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# Impact of Technology Adoption on Household Income: The Case of Tef in Dendi District, Ethiopia

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**Abstract:** Tef is the most important cereal crop and the main staple food for more than 70 million people. It is the second-largest crop in terms of the area of production next to maize. But, the average productivity of the crop is very low compared to other cereal crops, and the spatial variability of the productivity of the crop is very high across different districts and peasant associations within the region and across different regions of the country. This variability may arise from different factors like the adoption of high-yielding improved varieties, implemented agronomic practices, soil and environmental conditions, and others. Therefore, this research was intended to assess the impacts of the adoption of improved and high-yielding tef varieties on the improvement of household income in the Dendi district, taking 210 sample households from five peasant associations. Descriptive and econometric data analyses were done. The propensity score matching method and logistic regression model were used for econometric data analysis. Accordingly, the result revealed that household heads who adopted improved and high-yielding tef technologies on average get more income of 7943 birr compared to household heads that are non-adopters of tef technologies. Therefore, improving the awareness of tef farmers towards adoption of high yielding improved tef technologies will contribute to improving the national income generally, and the livelihood of the farm households specifically.

**Keywords:** Impact, Adoption of Tef, Income, Dandi District, PSM, Logistic Regression

## 1. Introduction

Tef is the most important indigenous cereal crop in Ethiopia, which is the leading crop in terms of the area of production, that is about 3 million hectares, and the second in total production next to Maize [1]. Tef serves as the main staple food for more than 70 million people, and its straw is highly utilized as livestock feed [2, 3]. It is also getting popularity across the globe as it is a gluten-free and healthy food [4]. Tef is grown for food and animal feed in di erent countries like Australia, the United States, Israel, the Netherlands, Eritrea, India, Pakistan, South Africa, Uganda, Mozambique, and Kenya [4-6].

Tef is a nutritionally rich crop and contains essential and important nutrients like carbohydrates, protein, fat, fiber, and minerals [7]. It is also rich in some minerals like iron which is significantly higher than the amount that we can get from bread wheat [8]. But, the average productivity of tef is lower compared to other cereals as different factors are contributing to this low productivity. Tef production in Ethiopia is facing immense production constraints that affect the yield potential of the crop, including lodging, low inputs, inappropriate sowing method, post-harvest losses, and using low yielding local varieties [9, 10].

The agricultural sector of Ethiopia in general is mainly characterized by small scale and subsistence, which is inevitably affected by different factors like extreme weather, poor agronomic practices, lower rates of inputs, and low qualities of inputs. To overcome these problems and improve production and productivity, the Ethiopian government is recently implementing cluster farming as a new farming approach in which the leading and coordination role was given to agricultural research centers, regional state, governmental and non-governmental organizations. Technical and material support like provision of training, seed, fertilizer, and machinery, certification of product quality, and facilitation of market linkage. This approach is expected to accelerate technology dissemination, enhance information about production and marketing, and also enhance the efficiency of farm households through the diffusion of best practices across individual members.

Tef, (Eragrostis tef) is the most important cereal crop serving as a staple food for the majority of Ethiopian people that contributes more to improving food and nutritional security, and serving as a source of income for small-holder farmers to cover their expenses. Its cultivation area is expanding from time to time over many years and continued to date [11]. But, the productivity of tef is lower compared to other cereals, and its spatial variability across the regions of the country and across different zones within the regions is high for different reasons. Among the contributing factors, using low-yielding local varieties, drought stress, lodging effects, shattering, and poor agronomic practices are reported to be the most significant factors [12]. The existence of such factors significantly affects farmers' efforts to improve production, productivity, income, and food security.

According to the report [1], tef productivity is showing wider spatial variabilities across different regions of the country. For example, during the 2020/21 main production season, the regional average of Tef productivity varied from 19.31 quintals per hectare in the Oromia region to 15.19 quintals per hectare in the Benishangul Gumuz region. Similarly, there are also spatial variabilities across different zones, in which it varied from 15.84 (in the southern) to 17.67 quintals per hectares (in the northern) zones of the Tigray region; from 10.09 (in waghimra) to 22.65 quintals per hectare (in east gojam) zone of Amhara region; from 15.50 (in east Bale) to 21.26 quintals per hectare (in southwest Shewa) zones of Oromia region; from 10.53 (in Mao-Komo) to 15.44 quintals per hectare (in metekel) zones of Benishangul Gumuz region; and from 12.74 (in segen people) to 18.10 quintals per hectare (in Sidama) zone of Southern nations and nationalities region.

Based on the information listed above, adoption of the new tef technology may be one of the sources of variation, and similarly, there may be income differences between tef technology adopters and no-adopters. Therefore, this research is intended to assess the impact of tef technology adoption on household income in the study area.

# 2. Research Methodology

### *2.1. Description of the Study Area*

The study was conducted in the Dendi district, West Shewa zone, Oromia regional state, Ethiopia. The district lies between 38°10'54" East and 9° 01'16" North and is also found at 80 km to the west of the capital city, Addis Ababa. The district is bordered by Dawo and Wenchi districts on the south, by Ambo and Ilfata on the west, by Jaldu on the north, and by Ejersa Lafo on the east. The district has 79,936.29 hectares of land (39,227.5 cultivated, 14,912.36 grazing, 7,925.93 forest and 14,829.5 uncultivated and 3,041 homestead and others), 38 kebeles (35 rural and 3 urban), 200715 population (42953 urban and 157762 rural), 19231 households (85.6% male and 14.4% female). The mean annual rainfall of the district is 1094 mm (ranging from 750mm to 1170mm), mean temperature of 16.3°C (ranging from 9.3°C to 23.8°C), and mean altitude of 2200masl. T*ef*, wheat, barley, maize, and sorghum are the major cereals crops grown in the district [13].

### *2.2. Sampling Technique and Sample Size Determination*

Multi-stage sampling technique was employed. Dendi district was purposively selected based on its tef production potential. Of 38 kebeles in the district, 24 tef producing kebeles were identified. Then, five kebeles were randomly selected from a total of 24 tef producing kebeles. Finally, a total of 210 sample households were randomly selected. The sample size of 210 was determined using [14], which can be expressed as follows:

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

Where n = sample size, N = population size and e = level of precision.

The sample households from each kebeles were selected using the proportional sampling method of:

$$ni = \frac{(Ni)(n)}{\sum Ni} \quad (2)$$

Where ni = sample from the $i^{th}$ kebele,

Ni = total population in the $i^{th}$ kebele.

ΣNi = population of the five sample kebeles, and

n = total sample from the district.

### *2.3. Data Type, Source, and Method of Analysis*

Both primary and secondary data were used in this research. The primary data was collected from sample households using structured and semi-structured questionnaires. The collected data were analyzed using descriptive, inferential, and econometric data analysis methods. Mean, percentage, minimum and maximum were used to report descriptive data analysis. Similarly, the t-test and chi-square test were used to infer the mean difference of descriptive data analysis. For econometric data analysis, the propensity score matching method and logistic regression model were employed.

In a quasi-experiment, the independent variables are manageable, but the problem is selection bias as program participants were not randomly selected to the conditions. In such cases, the propensity score matching method can be used to reduce the selection bias if some conditions are fulfilled. The propensity score is the probability of belonging to the treatment, and it accounts for the selection bias of the auxiliary variables, but not for the variables not measured (hidden bias). It replaces a number of variables with a single score, that is propensity score.

Propensity scores can be estimated using different statistical methods. Logistic regression is the most frequently used method. The logistic regression model specifies the propensity score as a logistic function of m predictor variables (P1, P2, …, Pm). In this method, estimation of the propensity score is done first using logistic regression that can be expressed as follows:

$$Pi = \frac{1}{1+e^{-(\beta o+\beta iXi)}} \quad (3)$$

Where Pi = probability of adopting the technology for the $i^{th}$ participant.

$\beta_i$ = are the model parameters.

The equation of the probability of adoption can be simplified as:

$$Pi = \frac{1}{1+e^{-Zi}} \quad (4)$$

Using the probability of adoption, the probability of non-adoption can be derived as:

$$1 - Pi = \frac{1}{1+e^{Zi}} \quad (5)$$

The odds ratio, the ratio of the probability of adoption to non-adoption, can also be derived as:

$$\frac{Pi}{1-Pi} = \frac{\frac{1}{1+e^{Zi}}}{\frac{1}{1+e^{-Zi}}} = e^{Zi} \quad (6)$$

Taking the natural logarithm of the odds ratio, it can be further simplified as:

$$Li = \ln e^{Zi} = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_n X_{ni} + \varepsilon \quad (7)$$

Where: Li = natural logarithm of the odds ratio in favor of adopting tef technology.

β's = are the parameters to be estimated.

Xi's = are the vectors of explanatory variables, and

ε = is the error term.

# 3. Result and Discussions

## 3.1. Descriptive Results

The majority of the interviewed sample households (66%) were adopters of tef technologies, while the rest (34%) were non-adopters during this specific production season.

***Table 1.*** *Descriptive results for dummy variables by the adoption of tef.*

| Variables | | Adoption of tef technologies | | | $X^2$ |
|---|---|---|---|---|---|
| | | No | Yes | Total | |
| Sex of the household head | Female | 17 | 21 | 38 | 2.3 |
| | Male | 55 | 117 | 172 | |
| Access to credit services | No | 66 | 105 | 171 | 7.6*** |
| | Yes | 6 | 33 | 39 | |
| Access to off-farm income | No | 42 | 62 | 104 | 3.4* |
| | Yes | 30 | 76 | 106 | |
| Access to extension contact | No | 28 | 26 | 54 | 9.9*** |
| | Yes | 44 | 112 | 156 | |
| Cooperative membership | No | 45 | 52 | 97 | 11.7*** |
| | Yes | 27 | 86 | 113 | |
| Access to information | No | 20 | 34 | 54 | 0.2 |
| | Yes | 52 | 104 | 156 | |

**and *** the significance levels at 10% and 1% probability levels*

*Source:* Own computation from survey data.

According to the result in Table 1, from 210 sample households, 38 (18%) were female-headed households, while 172 (82%) were male-headed. 21 out of 38 female-headed households (55%), and 117 out of 172 male-headed households (68%) were tef technology adopters. From this result, the mean difference of tef adoption does not significantly differ for female and male-headed households as the chi-square test was not significant.

Access to credit services showed positive and significant relation with households' decision to adopt tef technologies. Table 1 showed that 84% of households having access to credit services are adopters of tef technologies while only 38.5% of households without access to credit were adopters of tef technologies, and the chi-square test also revealed that the mean difference was significant at 1 percent. This result is similar to the one reported by Habtewold [15].

Access to off-farm income also showed a positive relation with the household decision to adopt tef technologies. According to the result in Table 1, 72% of households having access to off-farm income were adopters of tef technologies, while 60.7 of the households without access to off-farm income were adopters of tef technologies. From the chi-square test, the mean difference is statistically significant at 10 percent probability level. This is in line with the finding reported by Milkias and Muleta [16].

According to the result, households having access to extension services are more adopters of tef technologies. As displayed in Table 1, the majority of the sample households 156 (74%) have access to extension services out of which 112 (72%) were adopters of tef technologies. The chi-square test also showed that the mean difference of extension was significantly different at 1 percent for the adoption of tef technologies. This result is similar with the one reported by Wossen et al. [17].

Based on the result in Table 1, 113 (54%) of the sample households were members of cooperatives, while 97 (46%)

were not. This shows that households that are members of cooperatives are more likely to adopt tef technologies. The result of the chi-square test also showed that there is a significant mean difference of adoption of tef technologies between cooperative members and non-members. This result is similar with the one reported by Wossen et al. [17].

Finally, access to different sources of information was also assessed and the result revealed that there is no significant difference between adopters and non-adopters regarding access to different sources of information.

***Table 2.*** *Descriptive results of continuous variables by the adoption of tef.*

| Variables | Adopters | | Non-adopters | | Combined | | t-test |
|---|---|---|---|---|---|---|---|
| | mean | Std.dev | mean | Std.dev | mean | Std.dev | |
| Age of the household head | 41.4 | 11.3 | 46.5 | 11.1 | 43.2 | 11.4 | -3.1*** |
| Education status of the head | 4.9 | 3.7 | 2.8 | 2.5 | 4.2 | 3.5 | 4.4*** |
| Tef farming experience | 20.3 | 10.4 | 22.3 | 10.3 | 20.9 | 10.4 | 1.4 |
| Livestock holding (TLU) | 5.9 | 2.7 | 4.1 | 2.1 | 5.4 | 2.6 | 5.1*** |
| Family size (ME) | 2.9 | 1.3 | 2.8 | 1.1 | 2.8 | 1.2 | -0.9 |
| Land owned (hectares) | 1.3 | 0.6 | 0.9 | 0.5 | 1.2 | 0.6 | 3.7*** |
| Market distance (KM) | 1.1 | 0.5 | 1.4 | 0.6 | 1.2 | 0.5 | -3.3*** |
| Distance from FTC (Minutes) | 17.7 | 16.6 | 21.5 | 16.9 | 19.0 | 16.7 | -1.6* |

**and *** the significance levels at 10% and 1% probability levels*
*Source:* Own computation from survey data.

According to the result in Table 2, the mean age of non-adopters is 46.5 years, while that of adopters is 41.4. This shows that the age of the household head is negatively related to the household's decision to adopt tef technologies, and the mean difference is statistically significant at a 1 percent significance level. This result is similar with the one reported by Shita et al. [18].

Educational status of the household head is positively and significantly related with the adoption of tef technologies. From the result in Table 2, the mean educational level for adopters was 4.9 schooling years, while that of non-adopters was 2.8 schooling years. The t-test also showed that the mean difference was statistically significant at 1 percent probability. This result is similar with the findings reported by Jaleta et al. [19].

Livestock holding also positively and significantly affected households' decision to adopt tef technologies. According to this result, the mean livestock holding for adopters and non-adopters were 5.9 and 4.1 respectively. This is to mean that households having a greater number of livestock tend to adopt tef technologies compared to those households having a smaller number of livestock. The t-test result showed that the difference is statistically significant at 1 percent probability. This result is in line with the finding reported by Workineh et al. [20].

Land ownership is positively related with sample households' tef technology adoption decision, to mean that household heads having larger land size are more likely to adopt tef technologies compared to those household heads owning less land. From the result in Table 2, the tef technology adopters own 1.3 hectares of land while those non-adopters own 0.9 hectares. The t-test result also revealed that the mean difference was statistically significant at 1 percent. This is in contrary with the finding reported by Workineh et al. [20].

Distance from the main market and distance from farmers' training center both showed negative and significant relation with households' decision to adopt tef technologies. The result in Table 2, showed that the mean distance from the market and farmers' training center was 1.1 km and 17.7 minutes respectively for adopters, 0.5km and 16.6 minutes respectively for non-adopters. From this result, households living nearer to the main market and farmers' training center are more likely to adopt tef technologies. The t-test result also revealed that the mean difference was significantly different for both. This result is similar with the one reported by Zegeye [21].

### *3.2. Econometric Results*

For econometric data analysis, the propensity score matching method (PSM) was employed. Logistic regression was the model used to estimate the propensity score using adoption as dependent and 14 variables as independent, and the result is presented in Table 3.

***Table 3.*** *Estimation of the propensity score for impact assessment.*

| Adoption | Coef. | St. Err. | t-value | p-value |
|---|---|---|---|---|
| Sex of the head | 0.217 | 0.477 | 0.46 | 0.649 |
| Age of the head | -0.126 | 0.041 | -3.04 | 0.002 |
| Education of head | 0.058 | 0.067 | 0.88 | 0.380 |
| Family size (ME) | -0.061 | 0.134 | -0.46 | 0.648 |
| Farm experience | 0.106 | 0.046 | 2.32 | 0.021 |
| Livestock holding (TLU) | 0.159 | 0.102 | 1.55 | 0.120 |
| Land owned | 0.372 | 0.393 | 0.95 | 0.343 |
| Access to information | 0.044 | 0.393 | 0.11 | 0.911 |

| Adoption | Coef. | St. Err. | t-value | p-value |
|---|---|---|---|---|
| Coop membership | 0.031 | 0.420 | 0.07 | 0.941 |
| Market distance | -0.412 | 0.363 | -1.14 | 0.256 |
| Distance from FTC | -0.006 | 0.012 | -0.49 | 0.625 |
| Off-farm income | 0.923 | 0.407 | 2.27 | 0.023 |
| Extension contacts | 0.840 | 0.421 | 2.00 | 0.046 |
| Credit access | 0.504 | 0.530 | 0.95 | 0.342 |
| Constant | 1.888 | 1.302 | 1.45 | 0.147 |
| Mean dependent var | 0.656 | SD dependent var | 0.476 | |
| Pseudo r-squared | 0.223 | No. of obs. | 209.000 | |
| Chi-square | 41.529 | Prob > chi2 | 0.000 | |

*Source:* Own computation from survey data.

Before going for the econometric model, variance inflation factor and multicollinearity tests were done. As can be seen from Table 3, the model performance is good as the model fitness is significant at 1 percent and the pseudo-r-square is fairly low (0.2), which means adopters and non-adopters have similar characteristics favorable for comparison between adopters and non-adopters.

Using the estimated propensity score, restriction of the common support region was followed. According to the result in Table 4, the common support region is the region between 0.0759814 and 0.9219624. Based on this result, 33 households, (3 non-adopters and 30 adopters) were excluded from the model as they were out of the common support, and not used to do matching.

***Table 4.*** *Restriction of the common support region.*

| Variable | Observation | Mean | Std. dev | Minimum | Maximum |
|---|---|---|---|---|---|
| P score (0) | 72 | .482196 | .2337602 | .0179827 | .9219624 |
| P score (1) | 137 | .7465831 | .1990134 | .0759814 | .9871869 |

*Source:* Own computation from survey data.

Following the restriction of the common support region, choosing the matching algorithm was done.

***Table 5.*** *Choosing the matching algorithm.*

| Matching Methods | Matched sample | Balanced variable | Pseudo $R^2$ |
|---|---|---|---|
| The Nearest Neighbor Matching | | | |
| Nearest Neighbor (1) | 178 | 10 | 0.060 |
| Nearest Neighbor (2) | 178 | 14 | 0.038 |
| Nearest Neighbor (3) | 178 | 14 | 0.008 |
| Nearest Neighbor (4) | 178 | 14 | 0.011 |
| Caliper Matching | | | |
| Caliper (0.01) | 77 | 14 | 0.103 |
| Caliper (0.10) | 108 | 14 | 0.030 |
| Caliper (0.25) | 120 | 14 | 0.087 |
| Caliper (0.50) | 129 | 5 | 0.495 |
| Radius Matching | | | |
| Radius caliper (0.01) | 134 | 13 | 0.049 |
| Radius caliper (0.10) | 178 | 14 | 0.012 |
| Radius caliper (0.25) | 178 | 14 | 0.022 |
| Radius caliper (0.50) | 178 | 11 | 0.084 |
| Kernel Matching | | | |
| Kernel bandwidth (0.01) | 134 | 12 | 0.056 |
| Kernel bandwidth (0.10) | 178 | 14 | 0.013 |
| Kernel bandwidth (0.25) | 178 | 14 | 0.012 |
| Kernel bandwidth (0.50) | 178 | 12 | 0.050 |

*Source:* Own computation from survey data.

From the four matching algorithms tested, the nearest neighbor matching of the third neighbor was selected of all the algorithms as it showed good matching properties (a very small value of pseudo-R-square, larger number of covariates, lower value of mean bias that ranging from 3 to five, and larger number of observations or sample households) compared to other methods.

A balancing test is also done to check the matching quality, and the result is presented in Table 6.

***Table 6.*** *Covariates balancing test (Testing for matching quality).*

| Variables | Unmatched Matched | Mean Treated | Mean Control | bias | %reduct \|bias\| | T-test t | T-test P > \|t\| | V(T)/ V(C) |
|---|---|---|---|---|---|---|---|---|
| Sex of the head | Unmatched | .84672 | .76389 | 20.9 | | 1.48 | 0.141 | . |
| | Matched | .83333 | .85494 | -5.5 | 73.9 | -0.44 | 0.663 | . |
| Age of the head | Unmatched | 41.212 | 46.528 | -47.8 | | -3.28 | 0.001 | 1.02 |
| | Matched | 42.444 | 42.855 | -3.7 | 92.3 | -0.29 | 0.771 | 1.42 |
| Education of the head | Unmatched | 4.9927 | 2.8333 | 67.7 | | 4.39 | 0.000 | 2.29* |
| | Matched | 4.1481 | 4.0216 | 4.0 | 94.1 | 0.32 | 0.750 | 2.24* |
| Family size ME | Unmatched | 2.9504 | 2.7889 | 13.8 | | 0.92 | 0.357 | 1.38 |
| | Matched | 2.9657 | 2.9926 | -2.3 | 83.4 | -0.17 | 0.864 | 1.51* |
| Farm experience | Unmatched | 20.153 | 22.333 | -21.1 | | -1.45 | 0.149 | 1.01 |
| | Matched | 20.88 | 21.111 | -2.2 | 89.4 | -0.17 | 0.866 | 1.10 |
| livestock TLU | Unmatched | 5.989 | 4.1317 | 76.7 | | 5.09 | 0.000 | 1.59* |
| | Matched | 5.4617 | 5.3935 | 2.8 | 96.3 | 0.22 | 0.825 | 1.74* |
| Land owned | Unmatched | 1.2971 | .98958 | 55.8 | | 3.73 | 0.000 | 1.45* |
| | Matched | 1.2046 | 1.1684 | 6.6 | 88.2 | 0.51 | 0.609 | 1.35 |
| Access to info | Unmatched | .75182 | .72222 | 6.7 | | 0.46 | 0.644 | . |
| | Matched | .74074 | .76543 | -5.6 | 16.6 | -0.42 | 0.676 | . |
| Cooperative membership | Unmatched | .62044 | .375 | 50.4 | | 3.46 | 0.001 | . |
| | Matched | .53704 | .5216 | 3.2 | 93.7 | 0.23 | 0.821 | . |
| Market distance | Unmatched | 1.1153 | 1.3494 | -45.5 | | -3.23 | 0.001 | 0.66* |
| | Matched | 1.1817 | 1.1709 | 2.1 | 95.4 | 0.16 | 0.871 | 0.79 |
| Distance from FTC | Unmatched | 17.708 | 21.583 | -23.1 | | -1.59 | 0.113 | 0.97 |
| | Matched | 18.065 | 18.972 | -5.4 | 76.6 | -0.43 | 0.670 | 1.67* |
| Off-farm income | Unmatched | .55474 | .41667 | 27.7 | | 1.90 | 0.058 | . |
| | Matched | .46296 | .54012 | -15.5 | 44.1 | -1.13 | 0.259 | . |
| Extension contacts | Unmatched | .81022 | .61111 | 44.8 | | 3.19 | 0.002 | . |
| | Matched | .76852 | .75309 | 3.5 | 92.2 | 0.26 | 0.792 | . |
| Credit acces | Unmatched | .24088 | .08333 | 43.6 | | 2.82 | 0.005 | . |
| | Matched | .16667 | .17593 | -2.6 | 94.1 | -0.18 | 0.858 | . |

*Source:* Own computation from survey data.

The joint significance test in Table 7 is our guarantee that we can estimate the average treatment effect on the treated since the pseudo $R^2$ reduced from 0.223 to 0.008, the likelihood ratio reduced from 60.15 to 2.33 and the mean bias also reduced from 39.0 to 4.6.

***Table 7.*** *Joint significance test for covariate balancing.*

| Sample | Pseudo $R^2$ | LR $chi^2$ | p>$Chi^2$ | Mean Bias | Med bias | B | R | %var. |
|---|---|---|---|---|---|---|---|---|
| Unmatched | 0.223 | 60.15 | 0.000 | 39.0 | 44.2 | 121.8* | 1.04 | 50 |
| Matched | 0.008 | 2.33 | 1.000 | 4.6 | 3.6 | 20.7 | 1.53 | 50 |

*Source:* Own computation from survey data.

Finally, the average treatment effect on the treated (ATT) was estimated. The result in Table 8 revealed that the average treatment effect is 7943 Birr. According to this result, households who are adopters of tef technology earn 7943 Birr more income on average compared to household heads that are not adopters of teff technology. The t-test result also showed that the mean income difference for adopters and non-adopters is statistically significant at 5 percent probability level.

***Table 8.*** *Estimation of average treatment effect (ATT).*

| Variable | Sample | Treated | Controls | Difference | S.E. | T-stat |
|---|---|---|---|---|---|---|
| Income | unmatched | 38742.38 | 25296.81 | 13445.57 | 2683.48 | 5.01 |
| | matched | 38880.46 | 30937.38 | 7943.100 | 4824.40 | 1.65 |

*Source:* Own computation from survey data.

To check whether the estimated average treatment effect was the pure effect of the adoption of tef technologies, a sensitivity analysis was conducted. The result proved that the estimated treatment effect was the pure effect of tef technology adoption as it was insensitive to unobservable bias if the gamma value increased to 3.

# 4. Conclusion

Based on the result of this research, household heads who adopted high-yielding improved tef technologies earned a higher income of 7943 Birr than non-adopter household heads on average. From the t-test result, the mean income difference between adopters and non-adopters was statistically significant. Therefore, the adoption of tef technologies significantly improves the household income in the study area.

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