Attribution of Gross Margin Differential to Quality Declared Seeds in Tanzanian Sunflower Sub-Sector: Difference-in-Differences Analysis.

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Abstract: *This study was conducted to investigate the causal effect of quality declared seeds (QDS) on changes in gross margin in sunflower agribusiness. Longitudinal survey design was employed to collect panel data from 357 sunflower farmers who were members of 11 agricultural marketing cooperative societies (AMCOS) in Kondoa and Itigi districts, Tanzania. The subsequent analysis was done based on a continuous difference-in-differences (DiD) econometric model by taking into account the treated and controlled farmers from two periods, including seasons 2022 and 2023. It was found out that the use of QDS positively (β=0.204) caused an increase of TZS. 284.94/Kg of sunflower farmers' gross margin from TZS. 105.48/Kg for controlled farmers. This gross margin differential of 72.98% was explained by 67.31% influence of the use of QDS by the treated farmers, of which the causal effect was statistically significant (p=0.031). The findings are important to the Tanzanian government, where policy could be developed to encourage smallholder farmers to switch from conventional seeds to QDS in their localities. The knowledge of the impact of QDS on gross margin is more important for smallholder farmers themselves to hold on in sunflower farming instead of abandoning the sub-sector, as was recently witnessed in research areas.*

Keywords: Sunflower, Conventional Seeds, Quality Declared Seeds, Gross Margin, Difference-in-Differences Model.

JEL classification: C35, D63, I41

1.0 Introduction

Sunflower ranks among the major oil-seed crops in the world, with Russia and Ukraine being the two leading global producers (Shahbandeh, 2024). Other countries with noticeable production volume in the world include the European Union, Argentina and Turkey, which together with Russia and Ukraine accounted for 86.18% of the total global production. In the African context, South Africa was the largest producer, followed by Tanzania, which ranked eleventh in the world (Lyanga, 2024). Despite its contribution of 35% to the basket of total production on the continent, Tanzania still suffers from an

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extreme shortage of edible oil (Msafiri, Lumanyela & Nyanda, 2023). A report by Erasmus and Kaungal (2024) states that the country used to import half (50%) of the total annual demand to solve for a shortage is evidence that there was underproduction of sunflower seeds. Sunflower underproduction is the pervasive problem that faces not only the small producing countries like Tanzania but also the big producers, including Turkey and others (Haliloglu & Aydogdu, 2024).

Haliloglu and Aydogdu (2024) identified nutrient deficiencies in soil as one of the factors behind the low production of sunflower seeds. Other factors include poor weather conditions, diseases, bird damage, poor harvesting techniques and poor agronomic practices, including incorrect seed variety (Das, Dash, Pattnaik & Mohapatra, 2024; Georgiev, 2023). Abandoning sunflower farming to engage in other agricultural sub-sectors like lentil production was another factor for sunflower underproduction in Tanzania (Molela, Kaluse, Baraza, Mlay & Msese, 2021). A study further mentioned the gross margin difference as the driving factor behind a switch between the agricultural sub-sectors among smallholder sunflower farmers.

Several studies were conducted to suggest various solutions to circumvent the problem of underproduction by addressing the challenges imposed by the factors mentioned above. Hanafy and Sadak (2023) found a strong positive impact of stigmasterol in improving the drought tolerance of sunflower during periods of critical drought. Likewise, adhering to proper intervals between irrigation and application of fertiliser solves the challenge brought about by drought and nutrient deficiencies in soil (Mekkei & El-Haggan, 2019). Other studies, including Darwesh and Elshahawy (2023), assessed the relationships between various extracts and derivatives and sunflower diseases to deal with the problem of underproduction. Chellappan, Ranjith, Chaudhary and Sreejeshnath (2024), among other studies, discovered that a sunflower hybrid variety with thorns is not attacked by birds. Furthermore, Amankulova, Farmnov and Musci (2023) found a strong relationship between the proper time of harvesting and sunflower yield. This finding also applies to agronomic practices including farm preparation, planting, fertiliser/manure application, weeding and application of pesticides/insecticides (Puttha, Venkatachalam, Hanpakdeesakul, Wongsa, Parametthanuwat, Srean, Pakeechai & Charoenphun, 2023).

Despite several suggested solutions from previous studies, there was still a research gap regarding sunflower farmers' switching to other agricultural sub-sectors that offer higher gross margins. This study, in particular, narrowed down this research gap by assessing the impact of quality declared seed on sunflower gross margin. Msafiri, Lumanyela and Nyanda (2023) contended that smallholder farmers would not abandon sunflower farming for another agricultural sub-sector if the sunflower gross margin is enough to make them stay.

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2.0 Literature Review

2.1 Sunflower Production and Gross Margin in Tanzania

Sunflower is among the major cash crops in Tanzania, which is grown in abundance in central zonal regions, including Dodoma and Singida (Msafiri et al., 2023). Like other cash crops in the country, sunflower is largely grown by smallholder farmers who account for almost 95% of total production in the country (Msemwa, Macha & Kiwia, 2024). Despite the country being the second next to South Africa in terms of production volume on the African continent, average production of 360 kg per acre was still far below the optimal yield of 900 kg per acre (Lyanga, 2024; Kingu, Msuya & Kalungwizi, 2024). Low gross margin, which is the indirect reflection of underproduction, was reported by Rugeiyamu, Chilingo and Chisanza (2024) as the significant factor behind the poor livelihoods of smallholder sunflower farmers in Tanzania. Puttha et al. (2023) associated this underproduction with the effect of low seed productivity among other agronomic factors. In response to poverty, sunflower farmers tend to switch to other agricultural sub-sectors with the promise of a higher gross margin (Molela et al., 2021).

Gross margin for sunflower is the profit earned or loss incurred after deducting the cost of production from revenue and adding other income related to sunflower farming activities (Molela, Kasoga & Ismail, 2024; Msafiri et al., 2023). It is said to be positive if the cost of production exceeds revenue earned, and it is negative if the situation is opposite. Molela et al. (2021) reported that sunflower farmers, just like other smallholder farmers in Tanzania, did not tend to keep records, hence, the majority did not know gross margin in their operations. Nevertheless, smallholder farmers through bulk selling are roughly able to estimate the gross margin they earn, hence their satisfaction becomes the driving factor of their subsequent decisions (Nyagango, Sife & Kazungu, 2024).

Different hybrid seeds of sunflower are introduced to address the problem of low productivity of conventional seed varieties in the country (Tibamanya, Henningsen & Milanzi, 2022). Even though the introduction of such seed varieties aims at improving farmers' income through productivity but very few smallholder farmers can afford to buy them. The idea of quality declared seed was then conceived to address the challenge of cost-input seeds while maintaining the productivity (Lyakurwa, 2021). How much sunflower farmers earn in excess by switching to quality declared seeds from conventional seeds was the question to be answered by this study. The two main parameters of quality declared seeds that are considered in the computation of gross margin include the productivity per acre and purchasing cost (Tibamanya, Kuzilwa & Mpeta, 2021). Gross margin differential is thus determined by accounting for the differences in such parameters between the quality declared seeds and conventional seeds. This study in particular employed the difference-in-differences model to explore the contribution of quality declared seeds to sunflower farmers' income by measuring the gross margin differential for one year (season 2022 and 2023).

2.2 Cost-Volume-Profit (CVP) Analysis

CVP analysis is a useful model often employed in small businesses to assess profitability based on changes in production volume and cost structures (Aliamutu & Mkhize, 2024). Because of its simplicity, it is the popular approach used by the management of small agribusinesses for decision-making concerning gross margin (Lopes & Costa, 2024). The two concepts, namely CVP and gross margin, are inextricable since they are defined by the same variables, including cost, volume and selling price (Bejinariu, Stancu & Radu, 2024). Molela et al. (2021) mentioned the common costs in sunflower farming, including farm rent, farm preparation, input seeds, planting, weeding, fertiliser/manure applications, bird control, harvesting, storage and transport. Volume is measured by considering the amount of yield obtained from all acres harvested, and it is expressed in kilograms (KG) (Mekkei & El-Haggan, 2019). It is the sunflower seed variety that determines the volume per acre based on the productivity aspect (Molela, 2016; Tibamanya et al., 2022). Selling price, which is used to determine the revenue alongside sunflower volume, is measured by Tanzanian shillings per Kg (Rugeiyamu et al., 2024). Nworie, Okafor, Igwebuike, and Innocent (2023) asserted that gross margin, being referred to as profit interchangeably, is the main component of CVP, hence, it is a part and parcel in decision-making as far as CVP analysis is concerned.

3.0 Methodology

The study employed the quantitative research approach and the longitudinal survey design to study the panel data of sunflower production in two study areas, namely Kondoa and Itigi districts, Tanzania. The design was purposefully selected to meet the conditions for a two-period difference-in-differences (DiD) model under continuous treatment. The two periods under consideration include the sunflower seasons of 2022 and 2023.

General secretaries of agricultural marketing cooperative societies (AMCOS) for sunflower in the respective districts were the units of inquiry, whilst members of such AMCOS were the units of analysis. Based on the national sample census of agriculture (2022), the population of the study was composed of 313,636 and 126,136 members from households in Dodoma and Singida regions engaged in sunflower farming. This population was equivalent to 71.32% and 28.60% of member proportions in Kondoa and Itigi district councils, respectively.

Using Yamane's formula (1967), the calculated sample size was 405 members, estimated from 399.63 value plus 5 more members. Given "N" is the population size and "e" is the confidence interval, then 'n", which is the sample size, was computed using the formula below;

$$n = \frac{N}{1 + N * e^2}$$

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$$n = \frac{439{,}772}{1+439{,}772*0.05^2} = 399.63$$

Furthermore, the study employed the multi-stage stratified sampling technique where simple random sampling was conducted at each stratum, namely AMCOS in Kondoa and Itigi districts. This exercise was preceded by a judgmental sampling technique of selecting 13 AMCOS with a large number of members. As per the TCDC report, URT (2023), all 3 AMCOS were selected from Kondoa with the target of collecting data from 95 members, each chosen randomly. Likewise, from the same report, only 8 AMCOS were selected out of 17 based on the number of members, where 15 members were randomly selected at each AMCOS. Table 1 below shows the estimated and actual sample composition in district-wise.

Table 1: Sample Size

Stratum	Estimated Percentage	Estimated Sample	Actual Percentage	Actual Sample
Kondoa District	71.32%	285	70.00%	250
Itigi District	28.68%	120	30.00%	107
Total	**100.00%**	**405**	**100.00%**	**357**

Source: Authors' Computation from NBS data of 2022

Data were subsequently collected using the questionnaire guide, which was adopted from previous studies of a similar nature and subsequently modified to fit the intended context. Out of 405 filled questionnaires, only 357 met the expectations of the data collection exercise after screening, hence making a response rate of 88.15%, which, as per Sataloff and Vontela (2021), was good enough for further analysis as it exceeded 50%.

The screened data were analysed based on the canonical DiD model using Stata 18 Statistical Program.

Table 2: DID Model

	Treatment	Control
Season 2023 (After QDS adoption)	$G_1 (u_i) / D_i=1$	$G_1 (u_i) / D_i=0$
Season 2022 (Before QDS adoption)	$G_0 (u_i) / D_i=1$	$G_0 (u_i) / D_i=0$
	$(\bar{\breve{G}}_1/D=1) - (\bar{\breve{G}}_0/D=1)$	$(\bar{\breve{G}}_1/D=0) - (\bar{\breve{G}}_0/D=0)$

Source: Authors' Summary of DiD Model

In summary, the DiD model is expressed below:

$$DiD = [(\bar{\breve{G}}_1/D=1) - (\bar{\breve{G}}_0/D=1)] - (\bar{\breve{G}}_1/D=0) - (\bar{\breve{G}}_0/D=0)]$$

Where: $\bar{\breve{G}}_1/D=1$ stands for Gross Margin for treated farmers after QDS

$\bar{\breve{G}}_0/D=1$ stands for Gross Margin for treated farmers before QDS

$\bar{\breve{G}}_1/D=0$ stands for Gross Margin for untreated farmers after QDS

$\breve{G}_0/D=0$ stands for Gross Margin for untreated farmers before QDS

5.0 Findings and Discussion

5.1 Tests for DiD Assumptions

Several assumptions were tested to make sure that DiD was the appropriate model that fits the data well in identifying the causal effect of average treatment effect on the treated sunflower farmers. The two main assumptions tested include the extended time consistency assumption and the parallel trends assumption.

5.1.1 Extended to Time Consistency Assumption

For the DiD to apply, there must be time (*t*) as one of the parameters in measuring the impact of the intervention. As far as this study is concerned, the test of this assumption was to prove that the gross margin differential was determined over time between the sunflower season of 2022 and 2023.

Equation (i) below summarises the extended time consistency assumption

$$\forall \tau,\ T = t \Rightarrow Y_\tau = Y_\tau\ (t) \text{ ....i}$$

Treatment		Control	
Causal Estimand	Satisical Estimand	Causal Estimand	Satisical Estimand
$\breve{G}\,[Y_\tau\ (1) \mid T=1]$ =	$\breve{G}\,[Y_\tau \mid T=1]$	$\breve{G}\,[Y_\tau\ (1) \mid T=0]$	$= \breve{G}\,[Y_\tau \mid T=0]$ ii

Based on the consistency assumption, equation (ii) proves that the statistical estimates in both treatment and control groups can be identified from causal estimates through the observed outcome at time *t*.

5.1.2 Parallel Trends Assumption

It is assumed from the parallel trends that the gross margin differentials between the observed gross margins for both the treatment and control are equal in the absence of treatment. The equation (iii) below summarises the parallel trends assumption.

$$\breve{G}[Y_1(0) - Y_0(0) \mid T=1] = \breve{G}[Y_1(0) - Y_0(0) \mid T=0] \text{ ....iii}$$

5.2 Research Findings

Table 4 below presents the synopsis of inferential results of 357 observed variables composed of both the treated and untreated farmers. *P*-values for all the items are less than 0.05; the effects of QDS on gross margin were statistically significant.

Table 4: DID Statistical Results from Stata

Source	SS	df	MS			
Model	1.2185e+11	3	6.0781e+10	Number of obs	=	357
Residual	2.7461e+11	354	0.9924e+09	F (3, 354)	=	43.13
				Prob > F	=	***
Total	**3.9646e+11**	**356**	1.3738e+09	R-squared	=	0.6731
				Adj R-squared	=	0.6702
				Root MSE	=	29817

Gross Margin	Coef.	Std. Err.	*t*	*P*-Value /*t*|	[95% Conf. Interval]	
Ğ̄1	390.42	344.79	7.18	***	3451.88	42685.65
nearinc	284.94	421.53	1.54	0.031	18769.09	6869.908
Ğ̄1nric	105.48	608.91	0.66	0.005	26547.71	3113.092
_cons	629.07	270.60	24.82	***	68794.20	76907.86

Source: DID Statistical Results

Where *SS* stands for *Sum of Squares*

MS stands for *Mean Squares*

df stands for *degrees of freedom*

t stands for *time*

5.2.1 The Effect of Control Before and After the Use of QDS

The findings show that the gross margin differential attributed to untreated items before and after the use of QDS is TZS. 105.48/Kg. This value is 3.7 times the gross margin differential attributed to treated items before and after the use of QDS. Given that β_u stands for the coefficient between control and gross margin differential, then their relationship is as summarised below;

$$H_{0\_u} = \beta_u = (\breve{G}1/D=0) - (\breve{G}0/D=0) = 0 \quad \text{.......................................} \quad iv$$

Since the p-value (p = 0.005) from Table 4 is less than 0.05, the null hypothesis (H_{0_u}) was rejected, which assumes that the effect of control before and after the use of QDS on gross margin differential is not statistically significant. Hence, the assumption by the alternative hypothesis (H_{1_u}) was upheld that the effect is statistically significant. The relationship between the variables is positive, as testified in Table 5 by a coefficient β = 0.619.

5.2.2 The Effect of Treatment Before and After the Use of QDS

The gross margin differential attributed to treatment before and after the use of QDS was TZS. 390.42/Kg, which is 3.7 times the value attributed to control. If β_t stands for the coefficient between treatment and gross margin differential, then their relationship is represented by the formula below;

$$H_{0\_t} = \beta_t = (\bar{\breve{G}}1|D=1)-(\bar{\breve{G}}0|D=1) = 0 \text{ ....} v$$

Null hypothesis (H_{0_t}) in (ii) was rejected because *p*-value ($p < 0.001$) is less than 0.05, hence the assumption from the alternative hypothesis (H_{1_t}) was upheld. It was deduced that the effect of treatment before and after the use of QDS was statistically significant. The coefficient $\beta = 0.362$ justifies the relationship between the variables since it is positive.

5.2.3 The Effect of Both Control and Treatment Before and After the Use of QDS

The observed gross margin differential of TZS. 284.94/Kg was attributed to the effects of both control and treatment before and after the use of QDS. This combined effect is statistically significant since the p-value ($p = 0.031$) is less than 0.05, leading to the rejection of the null hypothesis stated below.

$$H_{0\_t\&c} = \beta_{t\&c} = [(\bar{\breve{G}}_1|D=1)-(\bar{\breve{G}}_0|D=1)] - (\bar{\breve{G}}_1|D=0)-(\bar{\breve{G}}_0|D=0)] = 0 \text{.............} vi$$

Given that $\beta_{t\&c}$ stands for the coefficient between the combined effects of treatment and control against the gross margin differential, then it was the assumption by the alternative hypothesis that was held. The findings are further supported by the positive relationship between the variables as represented by $\beta = 0.204$ in Table 5 below.

5.3 Discussion of Results

The findings suggest that sunflower farmers earned TZS. 284.94/Kg more when they grew QDS variety than when they grew CSV. This increment in gross margin is equivalent to TZS. 21,370.53 and TZS. 128,223.17 for a one bag of 75 kg and one acre, respectively. Both backwards and forward market linkages attributed to the QDS system played a significant role in this contribution.

Summary results from table 4 above suggest that 67.31% of the gross margin differential of TZS. 284.94/Kg is explained by the combined effect of treatment and control before and after the use of QDS. Table 5 below summarises the effects on gross margin differential after the use of QDS.

Table 5: Gross Margin After the Use of QDS

	P-value	*β*	Gross Margin		Gross Margin Differential		
			TZS/Kg	TZS/Kg	TZS/Kg	TZS/Bag	TZS/Acre
Treated	***	0.362	390.42				
Control	0.005	0.619		105.48			
Combined Effect	0.031	0.204			284.94	21,370.53	128,223.17

Source: Summary Results from Inferential Statistics

6.0 Conclusion and Recommendations

It is concluded from the discussion above that QDS plays a significant role in raising the income of sunflower farmers. The use of this seed variety facilitates both the backwards and forward market linkages, which are essential in empowering smallholder farmers not only in sunflower but also in other crops.

The findings of the study are important to policymakers in devising the sunflower seed policy. The policy implementation will guide smallholder farmers to go for quality declared seed varieties produced in their respective districts. Since it proved positive for the sunflower crop, the policy on seed variety could be extended to other cash crops as well as non-cash crops.

Future research should be conducted on other crops to approve or disapprove the findings of this study. Because of national interest, it is recommended that the Tanzanian government should support such studies both financially and materially.

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