MEMORANDUM

To: Ms. Main

From: Andrew Zhu

Date: November 30, 2016

Subject: Effect of Microcredit Programs in Bangladesh

I am writing this memo to show the research and analysis that I have completed on the effect of microcredit programs in Bangladesh. I will explain the microcredit program results on annual household spending based on villages, household participants, and non-participants.

Impact on Villages

Based on the results of having a microcredit program for men in villages, the average household spending for those villages are 7.2% less than if the village never accepted the program (Model 1.2). I believe this is a result of the fact that we were only provided data for year 1. My interpretation is that many of the men invested the credit that was given to them in addition to funds of their own. As a result, the village would need to cut spending in order to compensate for the fact that the investments have not been liquidated yet. (See logarithm graph in appendix). Based on the results of having a microcredit program for women in villages, the average household spending for those villages is 10% higher than if the village never accepted the program (Model 1.2). This result is because females are either finding investments that have more liquidity or they are simply spending on essential needs such as food.

Impact on Household Participants

Based on the results of having a microcredit program for male participants, the average household spending of those male participants is 1.1% less than if they never accepted the program (model 1.5). This result shows us that the burden of the investments is less severe for individual males rather than the village of male programs as a whole. Based on the results of having a microcredit program for female participants, the average household spending of those female participants is 8.45 more than if they never accepted the program (model 1.6). Since villages with female programs benefits, it is apparent on the individual basis as well.

Impact on Non-Participants

Based on the results of male and female non-participants, we can see effects of both increases and decreases in annual household spending. What occurs depends on the variety of differences and similarities of how males and females of villages and households use their investments and expenditures (Model 1.7/1.8).

Future

Based on the results as a whole and the current state of the economy, we would need more data and more time before we make a more accurate assessment of the effect of microcredit programs on annual household spending. We need to wait several years before we can evaluate the men's investments with the credit that the programs gave them. In addition the length of time will help us evaluate the consistency of the women's current spending and investment patterns.

Sincerely,

Andrew Zhu (Gates Foundation Intern)

Statistical Analysis (Appendix)

1. Evidence of the effect of having microcredit program in the village for males?

Regression 1.0 Effect of Explanatory Variables on Household Expenditure per Year (Male)

Source	SS	df	MS
Model	2.9028e+09	12	241898224
Residual	1.6433e+10	1116	14724690.1
Total	1.9336e+10	1128	17141429.8

Number of obs	= 1129
F(12, 1116)	= 16.43
Prob > F	= 0.0000
R-squared	= 0.1501
Adj R-squared	= 0.1410
Root MSE	= 3837.3

exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhland	2.568733	1.010789	2.54	0.011	.5854724	4.551994
educhead	323.1591	34.42743	9.39	0.000	255.6093	390.7089
famsize	-300.3465	54.83417	-5.48	0.000	-407.9362	-192.7569
milk	101.4192	43.76131	2.32	0.021	15.55548	187.2829
program_male	-771.6134	261.2472	-2.95	0.003	-1284.204	-259.0224
agehead	37.66384	9.414461	4.00	0.000	19.1918	56.13588
egg	701.7138	407.1241	1.72	0.085	-97.1012	1500.529
hhasset	.000197	.0002363	0.83	0.405	-.0002666	.0006606
oil	27.40851	29.55577	0.93	0.354	-30.58262	85.39964
rice	32.97928	76.92443	0.43	0.668	-117.9535	183.9121
vaccess	22.95613	316.0419	0.07	0.942	-597.1471	643.0593
dmmfd	81.13873	322.7041	0.25	0.802	-552.0365	714.3139
_cons	891.6755	1578.086	0.57	0.572	-2204.674	3988.025

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Interpretation of Regression Model 1.0

I choose to run a regression with **total household expenditure spending per capita** as my dependent variable along with variables that I believed were somewhat relevant and linearly related to predicting household expenditures in order to figure out the effect of having microcredit programs for males in villages.

However, two main problems exist in this model as not a good fit and thus we cannot use it as a method of predicting total household per capita expenditures.

1) There are several independent variables that are statistically insignificant. This is evident by looking at the **p-value** of each of the independent variables.

2) The other problem is the value of the determination of coefficient which is represented by the R-Squared. As a result of the **R-Squared** in this model being 0.1501, this means that roughly only 15% of the variation in total household per capita expenditures is represented by the explanatory variables. The other 85% remains unknown based on this model.

Based on the large amounts of error that are found in this model, we will not use hypothesis testing to test for linearity in this model.

Explanation of Variables:

exptot: household per capita total expenditures measured in (takas) $1USD= $81.3TAKA *hhland:* households land measured in decimals *educhead*: education of household head measured in years *famsize:* household size measured in people *milk:* village price for milk measured in takas/litre
program_male: microcredit program for men in the village (dummy variable 1=yes, 0=no) *agehead:* age of household head measured in years *egg:* village price for eggs measured in takas/4 count *hhasset:* household total assets measured in takas *oil:* village price of edible oil measured in takas/kg. *rice:* village price of rice measured in takas/kg. *vaccess:*village is accessible by road all year (dummy variable 1=yes, 0=no *dmmfd;* household has a male microcredit participant (dummy variable 1=yes, 0=no)

Regression 1.1 Effects of Statistically Significant Variables on Household Expenditure per Year

Source	SS	df	MS
Model	2.8229e+09	6	470490686
Residual	1.6513e+10	1122	14717102.2
Total	1.9336e+10	1128	17141429.8

Number of obs	1129
F(6, 1122)	31.97
Prob > F	0.0000
R-squared	0.1460
Adj R-squared	0.1414
Root MSE	3836.3

exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
program_male	-795.8858	234.5146	-3.39	0.001	-1256.022	-335.7492

hhland	3.193462	.586843	5.44	0.000	2.042029	4.344896
educhead	317.0021	33.98856	9.33	0.000	250.3138	383.6904
famsize	-289.8618	54.20073	-5.35	0.000	-396.208	-183.5156
milk	146.3188	34.03422	4.30	0.000	79.54092	213.0967
agehead	37.19364	9.352658	3.98	0.000	18.84298	55.54431
_cons	3204.868	596.1063	5.38	0.000	2035.259	4374.477

Interpretation of Regression Model 1.1

I have adjusted the independent variables in this model from the previous model (1.0). As a result, each of the explanatory variables are now statistically significant based on the **p-value** of the variables. As a result we can now test for linearity between the independent variables and the dependent variable of total household per capita expenditures.

We will run an F-test at the 5% significance level to see if the data is useful in predicting linearity

Ho: B1=B2=B3=B4=B5=B6=0 Ha:
At least one B does not =0

DF=k, n-k-1
K=6
N-K-1= 1122

F-Critical 0.025,6,1123: **2.41**

F-Statistic: **31.97**

As a result of the F-Stat being higher than the F-Critical Value, there is enough evidence to **reject** the null hypothesis since at least one of the independent variables does not equal 0.

From this result, this model proves that some linearity exists between the independent variables and household per capita expenditure. Therefore this model is a good fit for predicting household per capita expenditures based on the explanatory variables.

However, despite the fact that we have adjusted the independent variables in this model so that the **p-values** are statistically significant, we have **removed** several explanatory variables that are very important and clearly have an impact on household per capita expenditures for villages that have male microcredit programs.

Regression Model 1.2 Effect of Relevant Independent Variables on Household per capita expenditure (% Change)

Source	SS	df	MS
Model	67.2457295	10	6.72457295
Residual	230.6142	1118	.206273882
Total	297.85993	1128	.264060221

Number of obs	1129
F(10, 1118)	32.60
Prob > F	0.0000
R-squared	0.2258
Adj R-squared	0.2188
Root MSE	.45417

ln_exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhland	.0003639	.0001189	3.06	0.002	.0001306	.0005971
educhead	.0518538	.0040505	12.80	0.000	.0439064	.0598013
famsize	-.0464369	.0064377	-7.21	0.000	-.0590682	-.0338056
milk	.0172109	.0051777	3.32	0.001	.0070519	.0273699
program_male	-.0720737	.028397	-2.54	0.011	-.127791	-.0163564
agehead	.0056265	.0011088	5.07	0.000	.003451	.0078021
egg	.1053135	.0475084	2.22	0.027	.0120979	.1985292

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      hhasset |   1.90e-08   2.79e-08     0.68   0.496    -3.57e-
              |08    7.36e-08
          oil |   .0080898   .0034834     2.32   0.020     .0012551
              |.0149245
         rice |   .0046168   .0090771     0.51   0.611    -.0131933
              |.0224269
        _cons |   7.570906   .1765342    42.89   0.000      7.22453
              |7.917282
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Interpretation of regression model 1.2

In this model I simply used the independent variables that I believed were the best reflection of household per capita expenditures without the problems of severe multi-collinearity as exhibited by model (1.0). One of the biggest differences in this model with model (1.0) is that I removed the variable of whether or not the household has a male microcredit program participant and I removed whether or not the village is accessible by road all year. Most notably, I changed the dependent variable of household per capita expenditures to the natural log of household per capita expenditures. As a result, the dependent variable now changes in percent for a change in the explanatory variables. By using the natural log of household per capita expenditures, one of the biggest differences I found was that the coefficient of determination increased approximately 10% from the first two models and the p-values of several variables became statistically significant compared to model (1.0).

We will now run a F-test at the 5% significance level to further access the model's validity and fit.

Ho: B1=B2=B3=B4=B5=B6=B7=B8=B9=B10=0
Ha: At least one B does not =0

DF=k, n-k-1 K=10 N-K-1= 1118

F-Critical 0.025, 10, 1118: **2.05**

F-Statistic: **32.60**

As a result of the F-Stat being higher than the F-Critical Value, there is enough evidence to **reject** the null hypothesis since at least one of the independent variables does not equal 0.

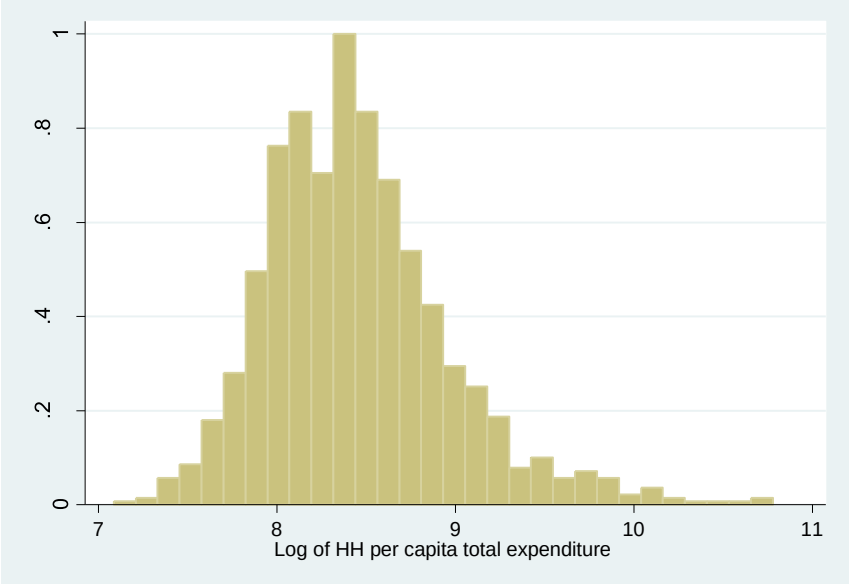
Based on this test, there is enough evidence at the 5% significance level to infer that linearity relates between a change in percent of household per capita expenditures and the explanatory variables.

The results show that this model is the best representation of household per capita expenditures based on the effect of having a microcredit program in the village for men. This model has the most **relevant explanatory variables**, the highest **F-Statistic** of all the models, and the highest **coefficient of determination.**

(Note: Independent Variables in Model 1.2 will be the fundamental model in all future regression models)

How I choose the Dependent and Independent Variables of my fundamental model

Ln_exptot: This represents the percentage change in household per capita expenditure spending from a unit change from any of the independent variables. I choose this for my dependent variable in all my regressions because it is the best fit model compared to if I just choose exptot based on the R-Squared being larger and the p-value being lower on most independent variables. In addition, this is normally distributed (see graph below)



Hhland: This represents the amount of land that was owned by the household. This would be linearly related to expenditures because the more land owned is generally more spending. However, we must note only households with less than 50 decimals of land will be considered.
Educhead: The household head years of education is linearly related because generally the more education the more spending because the more well off one would be.

Famsize: This is important because the larger the family, less spending would be incorporated because the bigger the denominator would be when dividing expenses.

Milk: Price of milk would be important because if the price of milk went up, people would directly need to spend more in order to purchase milk.

Agehead: The age of the household head would be important because the older one is, generally, the more one would spend because the more time one would have to acquire assets.

Egg: Price of egg would be important because if the price of egg went up, people would directly need to spend more in order to purchase eggs.

Hhasset: The more assets, the more spending because one would have more diversity and resources to invest and spend their money.

Oil: The price of oil would be important because if the price of oil went up, people would directly need to spend more in order to purchase oil.

Rice: The price of rice would be important because if the price of rice went up, people would directly need to spend more in order to purchase rice.

1. What is the effect of having male microcredit programs in the village?

Judging from model (1.2) it shows that if there is a microcredit program for men in the village, their household per capita spending would be approximately 7.2% less than if there was not a microcredit program for men in the village if we hold all other explanatory variables constant.

One explanation could be that by having microcredit programs in the villages, men in the village as a whole are spending too much and defaulting on their loans. Once the village realizes the men's mistakes, households on average would then have to spend less in order to compensate for their losses.

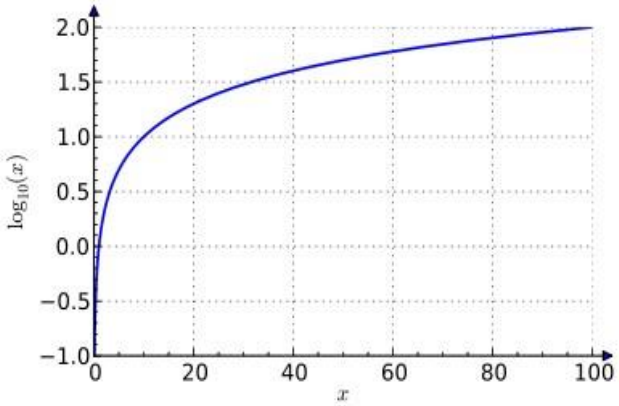
Another explanation could be that the men are using the microcredit programs as an investment program for men in the village, households would use the microcredit money in addition to a into portion of their personal savings to invest it into future developments. From this, they would resources such as businesses and future developments. For example, if there is a microcredit need to decrease spending in order to compensate for the money that is invested and is not liquidated yet.

Based on the fact that the results are all only reflective of **year 1**, by year 5 or year 10, the effect of having a male microcredit program in the village would likely result in more spending by that

time since the economy will be more advanced and stimulated by then and there would likely be an increase in total household assets as well.

In addition, we must note that based on the **R-Squared** being only 0.226 which means that most of the variation of household per capita expenditures is not a result of having a microcredit program for men in the villages.

Overall, since it is only year 1, the effects and the results of having the microcredit program for men is not yet clear compared to several years after the initial stimulation of microcredit programs for men in villages. (See Logarithm Graph for clarity)



Logarithm Graph: The Y variable would represent the economic power measured in dollars of villages that have microcredit programs. X would represent time. The interpretation is that it would take a long time even with huge grants of microcredit programs for the economy to get stimulated. At first it would be slow. After the initial boost, the economy would become more balanced.

2. Evidence of the effect of having microcredit program in the village for females?

Regression Model 1.3 Effect of Relevant Independent Variables on household per capita expenditure (% Change)

Source	SS	df	MS
Model	66.5337217	10	6.65337217
Residual	231.326208	1118	.20691074
Total	297.85993	1128	.264060221

Number of obs	1129
F(10, 1118)	32.16
Prob > F	0.0000
R-squared	0.2234
Adj R-squared	0.2164
Root MSE	.45487

ln_exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]

hhland	.0003398	.0001185	2.87	0.004	.0001072	.0005724
educhead	.0515623	.0040593	12.70	0.000	.0435977	.0595269
famsize	-.0459789	.0064473	-7.13	0.000	-.058629	-.0333288
milk	.015602	.005148	3.03	0.002	.0055013	.0257028
program_female	.0993458	.057541	1.73	0.085	-.0135546	.2122463
agehead	.0057989	.0011107	5.22	0.000	.0036197	.0079781
egg	.1192113	.0471087	2.53	0.012	.02678	.2116427
hhasset	2.30e-08	2.78e-08	0.83	0.409	-3.16e-08	7.76e-08
oil	.0081871	.0034887	2.35	0.019	.0013419	.0150323
rice	.0009058	.0089857	0.10	0.920	-.016725	.0185366
_cons	7.450164	.1836252	40.57	0.000	7.089875	7.810452

Interpretation of regression model 1.3

Based on the fact that model 1.2 was the best representation for predicting the effect of having microcredit programs in the villages for men, I used a similar model for predicting the effect of having microcredit programs in the villages for women. The one adjustment I made is by changing the variable of microcredit programs in villages for men to microcredit programs in villages for women (program_female).

The model's validity and fit is almost identical to model 1.2. The coefficient of determination, fstatistic, and the p-values are similar in both models.

2) What is the effect of having microcredit programs in the village for females?

Based on model 1.3, we see evidence that if the village has a microcredit program for females, household per capita spending increases by roughly 10% on average holding all other variables constant compared to if the village did not have a microcredit program for females.

Scenario 1 result could be that the villages that have microcredit programs for females are utilizing their resources more effectively and spending their money wisely compared to the villages with male microcredit programs that could be damaging their economy based on over-spending on credit they do not have. As a result of females utilizing their credits effectively, this will have a direct impact of the result of a 10% increase on average in household expenditures for villages that had a microcredit program for females because the economy is getting stronger.

Scenario 2 results could be that unlike the men, women could be less inclined to save their money for future investments. Instead, women may be more motivated to use the microcredit programs for immediate benefits such as spending on food and basic necessities.

The 95% confidence interval would be a good representation of both scenarios. If the village has a microcredit program for females, household per capita spending is between -1% and 21% increase in comparison to if the village did not have a microcredit program.

Overall the effect of having microcredit programs for villages for females is more spending for the households in the village because of the smart and effective spending of the credit given.

3) Evidence of the effect of participating in a microcredit program for males

Regression 1.4 Effects of relevant variables on household per capita expenditures for participation in microcredit programs

Source	SS	df	MS
Model	2.7732e+09	10	277316618
Residual	1.6562e+10	1118	14814281.4
Total	1.9336e+10	1128	17141429.8

Number of obs = 1129
F(10, 1118) = 18.72
Prob > F = 0.0000
R-squared = 0.1434
Adj R-squared = 0.1358
Root MSE = 3848.9

exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhland	2.190448	1.004717	2.18	0.029	.2191047	4.161791
educhead	325.0739	34.3886	9.45	0.000	257.6004	392.5473
famsize	-289.9449	54.83736	-5.29	0.000	-397.5407	-182.3492
milk	87.50301	43.62369	2.01	0.045	1.909488	173.0965
dmmfd	-291.7185	297.883	-0.98	0.328	-876.1912	292.7543
agehead	37.61131	9.4288	3.99	0.000	19.11117	56.11144
egg	807.0662	403.7105	2.00	0.046	14.95074	1599.182
hhasset	.0002526	.0002356	1.07	0.284	-.0002096	.0007148
oil	26.84186	29.5313	0.91	0.364	-31.10115	84.78488
rice	6.606535	76.57883	0.09	0.931	-143.6479	156.861
_cons	720.015	1496.218	0.48	0.630	-2215.696	3655.726

Interpretation of Regression Model 1.4

In this model, I am using the independent variables that are most likely to be linearly correlated with the variation in household per capita spending. Just by looking at the regression model, it is not surprising that many of these variables are identical to those that were used in model 1.2.

In this regression, I am using the variable of whether or not the household has a male microcredit program participant (dmmfd).

When we access the fit of the model, the coefficient of determination is only 0.143 which suggests that only 14.3% of the variation in household per capita spending is a result of the variation in the explanatory variables. The model has a high **f-statistic** and even though several of the variables have high **p-values**, they are still the most relevant variables in predicting household per capita spending.

We will now run a F-test at the 5% significance level to further access the model's validity and fit.

Ho: B1=B2=B3=B4=B5=B6=B7=B8=B9=B10=0

Ha: At least one B does not =0

DF=k, n-k-1 K=10 N-K-1= 1118

F-Critical 0.025, 10, 1118: **2.05**

F-Statistic: **18.72**

As a result of the F-Statistic being higher than the F-Critical Value, there is enough evidence to **reject** the null hypothesis since at least one of the independent variables does not equal 0.

Based on this test, there is enough evidence at the 5% significance level to infer that linearity relates between a change in **household per capita expenditures** and the explanatory variables. However, based on the **coefficient of determination** being lower than earlier models and various **p-values** being higher than other models, this may not be the best model that we can use in predicting the effect of household male microcredit participants on household per capita spending.

Regression 1.5 Effects of relevant variables on household per capita expenditures (% Change) for male participation in microcredit programs

Source	SS	df	MS
Model	65.9394386	10	6.59394386
Residual	231.920491	1118	.2074423
Total	297.85993	1128	.264060221

Number of obs	1129
F(10, 1118)	31.79
Prob > F	0.0000
R-squared	0.2214
Adj R-squared	0.2144
Root MSE	.45546

ln_exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhland	.000333	.0001189	2.80	0.005	.0000998	.0005663
educhead	.0518913	.0040693	12.75	0.000	.0439069	.0598757
famsize	-.0459222	.0064891	-7.08	0.000	-.0586544	-.03319
milk	.0157213	.0051622	3.05	0.002	.0055927	.0258498
dmmfd	-.0116074	.0352496	-0.33	0.742	-.0807702	.0575555
agehead	.0056911	.0011157	5.10	0.000	.0035019	.0078803
egg	.1206953	.0477725	2.53	0.012	.0269613	.2144292
hhasset	2.40e-08	2.79e-08	0.86	0.389	-3.07e-08	7.87e-08
oil	.0081199	.0034945	2.32	0.020	.0012633	.0149765
rice	.0014643	.0090619	0.16	0.872	-.0163158	.0192445
_cons	7.542847	.1770529	42.60	0.000	7.195453	7.89024

Interpretation of Regression Model 1.5

The adjustment that was made in model 1.5 compared to model 1.4 is that the variable of *household per capita expenditures* (exptot) was changed to the *change in percent per capita of household expenditures* (ln_exptot).

As a result of this adjustment, the models fit became stronger than the previous model. The *coefficient of determination* became 8% points stronger. In addition the *F-Statistic* changed from 18.72 to 31.79.

3) What is the Effect of Participating in a Microcredit Program for Males?

Judging from this model, there is evidence that if the household has a male microcredit program participant, the average household spending per capita would be 1.1% less than if the household did not have a male micro-credit participant if we hold all the other explanatory variables constant.

This result is likely to happen because if we refer back to model (1.2), if the village had a male microcredit program, the average household spending per capita would be 7.25 less than if the village did not have a micro-credit program while holding all other variables constant. With this being said, an individual household with a male participant is only one piece of the entire village. This is why the effect of participating in a microcredit program for men is smaller than the effect of having a microcredit program for males for an entire village.

In addition, if we look at the 95% confidence interval for the effect of a household with a male participant on on microcredit programs it varies between spending 8% less than the year before at the lower end compared to spending 5% more at the upper end. Judging from this result we can determine two things about male participation in microcredit programs.

Therefore the first result is that if men who are participants of microcredit programs are truly defaulting on their loans, (explained in effect of male programs in villages) the men are suffering less individually as compared to the village as a whole. The other result is that if men decided to invest the money from microcredit programs, some households with male participants who invested their money from the programs will be able to have high liquidity on their investments. This is because some of the male participants are already spending more than the year before which could likely be a result of the extra cash attained.

4) Evidence of the effect of participating in a microcredit program for females

Regression 1.6 Effects of relevant variables on household per capita expenditures (% Change) for female participation in microcredit programs

Source	SS	df	MS
Model	67.7106815	10	6.77106815
Residual	230.149248	1118	.205858004
Total	297.85993	1128	.264060221

Number of obs = 1129
F(10, 1118) = 32.89
Prob > F = 0.0000
R-squared = 0.2273
Adj R-squared = 0.2204
Root MSE = .45372

ln_exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhland	.0003831	.0001193	3.21	0.001	.000149	.0006172
educhead	.0533023	.0040778	13.07	0.000	.0453012	.0613033
famsize	-.045745	.0064315	-7.11	0.000	-.0583642	-.0331257
milk	.0161398	.0051377	3.14	0.002	.0060591	.0262205
dfmfd	.0824049	.0279163	2.95	0.003	.0276307	.137179
agehead	.0056387	.0011074	5.09	0.000	.0034659	.0078114
egg	.1157497	.0469988	2.46	0.014	.0235339	.2079656
hhasset	1.85e-08	2.78e-08	0.66	0.507	-3.61e-08	7.31e-08
oil	.0074899	.003487	2.15	0.032	.0006481	.0143317
rice	.0015386	.0089633	0.17	0.864	-.0160482	.0191253
_cons	7.521533	.1759901	42.74	0.000	7.176225	7.866841

Interpretation of Regression Model 1.6

The adjustment that was made in model 1.6 compared to model 1.5 is that the dummy variable for male participants in the microcredit program (dmmfd) was replaced with the variable for female participants in the microcredit program (dfmfd). All the other explanatory variables that was relevant for finding the effects on male participation based on a percentage change in household per capita expenditures applies for female participation as well.

This model' s fit is almost identical with model 1.5 based on the similarities of the *coefficient of determination*, the *f-statistic*, and the *p-values*.

4) What is the effect of female participation in a microcredit program

Based on the regression model 1.6, if a household had a female microcredit program participant compared to if the household did not have a female microcredit program participant, the household would spend on average 8.24% more annually if we hold all the explanatory variables constant.

If we apply scenario 1 in the description of 'the effect of having a microcredit program for females in a village' this result of the fact that the average household of female microcredit participation increases by an average of 8.24% would make sense. This is because the increase in household spending if a female microcredit program in the village existed would result in a 10% increase on average. We can interpret this as since the economy of the villages that have a female microcredit program is benefiting, it would be very likely that the individual females in that village who are participants of the program are also benefiting.

If we apply scenario 2 in the description of 'the effect of having a microcredit program for females in a village' the result that the average household of female microcredit participation increase by an average of 8.24% would also make sense. This is because if females in the village were spending their credit on immediate expenses such as food, the individual females would likely be related with the same actions.

Overall the effect of female participation in a microcredit program depends on how was the village that had female microcredit programs. If the village that had female microcredit programs
was effective in utilizing its credit, so would individual female participants. On the other hand if the village did not utilize the microcredit programs effectively, the individual participants would likely not have either. This is represented by the upper and lower bounds of the 95% confidence interval of household female microcredit participants. These are an increase of 2.7% and 13% respectively.

5) Evidence of whether or not there is a spillover effect for male nonparticipants?

Regression Model 1.7 of village without male microcredit programs on household per capita expenditure (Change in %)

Source	SS	df	MS
Model	60.7263801	10	6.07263801
Residual	195.91325	898	.218166203
Total	256.63963	908	.282642765

Number of obs = 909
F(10, 898) = 27.83
Prob > F = 0.0000
R-squared = 0.2366
Adj R-squared = 0.2281
Root MSE = .46708

ln_exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
agehead	.0055875	.001253	4.46	0.000	.0031283	.0080466
educhead	.0557309	.0047183	11.81	0.000	.0464706	.0649912
famsize	-.0450403	.0073084	-6.16	0.000	-.0593839	-.0306968
hhasset	7.69e-09	2.93e-08	0.26	0.793	-4.99e-08	6.53e-08
hhland	.0004017	.0001275	3.15	0.002	.0001514	.000652
milk	.0238671	.0061476	3.88	0.000	.0118018	.0359323
oil	.0059123	.0041317	1.43	0.153	-.0021966	.0140212
egg	.0586593	.0553212	1.06	0.289	-.0499147	.1672333
rice	-.0023683	.0108937	-0.22	0.828	-.0237483	.0190117
program_male	-.0826987	.031882	-2.59	0.010	-.1452707	-.0201268
_cons	7.733311	.2057688	37.58	0.000	7.329467	8.137154

Interpretation of Regression Model 1.7

In this model, I used the exact same explanatory variables that were linearly related to the change in household per capita expenditures from the previous models 1.6, 1.5, 1.3, 1.2. In order to evaluate the spill-over effect of male-non participants of the microcredit program, I included a dummy variable of (if dmmfd==0). This essentially means if the male is not a microcredit participant. One clear change we can see with this regression is that the number of observations is 909. This means that out of 1129 total observations, 909 are male who is not a participant in a microcredit program.

When we access the model's fit, the *F-statistic* is high at 27.83, the *p-values* are significant for the most part, and the *coefficient of determination* is similar to the other models that were a good fit for predicting household expenditure.

We will now run a F-test at the 5% significance level to further access the model's validity and fit.
Ho: B1=B2=B3=B4=B5=B6=B7=B8=B9=B10=0
Ha: At least one B does not =0

DF=k, n-k-1 K=10 N-K-1= 1118

F-Critical 0.025, 10, 1118: **2.05**

F-Statistic: **27.83**

As a result of the F-Statistic being higher than the F-Critical Value, there is enough evidence to **reject** the null hypothesis since at least one of the independent variables does not equal 0. Based on this, there is sufficient evidence at the 5% significance level to infer that this model is useful in predicting the change in percent of household per capita expenditures based on the explanatory variables such as male-non participants of microcredit programs.

5. Is there a spillover effect for male non-participants of microcredit programs?

Based on the regression results, if an individual was a male who did not participate in a microcredit program, their household would spend an average of 8.2% less than if the male was part of a microcredit program if we hold the other entire independent variables constant.

This result is likely to occur because if the male was a non-participant, that would mean he would not be entitled to the benefits of the microcredit program such as extra credit that could be used on immediate spending, or future investments. As a result, that individual would not spend as much as someone who was given the extra credit so this would have a negative reflection on the non-participants household spending per capita.

Another analysis that we should consider is the 95% confidence interval of male nonparticipants. At the lower end it shows that non-participant male households spend 14.5% less than male participant households. At the upper end it shows that non-participant male households spend 2.0% more on average than male participant households.

Overall we can say that the spill-over effect for male non-participants is taking place in varying degrees of speed and effectiveness if male-participants are investing their credit rather than spending it and drawing large deficits. Generally in a country with slow economy like

Bangladesh, it would take time for the money to generate and the economy to grow despite even a big grant in microcredit programs. (See Common Logarithm Graph)

6. Evidence of whether or not there is a spill-over effect for female nonparticipants of microcredit programs

Regression Model 1.8 of village without female microcredit programs on household per capita expenditure (Change in %)

Source	SS	df	MS
Model	47.8520887	10	4.78520887
Residual	105.369181	523	.20147071
Total	153.22127	533	.28746955

Number of obs = 534
F(10, 523) = 23.75
Prob > F = 0.0000
R-squared = 0.3123
Adj R-squared = 0.2992
Root MSE = .44885

ln_exptot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
agehead	.0058013	.001515	3.83	0.000	.0028252	.0087775
educhead	.0560164	.0052874	10.59	0.000	.0456293	.0664035
famsize	-.0410363	.008733	-4.70	0.000	-.0581923	-.0238803
hhasset	-2.66e-08	2.95e-08	-0.90	0.367	-8.45e-08	3.13e-08
hhland	.0005424	.0001309	4.14	0.000	.0002853	.0007995
milk	.0117564	.0068248	1.72	0.086	-.0016509	.0251637
oil	.0115429	.0050133	2.30	0.022	.0016942	.0213915
egg	.1741641	.0680325	2.56	0.011	.0405136	.3078146
rice	.008694	.0129621	0.67	0.503	-.0167702	.0341581
program_female	.0520242	.059378	0.88	0.381	-.0646244	.1686728
_cons	7.130533	.2535341	28.12	0.000	6.632463	7.628604

Interpretation of Model 1.8

This model is very similar to model 1.7. The only difference is that the dummy variable (dmmfd=0) is replaced with the dummy variable (dfmfd==0). This essentially means that the variable of non-male participants of microcredit programs is replaced with the variable of non-female participants of microcredit programs.

The model's fit is also very similar to model 1.7. However, the coefficient of determination is slightly higher at 0.31 which means that the female non-participants of the program has slightly greater correlation on the change in household expenditure expending than male-non participants of the program.

6) Whether or not there is a spillover effect for female non-participants of microcredit programs?

Based on the regression results, if an individual was a female who did not participate in a microcredit program, their household would spend an average of 5.2% more than if the female was part of a microcredit program if we hold all other independent variables constant.

This regression result could be a cause and effect of one main scenario. Shown by the previous analysis of female participants of microcredit programs, we could draw the conclusion that females were stimulating the economy either by investing their credit from the programs effectively and liquidating it quickly, or by purchasing necessities such as food and that would also boost consumer spending and the economy.

As a result of the positive impact of the economy as a whole being greater than the positive impact for individual female participant's based on a utilitarianisms perspective, it would explain why female non-participant households were spending 5.2% on average more than if females were participants of the microcredit program.

Another analysis that we should consider is the 95% confidence interval of female nonparticipants. At the lower end it shows that non-participant female households spend 6.4% less than female participant households. At the upper end it shows that non-participant female households spend 6.8% more on average than female participant households.

As a result of the confidence interval,we can interpret that for some villages, the economy has been quickly stimulated and this is why non-participants are spending more than female participants based on the upper end results. On the other hand, in a village that has not been economically stimulated as quickly, the non-participants spending less than female participants based on the lower end results.

Overall, we can conclude that there is a spill-over effect on female non-participants. How drastic the effects are will depend on several factors that are isolated towards each village's individual identity.