can be achieved through deliberate efforts to synchronise seed production with the grain market, requiring commitment from all value chain actors and integration into MSP [9]. MSPs work with lead firms to unite stakeholders within the common bean value chain, including companies like Tradeline, Pyxus, Demeter Agriculture, NASFAM, and Farmers' World. These firms enhance productivity by using certified seeds, running networks of agro –dealer shops, and marketing through retail outlets. Agricultural displays and strategic platforms organized by these firms provide equal opportunities for seed market and aiding in the demand for certified bean seeds. Private sector-led MSPs ensure the distribution and accessibility of seeds to all farmers, improving bean production, income, and household well-being. Information on market demand for quality grain stimulates seed value chain actors to invest in raising the volume and quality of seeds required.

This research aims to assess the effects of private sector-led multi-stakeholder platforms on the supply of certified common bean seeds. It is hypothesized that there is correlation between certified seed supply and demand, and that participation in MSPs positively affects the quantity of certified bean seed supplied. Understading these factors might help increase the number of smallholder farmers accessing improved common bean varieties, there by boosting their harvests amd improving the socio-economic well-being and dietary diversity of many smallholder farmer households.

2. Methodology

2.1. Design

This study employs a cross-sectional design utilizing face to face surveys with a semi-structured questionnaire. The interviews targeted certified common bean seed multipliers. Prior to conducting the interviews, participants were assured of total anonymity and confidentiality. They were provided with abrief description of the study, its aim, and the declarations of anonymity and confidentiality, as follows: 'I am conducting an academic research on private sector led multi-stakeholder platforms positively influence investment in certified common bean seed supplies in Malawi. The information you will provide will be used for academic purposes only and it will be kept confidential. Your ability to answer all the questions comprehensively and to the best of your knowledge will be highly appreciated. Feel free to ask for clarification if you don't understand the questions. Am I welcome to ask your some questions concerning my study?'. Participants were also informed of their right to withdraw from the interviews at any time. All participants provided informed verbal consent before participating. The study was approved by the Ethics Committee of the Lilongwe University of Agriculture and Natural Resources, with ethics approval letter.

2.2. Participants

The study was conducted in three districts of Malawi actively participating in the MSPs. Areas of focus were Mzimba District (Northern Region), Dedza District (Central Region), and Kasungu District (Central Region), the latter serving as the counterfactual. A purposive multistage sampling method was used to select the these districts. Extension Planning Areas (EPAs) were purposively selected based on their level of activity in common bean seed production. The focus was on four EPAs, thus, Linthipe and Bembeke EPAs in Dedza District, Chamama EPA in Kasungu District, and Champhira EPA in Mzimba District. From each of these EPAs, several clusters were drawn, and within these clusters, common bean seed suppliers were randomly selected. Each EPA is divided into sections and villages. For example, in Chamama EPA in Kasungu, the study focused on three sections: Ndonda, Chivweni, and Chipse. Clusters

were selected from these sections. Similarly, clusters were drawn from Linthipe and Bembeke EPAs in Dedza District. In the northern region of Malawi, the selected clusters included Chamaji and Kazingilila villages of Champhira EPA in Mzimba. A simple random sampling method was used to sample five sections within each EPA, with adjustments made based on proximity and topography. Subsequently, 185 certified common bean seed multiplying farmers were randomly chosen from these communities.

2.3. Theoretical framework

The theoretical framework for this study is based on the random utility theory, which suggests that rational individuals make choices to maximize their utility [10]. The utility derived from the adoption of improved crop technologies by smallholder farmers is influenced by various observed and unobserved factors, represented as follows:

$$M_{ij} = \boldsymbol{\beta}_j X_i + \boldsymbol{\varepsilon}_{ij} \tag{1}$$

Where *Mij* is the perceived utility of adoption decision of the improved crop technologies; *Xi* represents the farm household characteristics and attributes of the technology, $\boldsymbol{\beta}_j$ are the coefficients of covariates and $\boldsymbol{\varepsilon}_{ij}$ capture the unobserved factors. The common bean farmers will choose to adopt an alternative if its utility exceeds that of the next option.

$$Y_{im} = \begin{cases} 1, Pin > Pjn \; \forall j \neq i \; (1, 2, 3, 4 \ldots\ldots n) \\ 0, if \; otherwise \end{cases} \tag{2}$$

Where *j* represents different choices (use of the certified seed, non-certified seed, local seed) from the choice set *Un* and *n* represents common bean farmer. The utility system also accounts for constraints related to startup and shutdown actions, operational status, and level of production processing units, ensuring consistency with microeconomic theory and practical farming conditions.

2.4. The effect of smallholder seed multipliers participation in MSPs activities on the quantity of certified bean seed supplied in Malawi

Several econometric approaches, including ordinary least squares (OLS), linear regression with endogenous treatment maximum likelihood, and Three Stage Squares (3SLS), were considered. OLS was ultimately adopted due to the absence of endogeneity, as indicated by preliminary tests below.

2.4.1. Tests of endogeneity

H0. Variables are exogenous

$$\text{Durbin (score) chi2}(1) = .743287 \; (p = 0.3886)$$

$$\text{Wu} - \text{Hausman F}(1, 166) = .66964 \; (p = 0.4144)$$

The results show that the p-values greater than 0.05 level of significance (the chi_2 is also small), therefore we fail to reject the null hypothesis and conclude that there is no endogeneity problem in the model, hence we can rely on OLS output.

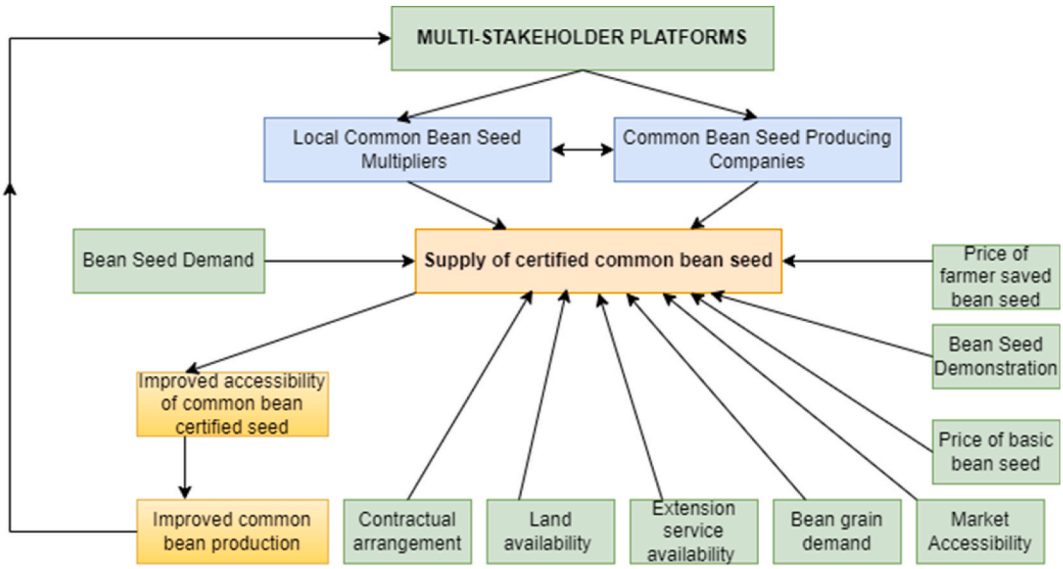

Fig. 1. The conceptual framework of effects of private sector-led multi-stakeholder platforms on supply of the certified common bean seed.

The robustness of OLS in handling the linear relationship between the independent and dependent variables was a key factor in it selection. The OLS model approach, with a continuous dependent variable being supply of certified common bean seed, which is influenced by a set of both categorical and continuous explanatory variables is specified below.

$$Q^S = \alpha_0 + \alpha_1 \text{store\_ty} + \alpha_2 \text{contract}_{ag} + \alpha_3 \text{land} + \alpha_4 \textit{main\_bus} + \alpha_5 \text{mrkt}_{st} + \alpha_6\ \text{MSP}_{know} + \ \alpha_7 \text{price}_{cert} + \alpha_8 \text{ext}_{service} + \alpha_9 \text{sex}_{own} + \alpha_{10} \text{dist}_{dest} + \alpha_{11} \text{inv}_{sub} + \varepsilon^d \quad (3)$$

Where Q^S represents quantity of certified common bean seed supplied (Kg), contract_{ag} represents contractual agreement, land represents land used in acres, mrkt_{st} represents market structure (Perfect Competition, Monopolistic Competition, Oligopoly, and Monopoly), MSPs_{know} represents Multi-Stakeholder Platform Participation (Seed demonstration and participatory seed selection), price_{cert} represents Price of certified common bean seed (Mk), price_{sub} represents Price of a substitute (Mk), $\text{ext}_{service}$ represents number of extension services acquired, sex_{own} represents sex of the owner of the firm, dist_{dest} represents distance to the market of the certified common bean seed (Km), inv_{sub} investment subsidy (Mk), β_0 is the constant term, $\beta_1 - \beta_{11}$ are parameter estimates and ε is the error term.

Table 1
Explanatory variables

Variables	Description	Expected signs at each stage
		Supply
Dependent		
Seed supply	Distribution of the certified common bean seed (KG)	
Independent		
Seed demonstrations	Participation in the seed demonstrations Yes = 1 No = 0	+
Extension service	The number of extensional services provided in a community	+
Seed demand	Quantity of common bean seed demanded by the market (KG)	+/−
Ownership	Sole proprietorship = 1 Partnership = 2 Corporation = 3 Cooperative = 4 Association = 5 Franchise = 6 Trust = 7 Private limited = 8 Public Limited = 9	+/−
Market structure	Perfect Competition = 1 *Monopolistic Competition = 2* *Oligopoly = 3* *Monopoly = 4*	−/+
Land availability	Amount of expansion or investment land available	+
Price of the basic seed	Amount of money spent to purchase a kg of certified common bean seeds (MK)	+
Price of substitute	Amount of money spent to purchase a kg of farmer-saved seeds (MK)	-
Investment subsidy	Amount of money subsidized on the inputs of common bean seed production	+
Payback period	The time is taken to repay the farmer's debt	+
Contractual agreement	Whether a farmer is under any contractual arrangement or not. Yes = 1 No = 0	+
Perception	Subject perception of relative advantages Advantageous = 1 Not advantageous = 0	+/−
Sex	Male = 1 Female = 0	+/−
Age	Age of the owner of the firm	–
Capital	Amount of money a farmer has to invest in the production of a certified common bean seed (Mk)	+
Total loan	Total investment loan acquired (MK)	+
Distance from the source	Distance to the source of the basic seed (MK)	–
Distance to the destination	Distance to the destination of the common bean farmers' production (MK)	–
Type of a supplier	Formal = 1 Informal = 0	+/−
Off-farm income	Income generation from off-farm activities	–
Farm system	Commercial = 0 Substitute = 1 Both = 2	+/−

2.5. Conceptual framework

The study's conceptual framework, as shown in Fig. 1, posits that production and supply of certified common bean seed are linked to farmer participation in MSPs and the roles played by non-state actors, including local common bean seed multipliers and common bean seed producing companies. The framework highlights the importance of farmer engagement in the development and dissemination of seed technology and how specific policies and strategies shape this engagement. Central to the framework is the interaction between demand and supply of certified common bean seed. Improved accessibility to certified seed is facilitated by factors such as contractual arrangements, land availability, extension services, bean grain demand, and market accessibility. Additionally, policies impacting the price of farmer-saved bean seed, the price of basic bean seed, and the effectiveness of the bean seed demonstrations are crucial in influencing the supply dynamics. The framework underpinned by the utility maximization theory, which suggests that farmers decisions to participate in MSPs and adopt new technologies are driven by the desire to maximize their utility. This utility maximization ultimately leads to enhanced income, greater dietary diversity, and overall improvement in rural livelihoods.

2.6. Variable definition

The study identified various independent variables likely to affect the supply of certified common bean seeds, supply of certified common bean seeds, summarized in Table 1.

3. Results

3.1. General characteristics of the study population

The general characteristics of those participating in MSPs are presented in Table 2. Overall the sample (n = 185). The table provides a summary of the continuous descriptive statistics for various MSP activities and institutional characteristics of the sampled population. The average average price of basic seed was MK 1178.73, with a standard deviation of MK 715.09, ranging from MK 0 to MK 2700 per kg. The mean price of certified seed was MK 1063.28, with a standard deviation of MK 486.86, and prices ranged from MK 150 to MK 3000 per kg. Substitute seeds had an average price of MK 757.99 and a standard deviation of MK 333.20, with a price range of MK 350 to MK 2500 per kg. The average investment cost incurred by farmers was MK 182,842.80, with significant variability, as the highest investment reported was MK 1,500,000. Investment subsidies averaged MK 100,399.80, ranging from zero to MK 306,000. On average, farmers supplied 1782.75 kg of seed, with a standard deviation of 576.91 kg, while the average demand for seed was 3571.91 kg, with a standard deviation of 1876.10 kg. Additionally, farmers received an average of 9.67 extension services and participated in 2.55 seed demonstrations, indicating varying levels of support and engagement in MSP activities.

Table 3 provides a summary of the categorical descriptive statistics for the socio-economic and institutional characteristics of the sampled common bean seed farmers in Malawi. The table shows that 78.89 % of the seed multipliers participated in seed demonstrations, while 21.11 % did not. Regarding contractual agreements, 32.97 % of the farmers were under a contract, whereas 67.03 % were not. Market accessibility was a challenge for 62.16 % of the seed multipliers, indicating a lack of accessible seed markets. Basic seed was available to 76.22 % of the farmers, with 23.78 % reporting unavailability. The gender distribution revealed that 52.43 % of the seed multipliers were female, and 47.57 % were male. Age-wise, 29.19 % of the farmers were youths, while 70.81 % were elderly.

3.2. Institutional and accessibility characteristics

Table 4 shows the results of the statistical t-tests and chi-squared tests, assessing significant differences in investment and seed supply characteristics among common bean seed farmers participating in the multi-stakeholder platforms. Male producers had a higher mean investment cost (MK 120,409.80) compared to female producers (MK 71,077.12), with a p-value of 0.07, indicating a significant

Table 2
Summary of continuous descriptive statistics for MSP activities and Institutional characteristics.

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Price of basic seed	185	1178.73	715.09	0	2700
Price certified seed	185	1063.28	486.86	150	3000
Price of substitute	185	757.99	333.20	350	2500
Investment cost	185	182,842.80	94,543.45	0	1500000
Investment subsidy	185	100,399.80	62,719.89	0	306,000
Seed supplied	185	1782.75	576.91	1	16,000
Seed demanded	185	3571.91	1876.10	.75	20000
Extension services	183	9.67	5.46	1	23
Seed demonstrations	185	2.55	2.07	0	15
Cost of entry	185	224,060.90	18,355.92	209060	339000
Capital	185	156,846.70	88,648.28	0	1300000
Quantity of seed produced	185	1158.23	408.73	0	14000
Quantity of seed used	185	37.01	27.29	0	250

1USD = 1028 MK.

Table 3
Categorical descriptive statistics for social-economic and institutional characteristics

Category	Yes (%)	No (%)	Total (%)
Seed demonstration participation	78.89	28.11	100
Contractual agreement	32.97	67.03	100
Market accessibility	37.84	62.16	100
Basic seed availability	76.22	23.78	100
Sex (Male)	47.57		
Sex (Female)	52.43		100
Age (Youth)	29.19		
Age (Old)	70.81		100

difference at the 10 % level. However, there was no significant difference in seed supply between male and female producers, with p-values indicating non-significance. Participants in seed demonstrations had a significantly higher mean investment cost (MK 121,835.60) compared to non-participants (MK 24,738.63), with a p-value of 0.00, showing significance at the 1 % level. There was no significant difference in seed supply between participants and non-participants. Age did not show significant differences in either investment or seed supply. Both youthful and older producers had similar investment costs and seed supply, with p-values of 0.35 and 0.99, respectively, indicating no significant differences between these groups.

Table 5 presents the institutional and accessibility characteristics for participants of the multi-stakeholder platforms, highlighting significant differences in investment loans, certified seed prices, and investment subsidies. Farmers in contractual agreements received substantially higher investment loans (MK 83,525.90) compared to those not in contracts (MK 3291.12), with a p-value of 0.00. They also sold certified seeds at higher prices (MK 1260.41 vs. MK 966.31) and received greater investment subsidies (MK 67,924.73 vs. MK 17,512.62), both significant at the 1 % level. Seed demonstration participants also had higher investment loans (MK 73,969.62) compared to non-participants (MK 33,946.52) and received more significant subsidies (MK 42,966.83 vs. MK 11,545.87), with p-values of 0.01 and 0.03, respectively. There were no significant differences in the cost of entry among the groups.

Table 6 presents the coefficient estimates for factors affecting the supply of certified common bean seed, with various variables showing significant impacts. Being in a contractual agreement was found to increase the supply of certified seeds by 20.55 % (p-value 0.039). Land availability also had a significant positive effect, with each additional acre increasing supply by 5.95 % (p-value 0.009). Market structure influenced supply, with monopsony conditions leading to a 19.33 % increase (p-value 0.000) and oligopoly conditions showing a marginally significant increase of 20.14 % (p-value 0.068). The type of storage also mattered; owning a granary (Nkhokwe) increased supply by 17.07 % (p-value 0.075), and having a well-structured, iron sheet thatched warehouse increased supply by 15.11 % (p-value 0.007)

Extension services were beneficial, with each additional service increasing supply by 1.25 % (p-value 0.085). Gender also played a role, as male producers supplied 23.85 % more certified seeds than female producers (p-value 0.002). Knowledge of multi-stakeholder platforms was significant, increasing supply by 32.84 % (p-value 0.007). Additionally, a kwacha increase in the price of certified seeds led to a 7.60 % increase in supply (p-value 0.022).

4. Discussions

The findings of this study highlight several key factors that significantly impact the supply of certified common bean seeds in Malawi. The analysis shows that participation in private sector-led multi-stakeholder platforms (MSPs) and contractual agreements play a crucial role in enhancing seed supply. The results reveal that male certified common bean seed producers invest significantly more in seed production compared to female producers. This is consistent with findings by Joe-nkamuke & Olagunju [11], who reported that female producers were 28 % less productive than their male counterparts after controlling for observed production factors. This investment disparity can be attributed to male producers having better access to resources and capital, allowing them to invest more in certified seed production. Despite having more female seed multipliers than males, male seed multipliers supply more certified

Table 4
Institutional and accessibility characteristics for participants of the multi-stakeholder platforms

Variables	Investment		Seed supply	
	Mean	p-value	Mean	p-value
Gender				
Male	120409.80*	0.07	557.05	0.89
Female	71077.12*		594.94	
Seed demonstration				
Yes	121835.60***	0.00	544.05	0.69
No	24738.63***		660.96	
Age				
Youth	75022.79	0.35	580.02	0.99
Old	102590.10		575.63	

*, **, *** Significant at 10 %, 5 % and 1 % respectively

Table 5
Institutional and accessibility characteristics based on contractual agreements and seed demonstration participation

Variables	Investment loan		Certified seed price		Investment subsidy		Cost of entry	
	Mean	p-value	Mean	p-value	Mean	p-value	Mean	p-value
Contractual agreement								
Yes	183,525.90	0.00	1260.41	0.00	67,924.73	0.00	224,595.10	0.7822
No	3291.12		966.31		17,512.62		223,798.10	0.7822
Seed demostration								
Yes	73,969.62	0.01			42,966.83	0.03	224,602.30	0.5226
No	33,946.52				11,545.87		222,676.20	0.5226
Member of a cooperative								
Yes					38,789.34	0.12	223,942.30	0.8482
No					11,881.41		224,628.10	0.8482
Market accessibility								
Yes			1113.10	0.28				
No			1032.97					

*, **, *** Significant at 10 %, 5 % and 1 % respectively

Table 6
Coefficient estimates for factors affecting the supply of certified common bean seed

Supply of certified common bean seed	Coefficient	Bootstrap Std. err.	t	P > t	[95 % conf.	interval]
Contractual agreement						
Yes	0.2055433**	0.0994887	2.07	0.039	0.0105491	0.4005375
land	0.0594766***	0.0228693	2.60	0.009	0.0146536	0.1042995
Market structure						
Monopolistic Competition	0.0893279	0.1053347	0.85	0.396	−0.1171244	0.2957802
Oligopoly	0.2013595*	0.1104577	1.82	0.068	−0.0151337	0.4178526
Monopoly	0.0919186	0.1143273	0.80	0.421	−0.1321589	0.3159961
Monopsony	0.1932965***	0.0387974	4.98	0.000	0.1172551	0.2693379
Storage type						
Granary (Nkhokwe)	0.1707174*	0.0957918	1.78	0.075	−0.0170311	0.358466
well-structured, iron sheet thatched warehouse	0.1511199***	0.0557318	2.71	0.007	0.0418877	0.2603522
Extension service	0.0125042*	0.0072597	1.72	0.085	−0.0017245	0.0267329
Sex						
Male	0.2384755***	0.0752487	3.17	0.002	0.0909908	0.3859602
Main business activity	0.0409724	0.0263424	1.56	0.122	−0.0110215	0.0929662
Knowledge of MSPs						
Yes	0.3283626***	0.1225395	2.68	0.007	0.0881896	0.5685355
Distance market	−0.0000182	0.0005559	−0.03	0.974	−0.0011078	0.0010715
Investment subsidy	−0.0332012	0.027661	−1.20	0.230	−0.0874158	0.0210134
Price of a certified seed	0.0760133**	0.0332726	2.28	0.022	0.0108002	0.1412264
Constant	0.2198556	0.2581004	0.85	0.394	−0.2860119	0.7257231

*, **, *** Significant at 10 %, 5 % and 1 % respectively

common bean seed than females, likely due to ownership of land and availability of investment capital. FAO [12] concluded that women face different forms of gender discrimination in agricultural supply chains, including limitations in land ownership/control, financial services, and formal market access.

Participation in seed demonstrations was found to significantly increase investment in certified seed production. Participants in seed demonstrations invested more than non-participants, indicating that these platforms provide valuable information and resources that encourage higher investment. This finding aligns with Chirwa [13], who noted that community-based land development programs increase the likelihood of participants investing in improved seeds. Additionally, while investment was higher among participants, the actual supply of seeds did not show a significant difference between participants and non-participants.

Farmers in contractual agreements received higher investment loans, sold certified seeds at higher prices, and received greater investment subsidies compared to those not in contractual agreements. These agreements provide financial and market stability, encouraging farmers to invest more in certified seed production. This supports the findings of Sriboonchitta & Wiboonpoongse [14], who highlighted the benefits of contract farming in reducing production risks and opening new markets for small-scale farmers. Contractual agreements also ensure farmers can access investment loans using the agreements as bank collateral, further enhancing their ability to invest.

The study found a positive correlation between the price of certified seeds and their supply. Higher prices incentivize farmers to produce and supply more certified seeds. This underscores the importance of fair pricing policies in encouraging higher production and supply of certified seeds.

Land availability was another significant factor influencing seed supply. Larger land holdings enable farmers to produce more

certified seeds, as they can cultivate more area. Additionally, access to proper storage facilities, such as granaries and well-structured warehouses, was found to significantly increase seed supply by reducing post-harvest losses.

The provision of extension services also had a positive impact on seed supply. Farmers who received more extension services were able to increase their productivity and market knowledge, leading to higher seed supply. This aligns with findings by Zeberga [15] and Kerbaga [16], who noted that extension services positively affect agricultural production and marketing. Extension services enhance both production skills and market accessibility, providing farmers with a comprehensive support system.

Knowledge of multi-stakeholder platforms was significantly associated with higher investment and seed supply. Farmers who were aware of MSPs invested more and supplied more certified seeds, indicating that these platforms effectively disseminate valuable information and linkages that encourage increased production. This highlights the role of MSPs in coordinating the entire common bean seed production pipeline, bringing together different players to address coordination failures and enhance efficiency [8,9].

5. Conclusions

Private sector-led multi-stakeholder platforms significantly enhance the supply of certified common bean seeds in Malawi. Participation in seed demonstrations and contractual agreements, higher prices for certified seeds, larger land holdings, and access to extension services are key factors driving this increase. These findings underscore the importance of structured programs and fair pricing in improving agricultural productivity and supply.

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CRediT authorship contribution statement

Wanangwa Gondwe: Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Alexander Phiri:** Writing – review & editing, Validation, Supervision, Project administration, Funding acquisition, Conceptualization. **Ruth Magreta:** Writing – review & editing, Supervision, Project administration, Methodology, Data curation, Conceptualization. **Eliud Birachi:** Writing – review & editing, Validation, Supervision, Funding acquisition, Conceptualization. **Catherine Larochelle:** Writing – review & editing, Supervision, Methodology. **Kennedy Machira:** Writing – review & editing, Validation, Methodology. **Mercy Mutua:** Writing – review & editing, Supervision, Data curation. **Jean Claude Rubyogo:** Writing – review & editing, Visualization, Validation, Supervision, Funding acquisition, Conceptualization. **Wilson Nkhata:** Writing – review & editing, Validation, Supervision, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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