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A synthesis of Ethiopian agricultural technical efficiency: A meta-analysis

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In Ethiopia, technical efficiency studies started about three decades ago. These studies have reached different conclusions regarding agriculture efficiency based on technical efficiency scores. This study represents the first attempt to use meta-analysis to examine the mean technical efficiency estimates in agriculture in Ethiopia. The current study employed 45 frontier studies published from 1993 to 2014 for the meta-analysis. The study employed fractional regression to model for the meta-regression analysis. The result of the study shows that there is no publication bias in technical efficiency studies in Ethiopia. The meta-analysis result shows the overall mean technical efficiencies are 68 and 71% based on fixed effect model and random effect model, respectively, suggesting that there are still opportunities for improvement in the efficiency of Ethiopian agriculture. The result also shows that technical efficiency was found to be decreasing over years for studies carried out in all the four regions together (Tigray, Amhara, Oromia, and South). Overall, the study obtained moderator variables (that is, wheat, maize, sample size, food crop, number of inputs) significantly affecting the estimation of the reported mean technical efficiencies in primary studies across the four meta-regression model specifications. The finding of the decline in technical efficiency over years implies that even though there is a scope of improving efficiency in the country, government should also consider side by side introduction and dissemination of new agricultural technologies to reverse the decreasing technical efficiency. This will ultimately boost the country's agricultural and food production. Besides, the results call upon researchers and academicians to be curious in identifying study-specific attributes, which are essential for modeling farm-level efficiency.

Key words: Meta-analysis, technical efficiency, fixed effect and random effect models.

INTRODUCTION

In Ethiopia, a range of policies and investments have been pursued to boost agricultural production and productivity, especially with respect to staple food crops to ultimately reduce poverty in the country at different

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times. The main goal of these efforts is to enhance and speed up the availability and adoption of improved seed, chemical fertilizers, and extension services for small-scale, resource-poor farmers, particularly those cultivating staple food crops, ultimately improving agricultural performance.

In order to document and justify the efforts done thus far, scholars have filled this gap using frontier approaches to technical efficiency (TE) measurement. To this end, a plethora of technical efficiency studies have been conducted in the country.

Although these TE literatures suggest evidence that the efforts of the governments have led to improvements in both production and productivity, these studies in literature in the country have reached different conclusions regarding agriculture efficiency based on TE scores. Some have revealed high scores (Ahmed, 2014; Tefaye and Beshir, 2014), while others have revealed low scores (Asres et al., 2013; Abebe, 2014; Yami et al., 2013). Obviously, the empirical estimates of technical efficiency will vary across several factors, e.g., the methodology used, the data type used, and the country or region where the studies are situated (Odeck and Bråthen, 2012).

Given TE studies in Ethiopian agriculture, to the best of the author no statistical study has summarized the available information across studies using meta-analysis in the country to provide overview of how frontier estimates of smallholder farmers' TE vary with different studies' circumstances. This study will be a pioneer attempt in the country in the realm of meta-analysis.

Henceforth, the current paper presents the results of a meta-analytical regression model that seeks to summarize the available literature on smallholder agricultural technical efficiency in Ethiopia. In doing so, the paper provides the readers with inference based on overview of how frontier estimates of smallholder farmers' TE vary. Thus, the study poses two questions that seek to answer:

(1) How did the average technical efficiency estimates of Ethiopian agriculture develop (that is, their direction) over the years?
(2) To what extent do variations in the study's characteristics influence reported average technical efficiency estimates from the case studies?

Review of stochastic frontier methodology and meta-analysis

Farrell (1957) was the pioneer that developed the concept of technical efficiency based on input and output relations. According to Farrell, technical efficiency is related to the physical input and output relation and refers to the success of the producer in approaching the frontier (the maximum possible) from a given set of input. If a producer approaches the frontier, its level of technical efficiency will be high, and this is attained by efficient utilization of the inputs.

The stochastic frontier production function, which was described by Aigner et al. (1977) and Meeusen and Broeck (1977), decomposes the error term into two components. A systematic component permits random variation of the frontier across firms, and captures the effects of measurement errors, caused from outside the firms' control, random shocks and other statistical noise. A one sided component captures the effects of inefficiency relative to the stochastic frontier. This is the strength of stochastic frontier production function and makes it increasingly popular among researchers.

There are two standard ways by which firm-level efficiency could be implemented under stochastic frontier production function: the primal frontier function (production or distance frontier function) and the dual frontier function (cost, revenue or profit frontier function), depending on the direction of the research, data availability or the decision to impose behavioral objectives on the study.

Meta-analysis

Meta-analysis is a quantitative method of combining the results of independent studies, exploring heterogeneity, and synthesizing summaries if appropriate. The principal purpose of a meta-analysis of observational studies is not to derive an overall estimate of effect but to investigate the reasons for differences in estimates among studies and to discover patterns of estimates (Card, 2012).

Meta-analysis is quite popular in medical and marketing research, but few reported studies in agricultural and resource economics have employed the technique to investigate how study-specific characteristics influence the empirical estimates from several outcomes over time (Ogundari and Brümmer, 2011).

Thus far, meta-analysis in agricultural efficiency is applied to investigate the efficiency estimates from primary studies by different authors. Thiam et al. (2001) applied meta-analysis first time in technical efficiency studies in developing countries, while Bravo-ureta et al. (2007) used a meta-regression analysis including 167 farm level technical efficiency (TE) studies of developing and developed countries. In Africa, Ogundari and Brümmer (2011) have used meta-analysis in efficiency studies in Nigeria.

EMPIRICAL MODEL

Publication bias test

There have been at least two attempts to produce significance tests to identify publication bias. These are Begg's test (Begg and Mazumdar, 1994) and Egger's test (Egger et al., 1997).). Both methods test whether the study estimate is related to the size of the study. The test proposed by Egger et al. (1997) is algebraically identical to a test that there is no linear association between the treatment effect and its standard error. Furthermore, you can formally test for asymmetry by regressing effect sizes onto sample sizes. The presence of an association between effect sizes and sample sizes is similar to an asymmetric funnel plot in suggesting publication bias (Card, 2012). In this study, the publication bias will be evident if the association between sample size and mean technical efficiency estimates is negative and significant.

In the current study, the regression method was employed to test for asymmetric funnel plot in suggesting publication bias.

$$MTE_i = \beta_0 + \beta_1 n_i + \varepsilon_i \quad (1)$$

where MTE_i mean technical efficiency of study i, n_i sample size of study i and ε_i error terms.

Meta-regression model

The thrust of this model is to provide answer to the second questions. In this model, the dependent variable will be the reported mean technical efficiency estimates of each primary study. Authors undertaking a meta-regression have used different regression models. For instance, Bravo-ureta et al. 2007 in their meta-regression analysis employed tobit model. On the other hand, Ogundari (2009) and Ogundari and Brümmer (2011) employed truncated regression model. In the current study, fractional regression is employed for the meta-regression analysis. Ogundari (2014) used fractional regression to model for the meta-regression.

$$MTE_i = \beta_0 + \beta_d x_{di} + \sum_{k=1}^{k} \beta_k x_{ki} + \varepsilon_i;\ \varepsilon_i \sim (0, \sigma_\varepsilon) \quad (2)$$

The Quasi-Maximum Likelihood Estimation (QMLE) method is the asymptotically efficient and consistent method used in estimating the fractional regression model (Ogundari, 2014). The STATA software was used in estimating the model using generalized linear model (glm) command with family (binomial), link (logit), and robust standard error option. The description of the variables employed in the regression model are presented in Table 1.

Data source and collection

The primary studies used for this meta-analysis were compiled from different sources. To this end, a variety of sources were used to compile the selected case studies in the present study, mainly Google scholar, Libraries and other economic database such as web of science. Besides, Masters' Theses were collected from the Website of Haramaya University, Ethiopia.

The inclusion and exclusion criteria used in selecting studies for the present analysis were the study reports mean efficiency estimates, data year, sample size functional forms, parametric models and cross-sectional studies. Accordingly, the study selected 45 frontier studies published from 1993 to 2014 for the current analysis.

Hence, the study collected around 20 aspects of studies, such as the characteristics of data, estimation, inclusion of control variables, region, and information on the publication outlet.

RESULTS AND DISCUSSION

Descriptive statistics

Table 2 presents the descriptive summary of the selected primary case studies employed in this meta-analysis. In Table 2, the average TE ratio of the total set of studies is 0.708 that is slightly lower than the Cobb-Douglas functional form. In terms of functional forms, the result shows that the Cobb-Douglas production functional form yields on average a higher estimate (0.717) than the Translog functional form (0.644).

With regard to the distribution of the reported mean efficiency of the selected primary studies, Figure 1 portrays the distribution of the mean technical efficiency estimates of the studies and it was found that the distribution is normal for the whole sample. However, when the efficiency estimates plotted by grouping the sample using publication type (Journal and Thesis), it was observed that the distribution skewed to the right for those unpublished studies (thesis) and normal for the published studies (journals).

Furthermore, a closer look at the result of Table 2 of efficiency estimates by disaggregating it across various moderator variables, the results revealed more information; for instance, with regard to product type maize crop yielded higher efficiency. While in relation to output measure, the result shows that studies that focus on single output reported higher efficiency estimates. The disaggregation by region shows that the Tigray Region shows the highest efficiency estimates; however, the sample is very small. Hence, the interpretation of this result should be taken with care.

Table 2 also presented that compared to studies published on journals, unpublished studies (thesis) reported higher efficiency. While the result obtained studies conducted in the 2000s have higher efficiency estimates compared to studies in 1990s and 2010s.

Meta-regression analysis

Before employing the meta-regression model, first we have to look at the publication bias and the heterogeneity problems using funnel plot and regression model (Card, 2012) to identify the publication bias and forest plot to identify the heterogeneity problem.

Exploring publication bias

Published studies do not represent all studies on a specific topic. Publication selection exists when editors, reviewers, or researchers have a preference for statistically significant results (Stanley, 2005). Publication bias is one type of publication selection. Publication bias refers to the possibility that studies finding null (absence of statistically significant effect) or negative (statistically significant effect in opposite direction expected) results are less likely to be published than studies finding positive effects (statistically significant effects in expected direction) (Card, 2012). Publication bias can be detected either visually using funnel-plot or

Table 1. The moderator (independent) variables and their description.

Variable	Description
MTI (MTE_i)	Mean efficiency score reported
Data year (x_{di})	Year of the data that a primary study used
Wheat (x_{1i})	Equal to 1 if article focused on wheat crop production and 0 otherwise
Maize(x_{2i})	Equal to 1 if article focused on maize crop production and 0 otherwise
Publication type (x_{3i})	Equal to 1 if article is published in journal and 0 if thesis
Sample size (x_{4i})	Number of observation in a primary study
Food Crop (x_{5i})	Equal to 1 if article focused on food crop production and 0 otherwise
Output measure (x_{6i})	Equal to 1 if article is with aggregated output measure and 0 if single output
Number of inputs (x_{7i})	Number of inputs in a primary study
Functional form (x_{8i})	Equal to 1 if article used Cobb-Douglas functional form and 0 if Translog functional form
National_dummy (x_{9i})	Equal to 1 if article is conducted in Tigray, Amhara, Oromiya and South regions and 0 otherwise
South_dummy (x_{10i})	Equal to 1 if article is conducted in South region only and 0 otherwise
Amhara_dummy (x_{11i})	Equal to 1 if article is conducted in Amhara region only and 0 otherwise
Oromiya_dummy (x_{12i})	Equal to 1 if article is conducted in Oromiya region only and 0 otherwise
Tigray_dummy	Equal to 1 if article is conducted in Tigray region only and 0 otherwise (reference)
Dummy_1990s (x_{13i})	Equal to 1 if article is conducted in the 1990s and 0 otherwise
Dummy_2000s (x_{14i})	Equal to 1 if article is conducted in the 2000s and 0 otherwise
Dummy_2010s	Equal to 1 if article is conducted in the 2010s and 0 otherwise (reference)

Table 2. Summary statistics for the moderator variables used in meta-regression model.

Category	Moderator variables	Number of case studies	Number of observations	Mean technical efficiency	Standard deviation
All case studies	-	45	50	0.7085	0.1159
Functional form	Cobb-Douglas	39	44	0.7171	0.1160
	Translog	6	6	0.6448	0.1029
Product	Wheat	12	13	0.7311	0.1133
	Maize	8	8	0.7622	0.0831
	Food crops	37	41	0.7029	0.1172
Output measures	Aggregated output	12	14	0.6759	0.0948
	Single output	33	36	0.7211	0.1220
Region	All four region (National)	5	8	0.6979	0.1340
	Tigray	4	4	0.7537	0.1007
	Amhara	12	12	0.6901	0.1478
	Oromiya	23	24	0.7182	0.1027
	South	4	4	0.6785	0.0392
Publication	Journal	26	31	0.6867	0.1318
	Thesis	19	19	0 .7439	0.0743
Data year	Dummy_1990s	6	7	0.6513	0.0908
	Dummy_2000s	13	16	0.7254	0.0985
	Dummy_2010s	25	25	0.7155	0.1328

Egger test.

Funnel plots are commonly used to investigate publication and related biases in meta-analysis (Sterne and Harbord, 2004). Funnel plots are a visual tool for

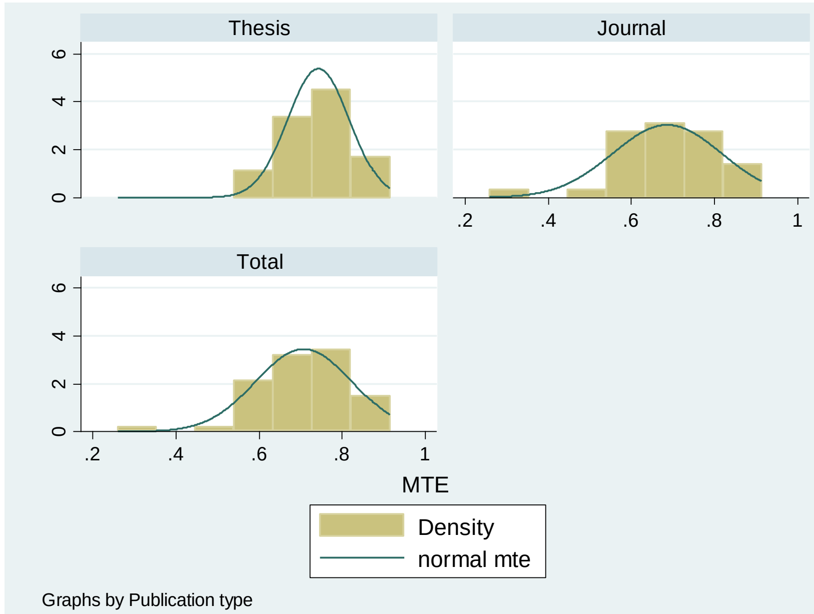

Figure 1. Distribution of mean technical efficiency.

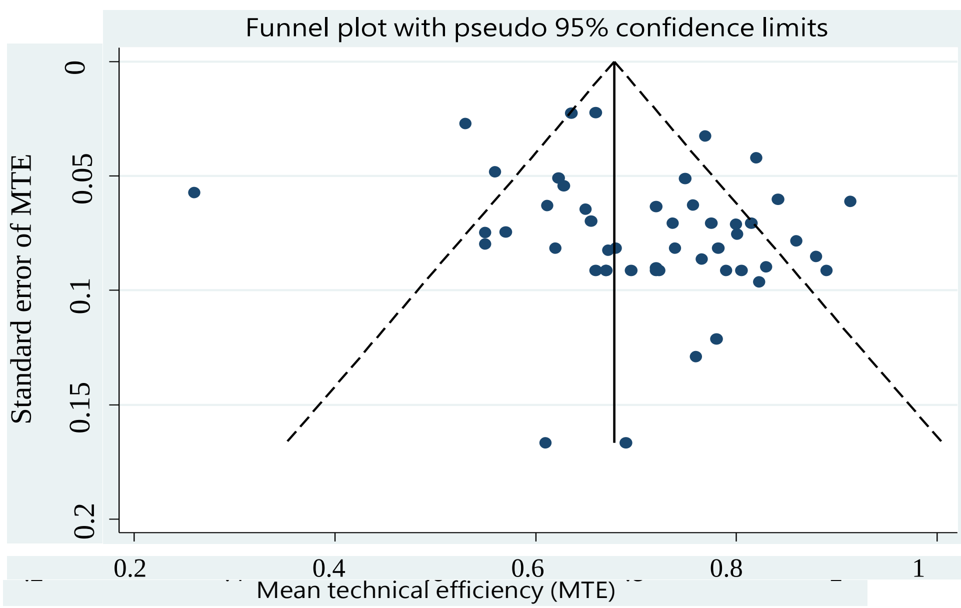

Figure 2. Funnel plot.

investigating publication and other bias in meta-analysis. They are simple scatter plots of the treatment effects estimated from individual studies (horizontal axis) against a measure of study size (vertical axis) or some other indicator of the precision of the estimate like standard deviations, inverse standard error or inverse variance (weight). Standard error is likely to be the best choice for the vertical axis (Sterne and Egger, 2001). Asymmetry in funnel plots may indicate publication bias. Figure 2 shows the funnel plot for the mean technical efficiencies of the sampled studies. It is found to be asymmetric.

Figure 3 shows the funnel plot stratified by publication type. As shown in Figure 3, compared to studies published in journals, theses' studies show some asymmetry. Whereas the majority of the studies out of the confidence intervals are from studies published on journals. This implies the main source of the heterogeneity came from studies published on journals.

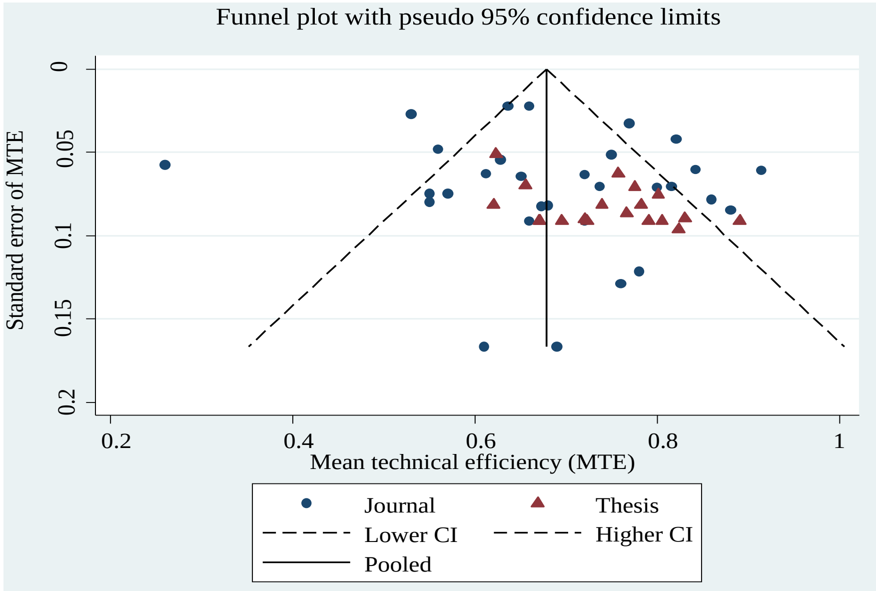

Figure 3. Funnel plot stratified by publication type.

Table 3. Regression model for publication bias.

MTE	Coef.	Std. Err.	t
Sample size	-0.0000547	0.0000372	-1.47
_cons	0.7257538	0.0226482	32.04***

Significance tests for publication bias

In Table 3, though the association between the mean technical efficiency estimates and sample size is found to be negative, the regression model result shows that the effect of sample size on mean technical efficiency is not significant. This suggests the absence of publication bias. The economic interpretation of the result is that, as sample size increases, the mean reported ATE from all the selected studies tends to approach 0.725.

Henceforth, these tests show that the selected frontier studies used in the Meta regression analysis can be relied on as a close or true representation of the distribution of technical efficiency in Ethiopian agriculture for further analysis.

Detecting heterogeneity among studies

Heterogeneity in meta-analysis refers to differences in underlying effects, so that estimates are more variable across studies than would be expected by chance alone. Heterogeneity can be graphically explored using forest plot. In this study to identify heterogeneity, forest plot is used. A forest plot provides at a glance a complete visual summary of results from individual studies included in the meta-analysis. Figure 4 also present the forest plot with 49 observations. The squares in the plots represent the mean technical efficiency estimated in each of the 49 observations, with the area of each square proportional to the studies weight in the meta-analysis. Figure 4 presents the forest plot for the mean technical efficiency for each study by publication type (that is, journal or thesis) using the random effect meta-analysis model. As shown in Figure 4, those studies published on journals have an average mean technical efficiency less than the unpublished studies (Theses). Besides, the forest plot portrays studies published in journals are more heterogeneous (I2=82.4%) while studies not published (Theses) are relatively homogenous. Hence, this makes the overall meta-analysis average mean technical efficiency estimate to be substantially heterogeneous (I2=75%) due to the heterogeneity of the published studies. Figure 5 shows the forest plot using the fixed effect model. Both results yield different estimates.

Moderator analysis: Meta-regression (MRA)

First, the study attempts to provide the first research

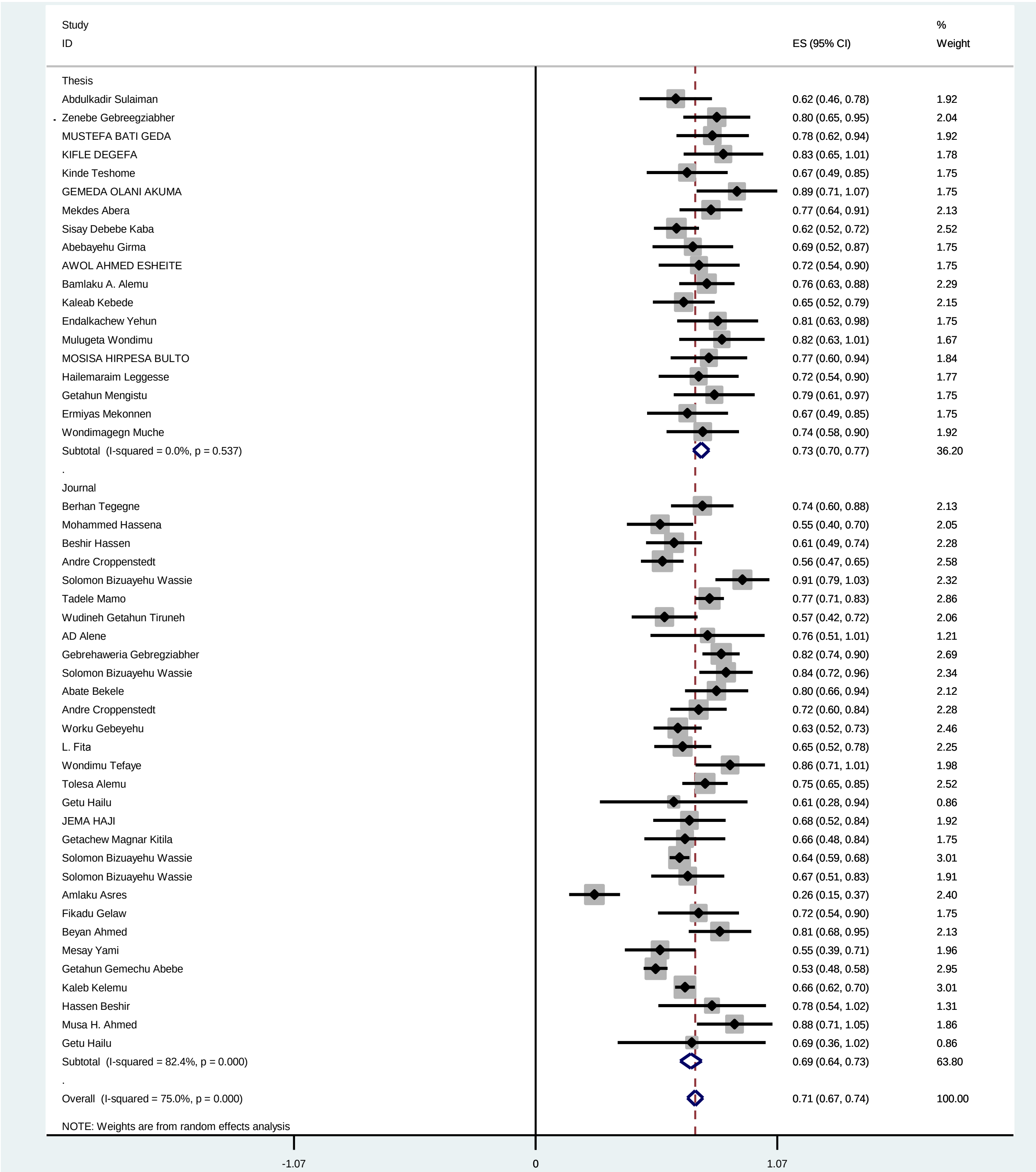

Figure 4. Forrest plot stratified by publication: Random effect.

question using the bubble plot with a fitted line of the relationship between the reported mean technical efficiency estimates and the year of survey in primary study. Figure 6 shows a positive linear relationship between reported mean efficiency estimates per study and year of survey for the whole sample under

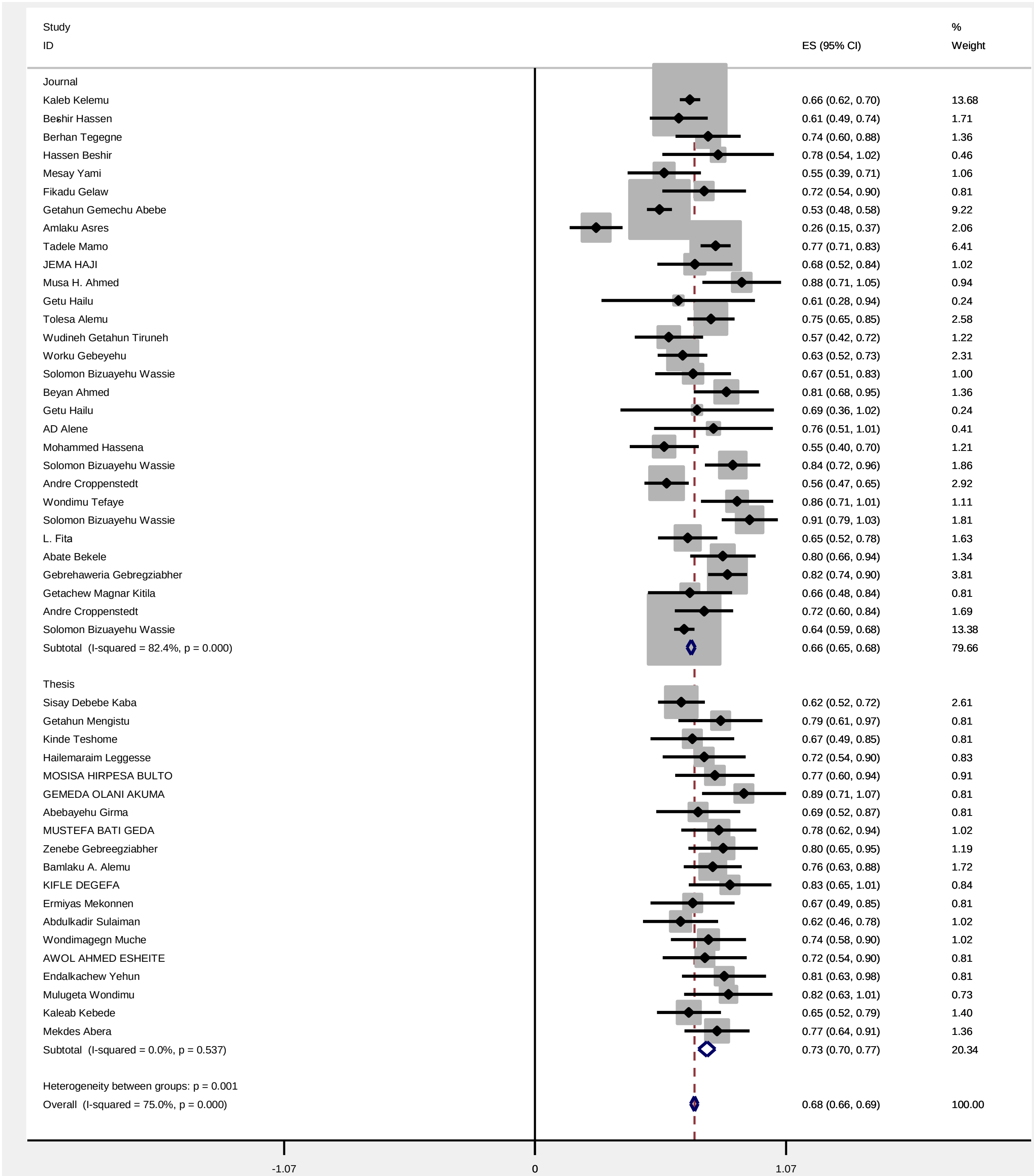

Figure 5. Forrest plot stratified by publication: Fixed effect.

consideration. However, when the relationship is stratified by publication type and pooled plot for each group are displayed (that is, by Journals and Thesis) presented in Figures 7 and 8, the results are mixed. The results reveal evidence of linear positive correlation for journal studies and negative linear correlation for thesis studies. However, the regression result using only single covariates yields non-significant results. Henceforth, this result might be inconclusive.

Subsequently by including other study characteristics

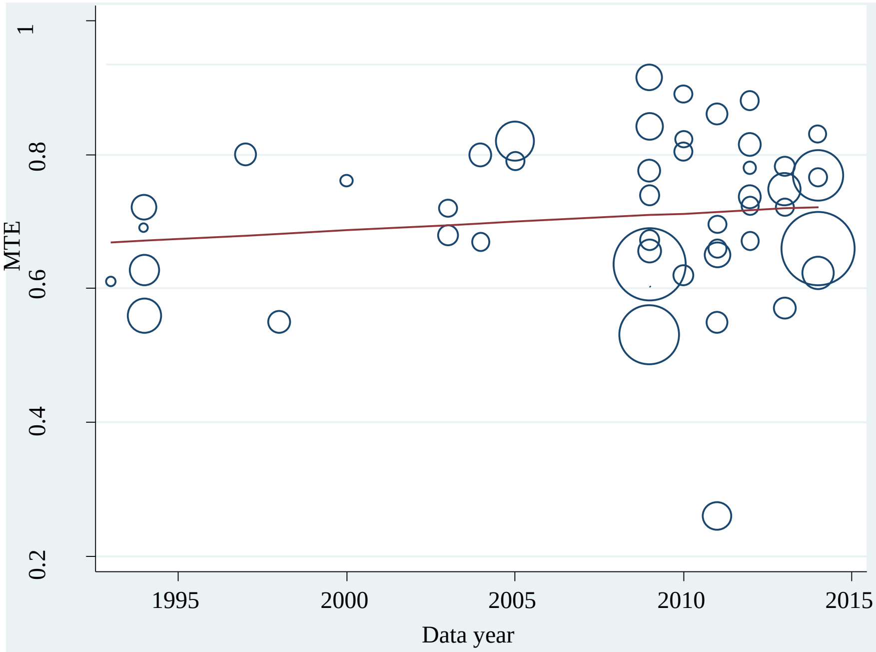

Figure 6. “Bubble plot” with fitted meta-regression line for the whole sample.

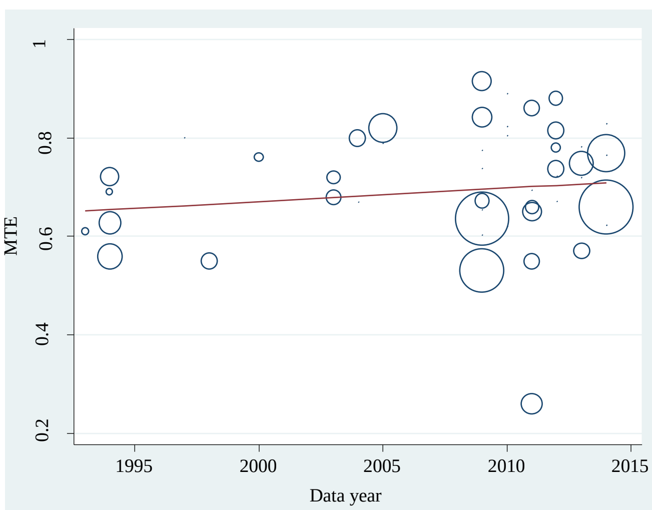

Figure 7. Bubble plot with fitted meta-regression for the published journals.

variables, a further investigation of the relationship between the estimates of the mean technical efficiency and year of survey using the meta-regression analysis was conducted using fractional regression model. For this, the study estimated five different models to enhance robustness for the variable data year particularly and for the all moderator variables employed generally. Ogundari (2014) employed five different models in meta-analysis study of technical efficiency in Africa to provide robustness check especially for the variable data year of the primary studies. The results of all the five fractional regression models are presented in Table 4. With regard to the models, model 1 is employed for all the moderator variables. While the rest models are estimated by stratifying with the national variable (model 2 for studies conducted in all the four regions, that is, Tigray, Amhara, Oromiya and South and model 3 for studies conducted either of the four regions) and publication type (that is, journal studies and thesis studies).

Among the results of the models, only model 3 shows a

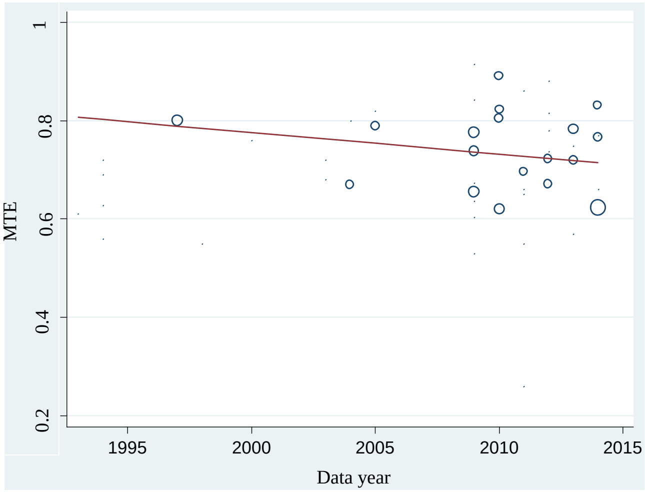

Figure 8. Bubble plot with fitted meta-regression for the theses.

negative significant result for the relationship between data year and mean technical efficiency estimates, suggesting that the mean technical efficiency estimates from the selected primary case studies decrease significantly, as survey in the primary study increases for studies conducted on all the four regions. The plausible explanation for this might be that on average, the efficiency levels of Ethiopian agriculture and food production have declined over the years (1993-2014). This finding is consistent with study by Ogundari (2014) who obtained the mean efficiency estimates from studies that decrease significantly as year of survey in the primary study increases. However, this result is not robust and should be taken in caution. First sample size of the selected primary studies conducted for all the four regions is small and is not found significant in the rest of the models.

With regard to the effects of the other study's characteristics on the reported efficiency estimates, we again take a closer look at the results of the five models presented in Table 4. As per the results, more or less a similar significant pattern was obtained for models 1, 2, 4 and 5 while model 3 is different a little bit.

Studies with a focus on wheat crops reported significantly higher efficiency estimates, compared to other crops and livestock studies on models 1, 2 and 4. The plausible explanation for this might be in relation to other crops and livestock; smallholder farmers have more access to improved wheat technologies and extension services than other crops and livestock. While studies with a focus on maize crops reported significantly lower mean efficiency estimates for models 3 and 5 and higher mean efficiency for model 4 as compared to studies with other crops and livestock.

The findings show that studies with a focus on food crops reported significantly lower efficiency estimates, compared to other crops and livestock studies for models 2 and 5, while model 3 yields a positive significant effect on efficiency estimates. A study by Ogundari (2014) showed that studies on food crop were found to have insignificantly lower mean efficiency estimates compared to studies on non-food crops. By contrast, studies on cash crops were found to have higher and significant efficiency estimates (Ogundari and Brummer, 2011). But similar to the finding of the present study, Bravo-Ureta et al. (2007) found consistently lower mean efficiency scores for studies on grain crops.

With regard to region or location effect, the empirical results show that South (models 2 and 3), Amhara (models 4 and 5) and Oromiya (model 2) regions report significantly lower mean efficiency estimates, while studies carried out in all the four regions (National_ dummy) show insignificantly lower mean efficiency estimates compared to Tigray region. This suggests that regional differences to some extent play a significant role in the systematic heterogeneity that exists in the reported mean efficiency estimates based on specific attributes in the study.

The mean technical efficiency estimates of studies using an aggregated dependent variable (Output type) appears to be higher as compared to studies with non-aggregated output measures according to the result of model 2; but this result is in conflict with the result of model 3.

The regression model also revealed that the studies published on journals have a significant negative impact on the reported mean technical efficiency estimates for model 2 but it was found insignificant for the rest of the models. This implies that compared to the thesis studies (unpublished), studies published on journals yield lower mean technical efficiency estimates. This result is in contrast with the finding of Ogundari (2014).

Furthermore, it is observed that input size (number of inputs) of the selected studies has a significant positive impact on the reported mean technical efficiency estimates across all the models with the exception of model 3. A similar finding was observed by Bravo-Ureta et al. (2007) and Ogundari (2009).

The study also obtained that the mean technical efficiency of studies surveyed between 2000 and 2009 years was significantly lower as compared to that of studies conducted between 2010 and 2014 (reference) for the model 5; while this result is insignificant for models 1, 2, 3 and 4. This implies technical efficiency estimates decreased over the years 2000 to 2014.

Conclusions

This study represents the first attempt to use a meta-analysis to examine the mean technical efficiency estimates in Ethiopian agriculture. It investigates whether Ethiopian agricultural efficiency levels have been improving or not as well as the variation of the reported mean technical efficiency estimates by different

Table 4. Meta-regression results.

Moderator variable	Total (Model 1)	Tigray, Amhara, Oromiya and South (Model 2)	National (Tigray, Amhara, Oromiya and South) (Model 3)	Journal (Model 4)	Thesis (Model 5)
	Coef.	Coef.	Coef.	Coef.	Coef.
Wheat	0.3430* (0.2029)	0.8082*** (0.1835)	0.4110 (0.4240)	0.5266** (0.2137)	-0.0031 (0.1415)
Maize	0.2599 (0.2053)	0.1120 (0.1864)	-2.2850*** (0.7820)	0.7209 (0.27689	-0.4949***(0.1100)
Publication type	-0.1358 (0.2053)	-0.4024*** (0.1530)	-	-	-
Sample size	-0.0004* (0.0002)	-0.0015** (0.0007)	0.0016** (0.0007)	-0.0004 (0.0003)	-0.0026*** (0.0003)
Food Crop	-0.0432 (0.2462)	-0.5108*** (0.19701)	2.1739*** (0.7767)	0.2636 (0.2608)	-0.9274*** (0.1182)
Data year	-0.0264 (0.03645)	0.0158 (0.0423)	-0.2590*** (0.0637)	-0.0231 (0.0658)	-0.0600 (0.0414)
Output type	-0.0776 (0.2361)	0.6042*** (0.2296)	-3.5366*** (0.9206)	-0.4495 (0.2876)	-0.2800 (0.6292)
Number of inputs	0.3331*** (0.1070)	0.3006*** (0.0832)	-	0.3429** (0.1489)	0.12697*** (0.0314)
Functional form	0.2352 (0.2091)	0.0698 (0.1682)	-	0.3489 (0.2521)	-
National_dummy	0.1289 (0.4045)	-	-	-0.3547 (0.4140)	-
South_dummy	-0.1908 (0.2296)	-0.5738*** (0.1540)	-	0.5607 (0.6425)	-0.6986*** (0.0753)
Amhara_dummy	-0.3682 (0.2254)	-0.2903 (0.1893)	-	-1.1712** (0.5854)	-0.3004* (0.1627)
Oromiya_dummy	-0.0996 (0.1897)	-0.3001* (0.1652)	-	-0.3525 (0.5026)	-
Dummy_1990s	-0.3514 (0.5479)	0.1585 (0.6459)	-	-0.0258 (1.0971)	-
Dummy_2000s	-0.1176 (0.3519)	-0.1475 (0.3476)	-	0.2334 (0.6241)	-0.2729** (0.1312)
_cons	52.3641	-31.3604	519.0151*** (127.4074)	45.4867 (132.2933)	122.7375 (83.2285)
Log pseudolikelihood	-16.7900	-13.2327	-3.1357	-11.6967	-4.8049
AIC	1.5614	1.6608	1.7839	1.7722	1.9700
BIC	-95.5701	-66.3846	-8.1680	-49.4888	-12.8128

characteristics which included: survey year, year of publication, functional form used, sample size, number of inputs used, location of the study, product type and output measure. The study employed fractional regression to model for the meta-regression analysis. The result of the study shows there is no publication bias in Ethiopian agricultural efficiency studies. The meta-analysis result shows the overall mean technical efficiencies are 68 and 71% based on fixed effect model and random effect model, respectively, suggesting that there are still opportunities for improvement in the efficiency of Ethiopian agriculture. The result also shows that technical efficiency was found to be decreasing over years for studies carried out in all the four regions together (Tigray, Amhara, Oromia, and South). Overall, the study obtained moderator variables (that is, wheat, maize, sample size, food crop, number of inputs) significantly affecting the estimation of the reported mean technical efficiencies in primary studies across the four meta-regression model specifications.

The finding of the decline in technical efficiency over years implies that even though there is a scope of improving efficiency in the country with the available agricultural technologies, government should also consider side by side introduction and dissemination of new agricultural technologies to reverse the decreasing technical efficiency. This will ultimately boost the country's agricultural and food production.

Besides, the results call upon researchers and academicians to be curious in identifying study-specific attributes, which are essential for modeling farm-level efficiency.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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