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Impact of Productive Safety Net Programme on Food Security: The Case of Babile District, Somali Regional State, Ethiopia

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Abstract
This Study analyzed the impact of productive safety net programme (PSNP) on household food security status. Multistage stage sampling technique was applied to draw 180 sample respondents considering PSNP participants and non-participants. A survey was conducted to collect primary data from the sampled households. In addition, secondary data were gathered by reviewing relevant documents. Propensity score matching (PSM) technique of impact evaluation preferred to overcome counterfactual problem and selection bias. Analysis results show that PSNP has increased calorie intake by 16.54% (415.26 kilocalories) for participant households. In conclusion, participant households were more likely to be food secured as compared to the non-participant households. The result from the logistic estimator also revealed that participation in PSNP was significantly associated with variables such as sex, education, family size, cultivable land size, house roofing materials, distance from nearest market place and access to improved agricultural inputs. Therefore, such programs should consider the roles of those variables in the selection of participants for desired impact under similar settings.
Keywords: Safety Net Program, Impact, Propensity Score Matching, Food Security, Babile

1. INTRODUCTION

Food insecurity is an enduring, critical challenge in today's world. A total of 842 million people around the world were suffering from chronic hunger in 2011-2014/15, regularly not getting enough food to conduct an active and productive life. Africa remains the continent with the highest prevalence of food security problems, with around one in four of its people estimated to be food insecure. However, level and trends in food insecurity differs within the continent and Sub-Saharan Africa has the highest prevalence of food insecure people (FAO[1], IFAD[2]and WFP[3], 2013).

Ethiopia is one of the most food-insecure, drought and famine affected countries in Sub-Saharan Africa. A large portion of the country's population has been affected by chronic and transitory food insecurity (Anderson *et al.,* 2015). The situation of chronically food insecure people is becoming more and more severe. Food security situation in Ethiopia is highly linked to recurring food shortage and famine, which are associated with recurrent drought. According to FAO (2010) more than 41 percent of Ethiopian's live below the poverty line and above 31 million people are undernourished. Using the threshold of 2,550 kilocalories (Kcal) per adult equivalent per day, 40 percent of Ethiopian households mostly residing in rural parts of the country were food insecure and undernourished (WFP and CSA[4], 2014).

In recent instances, Catley *et al.,* (2016) found that the 2015 Elino-drought was the strongest drought that have been recorded in Ethiopia for 50 years, causing more than 27 million people become food in secured and 18.1 million people requiring food assistance in 2016. Agriculture and pastoral production dropped by 50 to 90 percent in some regions, and failed completely in Eastern part of the country. Several hundreds of thousands of livestock units died in Afar Region, and many more in Somali Region, particularly in Siti and Fafan zones, leading to substantial losses in production (FAO, 2015). This drought was the strongest drought that has been faced in Ethiopian history as reported by different agents like Ethiopian Central CSA, WFP, and FAO. But human death-toll due to this draught was not reported by any government and NGOs (Abduselam A., 2017). Furthermore, there is evidence that climate is already changing leading to serious drought and human live insecurity.

In Ethiopia, humanitarian food requirements for vulnerable households were identified in 2015. The requirements indicated that 4.5 million people needed relief food assistance in 2015 and this figure was more

1 Food and Agricultural Organization
[2] International Fund for Agricultural Development
3 World Food Programme
[4] Central Statistical Authority

than doubled i.e., increased to 10.2 million at the end of the same year. Out of this, 31 percent is from Somali National Regional State which was highly affected by recurrent drought (UNICEF Ethiopia, 2015).The government bilateral ground assessment on food security of 2017 was released and indicated that food aid requirement was 5.6 million people at the end of 2016 and the figure increased to 7.8 million at the beginning of 2017.

The major reason of food security problem in the country could be attributed to reliance on rain fed agriculture. For instance more than 90 percent of rural households rely on livestock, crop production or combination of the two as a main occupation of their livelihood. In Somali National Regional State, 38 percent of rural households solely rely on livestock for their livelihoods as compared with 5 percent across the whole rural Ethiopia. Due to this farming system, rural households in Somali National Regional State tend to be poorer and particularly food unsecured mainly due to recurrent drought that eroded their productive assets (WFP and CSA, 2014). The 2016/2017 Humanitarian Requirements Document (HRD) estimated that more than 124,000 people had become Internally Displaced Persons (IDPs) in Somali National Region State. A recent joint assessment also predicted that by the end of January 2017, many more people would lose their food and water reserves in the Fafen zone including Babile, Gursum, Harshin, Awbare, and Tulli-Guled.

To address this problem, the Government launched a large scale consultation process called the New Coalition for Food Security (NCFS) in 2003. As a result of this initiative, the government made significant changes to its existing food security program, scaling up its level of intervention and incorporating a larger scope PSNP (MoARD[1], 2010).The PSNP, which began in 2005, is government's initiative in response to the above scenario. Its objective is to provide food/or cash transfers to chronically food insecure households in a way that prevents asset depletion at the household level and generates productive assets (Alemayehu *et al.,* 2008).

The PSNP is one of the major components of the food security program implemented by the Ethiopian government with the joint support of donors that aimed at providing more reliable and timely support to chronically food insecure households. It extends support to those households through two channels: public works (PW) which provides temporary employment on rural infrastructure projects such as road construction and direct support (DS) which delivers unconditional transfers to the households with disabled members. PSNP operates as a safety net, intended to enable households to smoothen consumption so that they do not need to sell their productive assets in order to overcome food shortages (MoARD, 2014).

From empirical point of view, there have been studies which show that PSNP has contributed to smooth households' food consumption, while some others contrarily prove that there is no significant difference between PSNP participants and non-participants on their levels of consumption. Our assessment indicates prior studies in this regard have generated varying results and showed procedural shortfalls. For instance study by Habtamu (2011) indicated that participation in PSNP reduces the asset size. Yitagesu (2014) who conducted similar study at Kebribeyah district of Ethiopian Somali National Regional State used data only from program beneficiaries before and after the program without examining the non-beneficiaries' food security status leading to counterfactual problem. Moreover, the study did not control for other factors that could affect food security status of the households as it relied on simple descriptive statistics.

Our objective is to evaluate the impact of productive safety net programme (PSNP) on household food security status for the selected study area. As such the study contributes to consolidating works in the PSNP evaluation as it covers longer time period; that is, 12 years since program was launched. To achieve this purpose the study uses Propensity score matching method. Unlike previous studies, selection bias that often complicates development program impact evaluation is also addressed by the current study.

2. RESEARCH METHODOLOGY

2.1 Study Area

This study was conducted in Babile[2] Woreda[3] (*Babile Somali*) which is located in the Ethiopian Somali Regional State. It is one of the eight Woredas of Fafan zones of the region. The Woreda is located at some 561Km to the East of Addis-Ababa, capital city of Ethiopia, 72 Km to the West direction of Somali region's capital Jigjiga. It is bordered by Gursum Woreda in the North East, Goljono Woreda in the East, Nogob (former Fik) Zone in the East and in South, South West by Oromia regional State. The Woreda has a total population of 92,702 out of which 50059 (54 percent) are Male (CSA, 2007[4]).

Babile Woreda is located 70°90'" North Latitude and "43°00'" East Longitude. The total land size of the district is about 1,325 km^2 from which 19, 823 hectare is cultivable land; the annual rate of temperature is 26.5^{0}c with uneven rainfall distribution (CSA, 2007). The Woreda is rich in natural resources including hot

[1]Ministry of Agriculture and Rural Development
[2]Babile is politically organized both under Somali and Oromia regional states as two separated districts due to its fluid border pastoralist and agro-pastoralism phenomena. Thus, this study specifies the study area as Babile Somali, to avoid this confusion.
[3] Woreda is a unit of administrative structure in Ethiopia and it has equal weight with district.
[4]Latest Census conducted in Ethiopia was in 2007.

springs, mineral water, elephant sanctuary and Daketa valley (which is also called as the "Valley of Marvels"). It is known for its variety of wildlife and astonishing rock formations, which lies just seven kilometers from Babile town.

2.2. Sampling and Method of Analysis

Babile Woreda selected purposively due to its wide coverage of the PSNP programme. Then after following, a stratified random sampling technique was employed to select three kebeles and a total of 180 households using formula by Kothari (2004) given by:

$$n = \frac{Z^2 * p * q * N}{(N-1) * e^2 + Z^2 * p * q}$$

A total 60 households were randomly selected from each Kebele and following an equal share principle to distribute sampled households in to program participants and non-participants

2.2.1 Estimation Strategy: Logit Model Specification

Following Kothari (2004), the logistic distribution function of determining factors in livelihood status of households is specified as follows:

$$P_i = E(y = 1|X_1) = \frac{1}{1 + e^{(\beta_0 + \beta_1 X_1)}} \quad (1)$$

Equation (1) can be simplified as:

$$P_i = \frac{1}{1 + e^{Z_i}} \quad (2)$$

The probability that a given household is PSNP participant is expressed by equation (2) while, the probability for being program non-participant is given by:

$$1 - P_i = \frac{1}{1 + e^{Z_i}} \quad (3)$$

Therefore, the odds ratio can be written as:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \quad (4)$$

Now $\frac{P_i}{1-P_i}$ is simply the odds ratio in favor of participation in PSNP- the ratio of the probability that a household would be influenced by the program to the probability of that they are not influenced. Finally, taking the natural logarithms of the odds ratio of equation (4) would result in the logit model as indicated below.

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = \ln[e^{Z_i}] = e^{Z_i} \quad (5)$$

Where: Z_i= is a function of n explanatory variables (X_i) which can also be expressed as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_n X_n \quad (6)$$

Where β_0 is an intercept β_1, β_2 ,. .., β_n are partial slopes of the equation in the model. L_i is natural logarithm of the odds ratio, which is not only linear in variable X but also linear in the parameters. X_i is vector of explanatory variables for household i. Finally, we incorporate disturbance term $\mu_i$such that $\mu_i \sim N(0, \sigma^2)$. Thus, the complete logit model specified as below:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_n X_n + \mu_i$$

2.2.2 Propensity Score Matching (PSM) Model

In case of binary treatment of the programme, the treatment indicator D_i equals 1 if individual i receives treatment and 0 otherwise. In the context of this study, treatment group refers to households who are programme participant while control group are those who do not participate in the programme. The potential outcomes are then defined as:

$Y_i(D_i)$ for each individual i,where $i = 1, 2, \ldots, n$, then the treatment effect of individual i can be expressed as;

$$T_i = Y_i(1) - Y_i(0) \quad (7)$$

This is used only to evaluate potential observable outcomes for each individual and leads to counterfactual problems since other unobservable individual's characteristics which are known as counterfactual outcomes are there. Hence, estimating individual treatment effect Ti is not possible. Therefore, Average treatment effect on the treated (ATT) is developed which is specified as:

$$\tau_{ATT} = E(\tau|D = 1) = E[Y(1)|D = 1] - E[Y(0)|D = 1] \quad (8)$$

Therefore, the counterfactual mean for those being treated represented by $-E[Y(0)\,|\,D = 1]$, which is actually not observed.

Following Caliendo and Kopeinig (2008) and further manipulation, we have the following expressions:

$$E[Y(1)|D = 1] - E[Y(0)|D = 0] = \tau_{ATT} + E[Y(0)|D = 1] - E[Y(0)|D = 0] \quad (9)$$

τ_{ATT} is so-called 'self-selection bias'; then the true parameters of $\tau_{ATT}$is only identified if $E[Y(0)|D = 1] - E[Y(0)|D = 0] = 0$. By rearranging equation (9), we have:

$$[\mathrm{Y}(0)|\mathrm{D}=1]-\mathrm{E}[\mathrm{Y}(0)|\mathrm{D}=0]=0 \Rightarrow \tau_{ATT}=\mathrm{E}[\mathrm{Y}(1)-\mathrm{Y}(0)] \quad (10)$$

Common support region given by: (overlap) $0 < p(\mathrm{D}=1|\mathrm{X}) < 1$

Ultimately, the general PSM model specified as a fallow:

$$\tau_{ATT}^{psm}=E_{\mathrm{p(x)}\,|\,\mathrm{D}=1}\{\mathrm{E}[\mathrm{Y}(1)|\mathrm{D}=1,\mathrm{P}(\mathrm{X})]-\mathrm{E}[\mathrm{Y}(0)|\mathrm{D}=0,\mathrm{P}(\mathrm{X})]\} \quad (11)$$

This shows that PSM estimator is simply the mean difference in outcomes over the common support region; appropriately weighted by the propensity score distribution of participants.

3. RESULTS AND DISCUSSION

3.1 Data and Summary Statistics

The study utilized primary data collected during January and February 2017 from 180 households of three Kebeles of Babile Woreda. Table 1 and Table 2 present characteristics of respondent households with respect to PSNP participation. Statistical analysis for this study revealed that there is a significant difference between program participants and non-participants in terms of their age, educational background, family size, and distance from the nearest market and cultivable land holding size. But, the study result shows insignificant difference between the two groups in terms of livestock holding capacity which might be due to the recurrent drought which eroded thousands of livestock as the area was highly distressed by drought.

Table 1: Summary statistics and mean difference t-test for continuous variables

Variable	Participants		Non-participants		Total		
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev	t-value
Age of HH head	37.57	5.91	37.35	5.60	37.46	5.74	0.25NS
Education level	6.55	5.31	3.23	4.24	4.89	5.07	4.64***
Family size	8.20	2.86	6.17	1.99	7.20	2.66	5.49***
Active labor force	3.29	1.57	3.39	1.46	3.34	1.51	0.44NS
Cultivable land	1.73	0.94	2.39	1.12	2.06	1.08	4.29***
Livestock (TLU)	5.12	2.99	5.54	3.68	5.33	3.35	0.84NS
Distance from mrkt	61.67	27.75	39.44	23.06	50.55	27.77	5.73***
Food shortage Mnth	5.93	1.23	5.31	1.25	5.62	1.31	1.85*

Source: survey result, 2017.

*** & * indicates significance at 1% and 10% significant levels, respectively.

As shown in Table 1, sampled number of male headed households is greater than female headed households. However, programme participant households had significantly higher percentage of female headed households as compared to non-participating households, Sex of household head appeared statistically significant implying female-headed households had high probability to participate in the food security programs than their male counterparts.

With three marital statuses observed in the study sample, the majority (85%) is married and there was no significant difference between participant and non-participant households with regard to this variable (Table 2).

Study assessed sample households housing status through asking the roofing material used. Greater proportions of households live in houses with roofs made of grass; roofing type comparison between program participants and non-participants shows significant difference (Table 2).

In terms of whether improved seed was used by the households, out of total sampled households 59.44 percent used improved seed and 40.56 percent did not. Improved seed use comparison by participation revealed that 36.11 percent of PSNP participants had access to improved seed while 23.33 percent for non-participant households. Ch2 test between the two groups in the use of improved seed use showed statistically significant difference (Table 2).

Table 2: Summary statistics and proportional difference Chi2-test for dummy variables

Variable	Category	PSNP participants		PSNP Non-participants		Total		χ2	P-value
		N	%	N	%	N	%		
Sex	Male	47	26.11	58	32.22	105	58.33	2.76	0.09*
	Female	43	23.89	32	17.78	75	41.67		
Marital status	Married	76	42.22	77	42.78	153	85.00	0.41	0.82NS
	Widowed	7	3.89	5	2.78	12	6.67		
	Divorced	7	3.89	8	4.44	15	8.33		
Roofing	Grass	73	40.56	50	27.78	123	68.33	13.58	0.00***
	Iron roof	17	9.44	40	22.22	57	31.67		
Improved seed use	Yes	65	36.11	42	23.33	73	59.44	12.19	0.00***
	No	25	13.89	48	26.67	107	40.56		
Marriage form	Monogamy	54	30	66	36.67	120	66.67	3.60	0.05**
	Polygamy	36	20	24	13.33	60	33.33		

Source: survey result, 2017.
***, **, & * indicates significance at 1%, 5% and 10% significant levels, respectively.

3.1.1 Outcome variable and mean difference test

Mean calorie intake per adult equivalent considered outcome variable to measure food security impact of program participation. Estimated mean calorie intake per adult equivalent was 2939.91 and 2505.72 for PSNP participant and non-participant households respectively. Result indicates PSNP participant households had higher calorie intake of 434.19 Kcal/AE per day compared to non-participant households. The mean difference between the groups was highly significant (at p=0.00). The finding agrees with that of Anwar (2015) and Abiyot (2012).

3.2 Model Estimation Results

In order to get the most preferred propensity score equation, different model specifications were employed. The number and sign of key variables and accuracy of the whole model are important parameters used to select a particular propensity score equation. The choice between different models have been made by adding and eliminating different variables as well as taking logarithmic form of variables in the specified binary logit model (see Table 3).

The selection of these variables has been based on economic theory and previous empirical studies, and only relevant variables related to the intervention and outcome were considered in the propensity score function. The first model (Model1) was selected based on model selection criteria of propensity score matching technique.

Table 3: Model Specification of the Study

Model variables	Model 1	Model 2	Model 3	Model 4
Gender (1= male)	0.73*	0.74	0.628	0.71
Age	-0.02	-0.02		
Education(1= educated)	0.13*	0.12**	0.13**	0.13**
Family size	0.37***	0.37***	0.39***	
Active labor forces	-0.09	-0.08	-0.07	-0.01
Farm land size	-0.62**	-0.60**		
Months of food gap	-0.06	-0.06	-0.01	0.02
Livestock ownership	-0.02	-0.03	-0.05	
Roofing type	-1.10*			
Market distance	0.03**	0.03**	0.03**	0.03**
Use of improved inputs	0.92*			
Monogamy (1= yes)	0.57			
Polygamy (1= yes)		0.59	0.43	0.38
Married (1= yes)	-0.39			
Widowed (1= yes)		-0.95	-0.94	-0.95
Divorced (1= yes)		-0.54	-0.05	-0.04
Iron sheet roofed		-1.10*	-0.94	-0.84
Age^			-0.92	-1.18
Farm size^			-1.23**	-1.21**
Family size^				2.5**
Tropical livestock unit^				-0.233
_cons	-2.11	-3.29	-1.57	-3.03

Note: *, **; and *** denote statistically significant variables at 10%, 5% and 1% respectively.
Source: estimated based on survey data (2017)

3.2.1 Propensity Score Estimation

For this study, thirteen explanatory variables were selected to be included in the model based on previous studies and theories. Among these variables, the programme participation decision is significantly influenced by seven explanatory variables such as sex and education level of the household head, family size, cultivable land units owned, house roofing materials, distance from nearest market place and access to improved agricultural inputs.

Looking at the standard errors and estimated coefficients given in Table 4,sex and education level of the household head, family size, distance from nearest market place and access to improved input of the household heads had positive and significant effect on the decision of the PSNP participation. However, cultivable land owned and house roofing materials had negative and significant effect on the PSNP participation decision. In contrast to previous studies such as Yitagesu (2014) and Habtamu (2011) on the impact of PSNP, this study found that age of household heads, livestock holding capacity and active labor forces do not seem to explain participation, while household head education level has positive significant effect on programme participation decisions.

Table 4: Participation Model Results of Estimated Propensity Score

Variable	Coefficient
Gender (male =1)	0.73
	(0.43)*
Age in years	-0.02
	(-0.05)
Married (1= yes)	-0.39
	(-0.36)
Educational level in years	0.12
	(0.05)***
Family size (number)	0.37
	(0.11)***
Active labor forces (number)	-0.09
	(-0.15)
Cultivable land owned	-0.62
	(0.21)***
Months of food gap (number)	-0.06
	(-0.17)
Tropical livestock unit	-0.02
	(-0.06)
House type (Roofing material)	-1.09
	(0.47)**
Distance to nearest market center	0.03
	(0.01)***
Use of improved inputs (1= yes)	0.92
	(0.42)**
Polygamy (1= yes)	0.57
	(-0.45)
Constant	-2.11
	(-2.39)
Sample households 180	Prob>chi2 0.00
LR chi2(13) 97.30	Log likelihood -76.12
	Pseudo R2 0.38

Note: Standard errors in parentheses
*, ** and *** denote statistical significance at 10%, 5% and 1% respectively
Source: Own estimation (2017).

3.2.2 Matching Estimated Propensity Score for Treated and Controlled Groups

This technique applies the common support region, which is the area that contains the minimum and maximum propensity scores of treatment and control group households respectively. As shown in Table 5, based on the minima and maxima criterion, the common support region lies between 0.03 and 0.95.In other words, households with estimated propensity scores less than 0.03 and greater than 0.95were not considered for the matching exercise and discarded from the sample. As a result of this restriction on the common support condition, out of 180 sampled households 20 households (13 from PSNP participants and 7 from non-participants) were discarded from the analysis and considered as the opportunity cost of using matching estimator.

Table 5: Estimated Propensity Scores Distribution by Sample Household

Group	Observation	Mean	Std. Dev.	Min	Max
Participants Households	90	0.73	0.23	0.03	0.99
Non-participants Households	90	0.27	0.27	0.02	0.95
Total Households	180	0.5	0.34	0.02	0.99

Source: Own estimation based on survey 2017.

3.2.3 Treatment Effect on the Treated (ATT)

The estimation result provided in Table 6 gives supportive evidence of statistically significant effect of PSNP on household Calorie intake important proxy to household food security status. After controlling for pre-intervention differences in characteristics of the PSNP participant and non-participant households, it was found that, on average, the program has increased calorie intakes of the participating households by 415.26 Kcal/AE[1],

[1]Adult equivalent

and this shows that due to PSNP intervention, the treated household's calorie intakes increased by 16.41 percent as compared to the controlled households.

Generally, the study results in Table 6 show that since 2009, the year of the program intervention begun in the district, PSNP had brought positive impact on household calorie intake significant at 1 percent probability level.

Table 6: Results of program Impact (ATTs)

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Calorie intake	ATT	2945.09	2529.84	415.26	107.85	3.85***

Note: *** indicates significance at 1% probability level.
Source: Own estimation based on survey 2017.

3.2.4 Sensitivity Analysis

Table 7 provides the result of sensitivity analysis on significant outcome variable indicate that the PSNP impact estimators ATTs are insensitive to unobserved selection bias and are a pure effect of PSNP participation on households' food security status (calorie intake),

Table 7: Sensitivity Analysis Using Rosenbaum Bounding Approach

p-critical values(the upper bound of Wilcoxon significance level (Sig+) at different critical value of Gamma(e^{γ})									
Outcome	e^{γ}=1	e^{γ}=1.25	e^{γ}=1.5	e^{γ}=1.75	e^{γ}=2	e^{γ}=2.25	e^{γ}=2.5	e^{γ}=2.75	e^{γ}=3
Kcal/AE	P<0.00	0	0	0	1.1e-16	4.3e-15	9.3e-14	1.1e-12	9.2e-12

Source: Own estimation result 2017.
Note: e^{γ} is the natural logarithm of odds of differential due to unobserved factors where Wilcoxon significance level for the significant outcome variable i.e., calorie intake in this case.

4. CONCLUSION AND FUTURE POLICY IMPLICATIONS

This paper used propensity score matching technique to analyze the impact of productive safety net programme on household food security status of households. Analysis result shows that the likelihoods of participation in PSNP are influenced by variables such as sex and educational status of the household head, family size, and cultivable land units owned, house roofing materials, distance from nearest market place and access to improved agricultural inputs.

On comparing with non-participant households, program participants are found to be more likely to be food secured. This finding is intuitively appealing since the programme have been implemented in this area for more than ten years. The result of sensitivity analysis shows that estimated ATT for calorie intake (the outcome variable) is insensitive which clearly indicates its robustness.

Based on study findings, three basic future policy implications were developed: First, the study found that PSNP had significantly increased household calorie intake. This is an encouraging indicator for programme implementers, and funding agents. Therefore, channeling further efforts on this indicator is important for more pronounced impact of the programme. Second, concerned bodies including Woreda Agriculture and Rural Development offices, and food security sector programs need to improve the provision of short term as well as long term training for their experts in order to build their capacity in the implementation plan of the program. Third, given certain degree of variations of program impact studies, current study recommends further research with greater scope and at different locations on the impact of PSNP and other Food Security Program on household food security.

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