ACME Ghana Agricultural Profit Analysis
OMSBA-511 Summer 2020

By: Kaitlyn Jakubek, Gabe Boucaud & Brittney Cherry

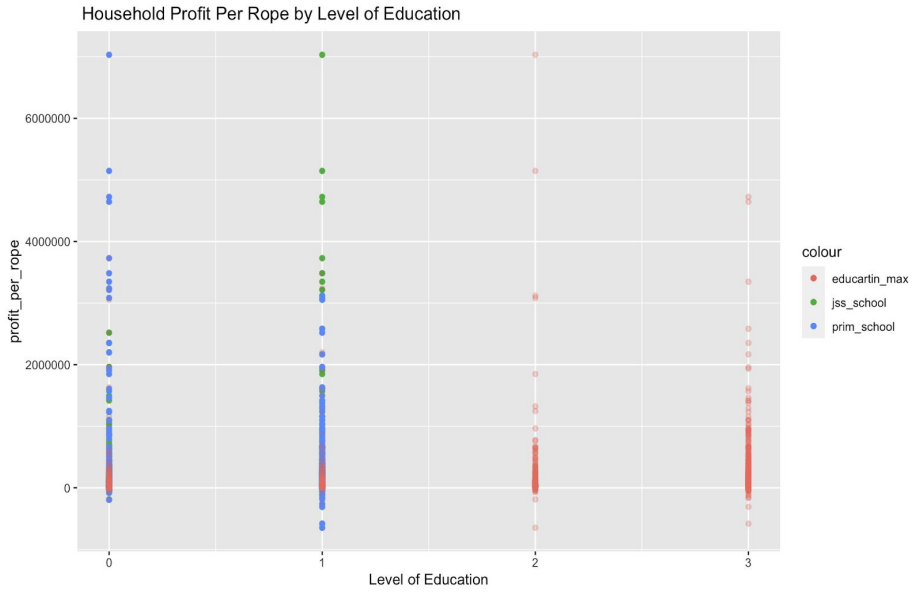
Memorandum

To: Board Members of ACME
From: Brittney Cherry, Kaitlyn Jakubek & Gabe Boucaud
Date: August 28,2020
Subject: Analysis of Agricultural profit in Ghana

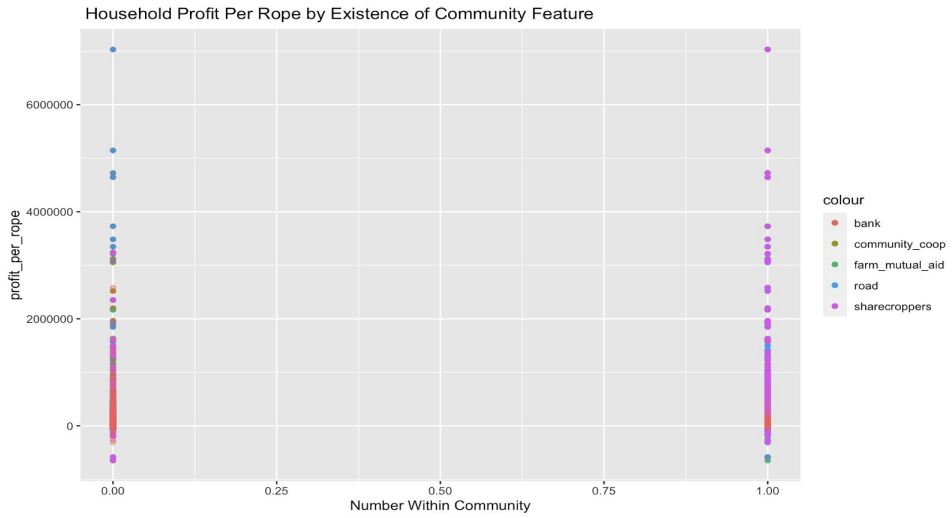
In determining the correct market for sales in Ghana, our team was able to identify educational and community characteristics to generate the greatest profits within Ghana.

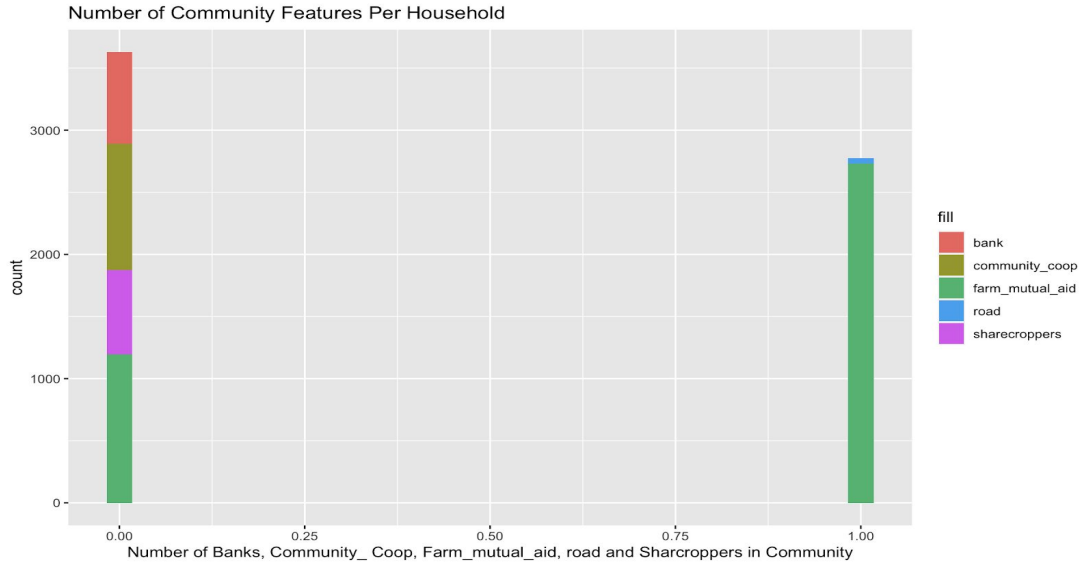
The data collected from 1998 to 1999, illustrates the effects of household education and community demographics on household agricultural profits in Ghana. The information gathered is useful in determining how ACME can successfully enter and expand in the Ghana Agricultural markets.

The following recommendations increase the likelihood of successful entry and profitability, measured by total agricultural profits by area of land(ropes) in Ghanaian households. In terms of education, an additional level of education from having completed no school to completing secondary school or above increases agricultural profits by 34%, but there is a caveat to this. This increase in agricultural profit eventually tapers off and even decreases between primary and secondary levels of education. We might expect this to happen because the more educated members of a community likely have alternative sources of income. Education also has a significant effect on agricultural profits for entire communities, communities with primary level schools are estimated to realize an 19% increase in household agricultural profits.



Looking deeper into community characteristics, communities that utilize mutual aid between farm and landowners realize a 21% increase in profits compared to those that do not use mutual aid. We likely see this result because farmers help one another by sharing supplies and equipment to achieve a successful harvest for the entire community. Finally, households in communities where land is sharecropped, see a 45% increase in agricultural profits. The landowners who hire others to work on their land and take most of the profit from the actual workers.





In summary we strongly recommended ACME consider the availability of primary education, cultivating an environment where high level farming equipment that can be shared within a community to, and owning land in order to

realize the greatest agricultural profits in rural Ghana.

Statistical Analysis

The survey includes information from 5,998 sampled households. We narrowed this down to include only those households with income and or expenses from agriculture. This encompasses estimated income from agricultural products grown and consumed by the same household. We also focused on households that own, rent, or sharecrop farmland in known units including: acres, poles, and ropes. With the end goal of understanding what leads to agricultural success, these land areas are combined with agricultural profit to allow comparison of households with both large and small quantities of land. After these filters are applied, our sample size includes the profits per rope of 3,927 households.

From our sample, profit per rope averaged 91,650 Cedi with a median value of 33,708 Cedi. This informs us there are a few higher income-per-area plots of land which bring the average above the median value.

Our analysis focuses on how community attributes and education within households affect agricultural profit. Within community attributes, we focused on the following located in rural areas: schools, agricultural extension centers, farm cooperatives, sharecropping, and farming mutual aid. Specific knowledge in reading, writing, and mathematics (simple calculations) was not found to be statistically significant, so we focused on the maximum education level obtained within a household.

```
Call:
lm(formula = profit_per_rope ~ road + prim_school * jss_school +
    community_coop + sharecroppers + farm_mutual_aid, data = hh_agri_edu_profit)

Residuals:
    Min      1Q  Median      3Q     Max
-902688  -70629  -37143    9782 5988120

Coefficients:
                     Estimate Std. Error t value             Pr(>|t|)
(Intercept)             64816       9102   7.121     0.00000000000127 ***
road                   -97361      13832  -7.039     0.00000000000227 ***
prim_school             48341      16042   3.013               0.0026 **
jss_school             872992      36793  23.727 < 0.0000000000000002 ***
community_coop          19859      10416   1.907               0.0566 .
sharecroppers           60161      10216   5.889     0.00000000422110 ***
farm_mutual_aid         25778      12002   2.148               0.0318 *
prim_school:jss_school -887208      38180 -23.238 < 0.0000000000000002 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 266100 on 3919 degrees of freedom
Multiple R-squared:  0.1496,    Adjusted R-squared:  0.1481
F-statistic: 98.47 on 7 and 3919 DF,  p-value: < 0.00000000000000022
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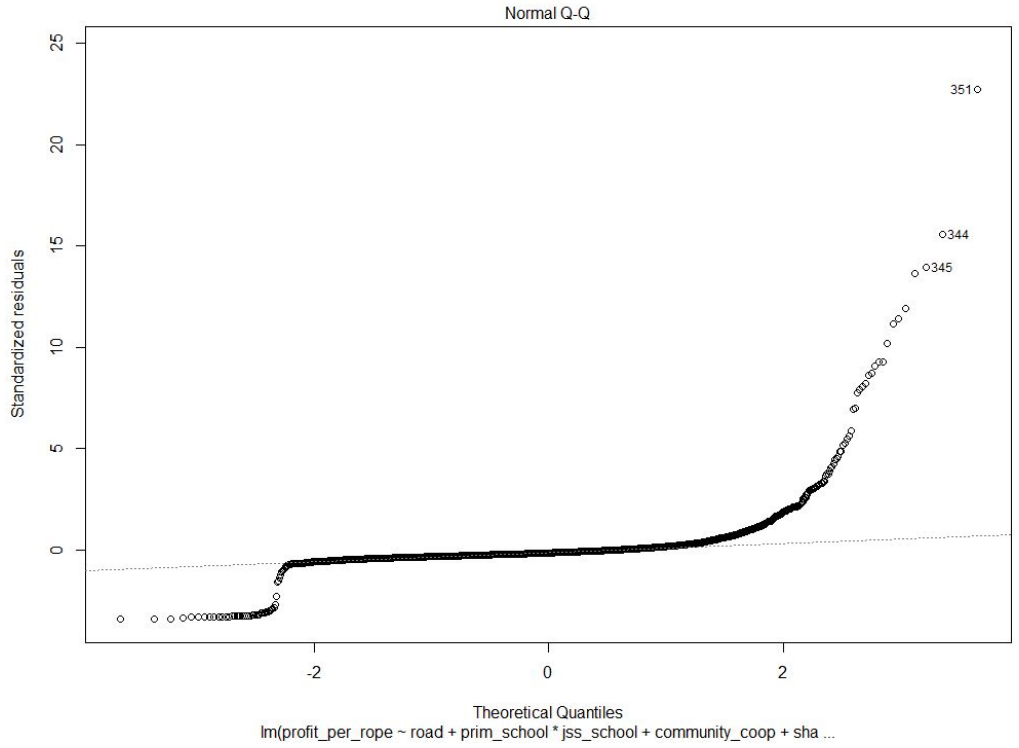
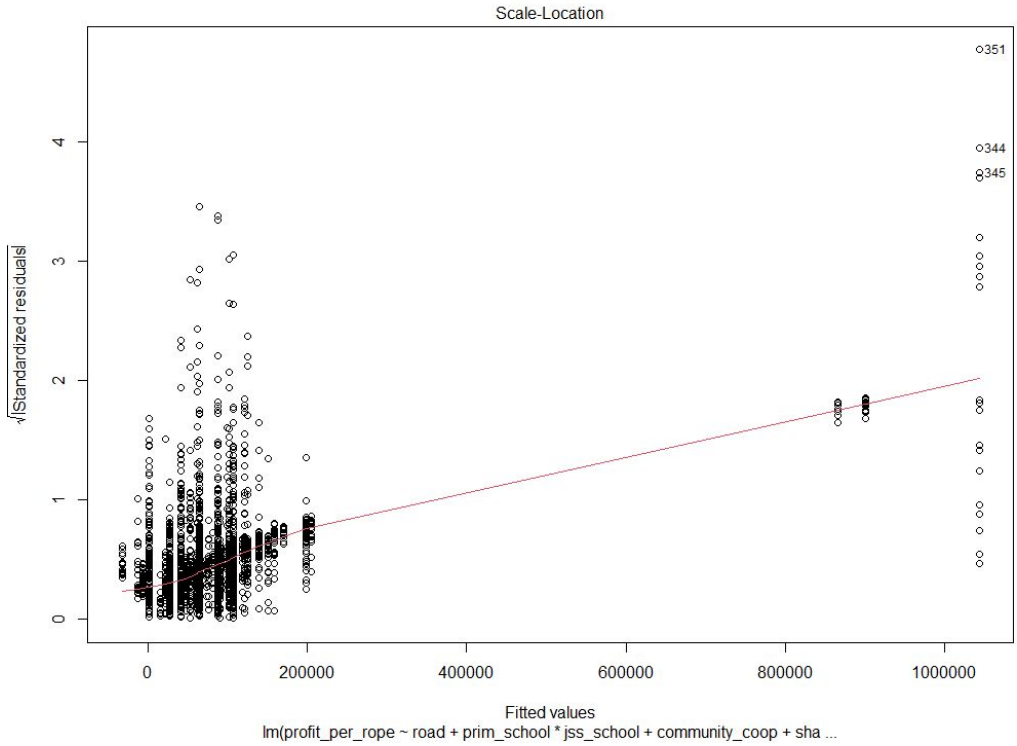
We can also see this in the Normal Q-Q plot shown below where the standardized residuals deviate from 0 at either end.

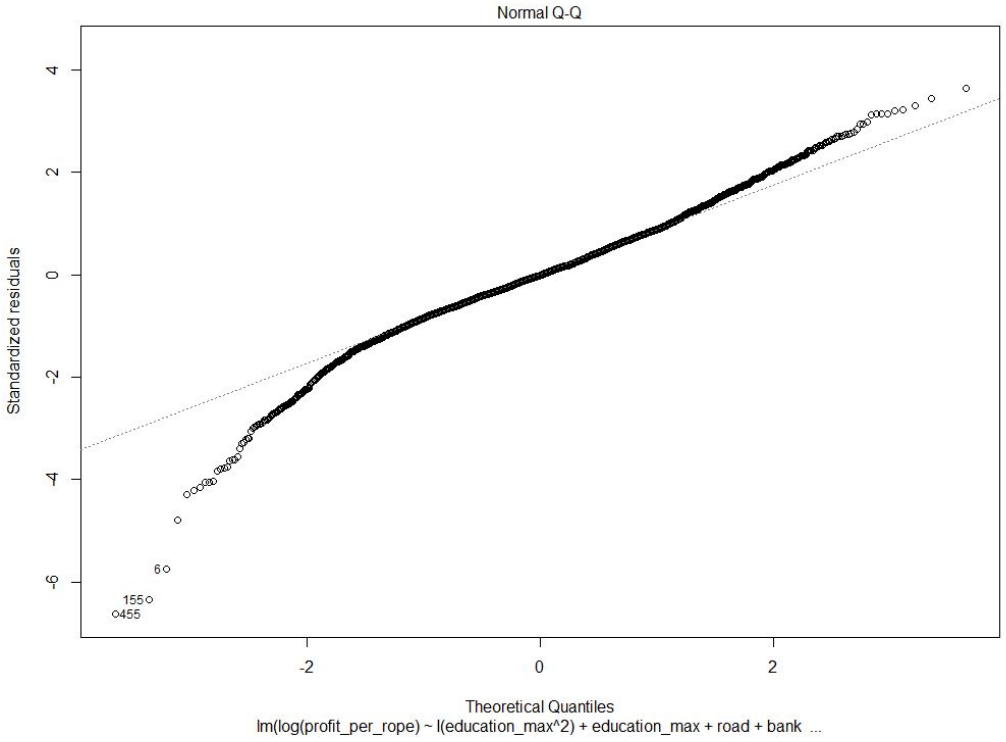


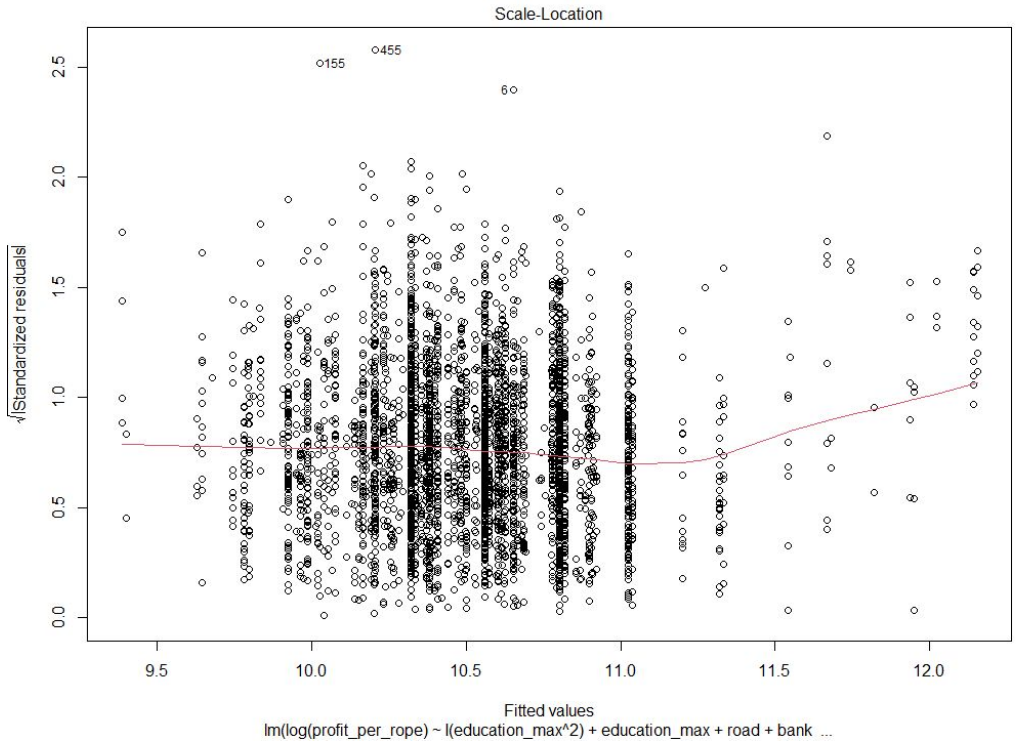


To begin analysing this data, we started with a linear model including multiple variables related to communities and education. When looking at the correlation between variables, we noted especially high correlation between the education variables and

Our linear model produced the Normal Q-Q plot below which is similar to a histogram, but works for models with multiple variables.

Next we included the education in a log model and found it was statistically significant there.


Normal Q-Q
Standardized residuals
Theoretical Quantiles
lm(log(profit_per_rope) ~ I(education_max^2) + education_max + road + bank ...
155
455
6


Scale-Location
√|Standardized residuals|
Fitted values
lm(log(profit_per_rope) ~ I(education_max^2) + education_max + road + bank ...
455
155
6

```
Call:
lm(formula = log(profit_per_rope) ~ I(education_max^2) + education_max +
    road + bank + prim_school + jss_school + community_coop +
    sharecroppers + farm_mutual_aid, data = hh_agri_edu_profit)

Residuals:
    Min      1Q  Median      3Q     Max
-8.6486 -0.7542 -0.0068  0.7851  5.0450

Coefficients:
                  Estimate Std. Error t value             Pr(>|t|)
(Intercept)       10.00326    0.06622 151.055 < 0.0000000000000002 ***
I(education_max^2) -0.07345    0.02523  -2.911             0.003624 **
education_max       0.34259    0.08267   4.144           0.00003491 ***
road               -0.26990    0.07030  -3.839             0.000126 ***
bank               -0.22073    0.08919  -2.475             0.013376 *
prim_school         0.18859    0.07663   2.461             0.013893 *
jss_school         -0.08143    0.05858  -1.390             0.164562
community_coop     -0.24033    0.05377  -4.470           0.00000807 ***
sharecroppers       0.43984    0.05283   8.326 < 0.0000000000000002 ***
farm_mutual_aid     0.20820    0.06278   3.316             0.000921 ***
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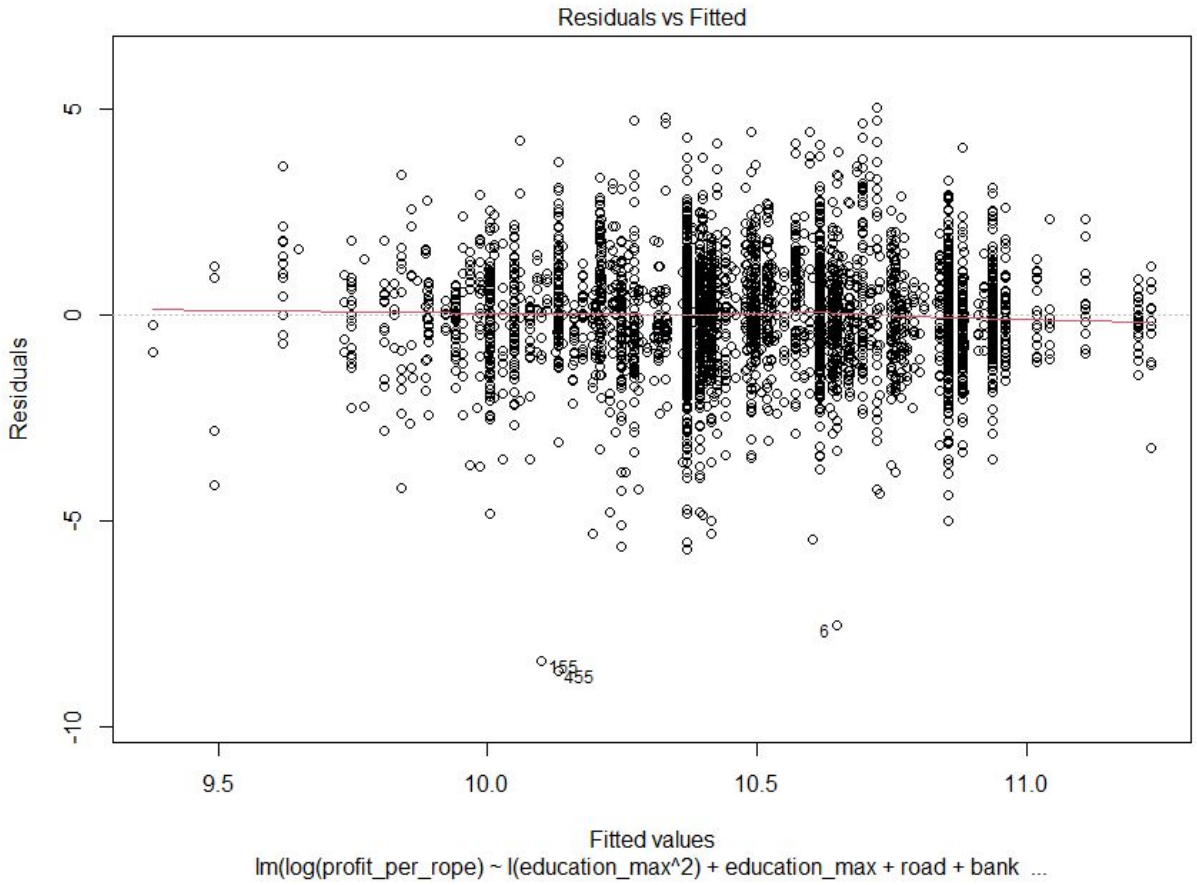
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.33 on 3701 degrees of freedom
  (216 observations deleted due to missingness)
Multiple R-squared:  0.04799,   Adjusted R-squared:  0.04568
F-statistic: 20.73 on 9 and 3701 DF,  p-value: < 0.00000000000000022
```

In our second model we continued with using a single log on the profit per rope, but this time using a polynomial function on the max level of education in a household. We used this model to see if profit eventually tapered off at a certain level of education, and this is what happened. The level of education that profit began to flatten and decrease occurred at about 2.33. Both education_max and the the polynomial function of education_max remained statistically significant at the 5% level. Sharecropping and farm mutual aid both retained their statistical significance and presented notable slopes.



The standardized residual plot showed that this model maintained the highest level of constant variance. This is why we chose to keep this model and we will look further into it.

It's worth noting that many of the statistically significant agricultural variables relate to collaborative farming techniques and learning opportunities. Farm cooperatives have multiple people invested in the outcome of a single plot of land which leads to higher profits. Sharecropping provides the opportunity for more households to participate in farming through rented land paid by a share of the crops grown. Lastly, farming mutual aid encourages resource and service exchanges between farmers for a mutual benefit. This could include the shared use of various agricultural equipment at different times in the harvesting process. ACME may want to consider entering the agricultural market in a manner that unites people to a common goal and assists with this community focused mindset.

Appendix

Correlation Table:

	nh	clust	ez	loc2	loc5	profit_per_rope
nh	1.0000000000	-0.0008304016	-0.006577890	0.008754925	0.0005994093	0.020643209
clust	-0.0008304016	1.0000000000	0.922478901	-0.171406249	0.4059929504	-0.083076920
ez	-0.0065778901	0.9224789011	1.000000000	0.028909713	0.5934457296	-0.055747619
loc2	0.0087549247	-0.1714062492	0.028909713	1.000000000	0.7797574115	0.037263104
loc5	0.0005994093	0.4059929504	0.593445730	0.779757411	1.0000000000	-0.013062921
profit_per_rope	0.0206432085	-0.0830769200	-0.055747619	0.037263104	-0.0130629209	1.000000000
education_max	0.0219340624	-0.0794587574	-0.130091350	-0.074389686	-0.1415913502	0.015590704
read_max	0.0302017490	-0.1031339615	-0.148896395	-0.076851050	-0.1553189798	-0.007342937
write_max	0.0272324219	-0.1012502485	-0.144031175	-0.074485680	-0.1514219534	-0.019146308
calc_max	0.0273644894	-0.0901747870	-0.131453591	-0.053154070	-0.1271499899	0.017826006
road	0.0084095664	-0.1245773692	-0.032197514	0.594807460	0.4219517999	-0.045960282
bank	0.0002867634	0.0094712247	-0.076660394	0.045523356	-0.0326016539	-0.027275605
daily_market	0.0013359290	-0.0316214222	-0.101850225	0.102713237	-0.0035431853	-0.021213096
periodic_market	0.0042475160	0.1661421430	0.223514047	0.186490357	0.2951817040	-0.003976085
prim_school	0.0012220530	-0.0086557335	0.102383520	0.638069722	0.5470033984	-0.047849860
jss_school	0.0087382798	-0.1750341735	-0.144606215	0.384375129	0.1855591593	0.034171694
agg_ext_center	0.0115671438	0.0776924021	0.029562239	0.182155597	0.1587190903	-0.016359863
community_coop	0.0122469917	-0.1100895476	-0.109540633	0.235673727	0.1042181234	0.054489112
irrigated_fields	0.0234877628	0.0531590463	0.009500384	0.115845480	0.0945549117	-0.018774473
sharecroppers	0.0180388093	-0.2502443516	-0.209679295	0.400350675	0.1527851428	0.091067783
farm_mutual_aid	-0.0026790994	0.0943990204	0.217260336	0.625561942	0.6250774350	0.050031019

	education_max	read_max	write_max	calc_max	road	bank
nh	0.0219340624	0.030201749	0.027232422	0.02736449	0.008409566	0.0002867634
clust	-0.0794587574	-0.103133961	-0.101250249	-0.09017479	-0.124577369	0.0094712247
ez	-0.1300913503	-0.148896395	-0.144031175	-0.13145359	-0.032197514	-0.0766603937
loc2	-0.0743896856	-0.076851050	-0.074485680	-0.05315407	0.594807460	0.0455233559
loc5	-0.1415913502	-0.155318980	-0.151421953	-0.12714999	0.421951800	-0.0326016539
profit_per_rope	0.0155907036	-0.007342937	-0.019146308	0.01782601	-0.045960282	-0.0272756047
education_max	1.0000000000	0.802601831	0.790905092	0.76099119	0.028281701	0.0536707849
read_max	0.8026018309	1.000000000	0.961201960	0.74153727	0.005820070	0.0691684067
write_max	0.7909050917	0.961201960	1.000000000	0.71580607	0.015882791	0.0739757581
calc_max	0.7609911876	0.741537270	0.715806075	1.00000000	0.031208096	0.0425495364
road	0.0282817010	0.005820070	0.015882791	0.03120810	1.000000000	0.1849680426
bank	0.0536707849	0.069168407	0.073975758	0.04254954	0.184968043	1.0000000000
daily_market	0.0510925395	0.056618146	0.062706735	0.05274325	0.243845040	0.4482133702
periodic_market	0.0006943613	0.004417238	-0.002560898	-0.01085833	0.112106591	0.0257285430
prim_school	-0.0068609789	-0.010215016	-0.004939149	-0.01002710	0.674780382	0.1734309782
jss_school	0.1297220423	0.107344193	0.115089442	0.12068680	0.550395572	0.2705227136
agg_ext_center	0.0302720633	0.028385094	0.031221071	0.03851087	0.231071910	0.3876603942
community_coop	0.0560810231	0.055891956	0.054309674	0.04397692	0.235347230	0.1313925331
irrigated_fields	0.0828385758	0.065833086	0.067599413	0.07401934	0.167284496	0.0123053057
sharecroppers	0.1224198901	0.101273341	0.100316038	0.13038060	0.476861968	0.0471614978
farm_mutual_aid	-0.1004160511	-0.106348363	-0.099506163	-0.09022999	0.475824333	-0.0855837801

Continued on the next page.

	daily_market	periodic_market	prim_school	jss_school	agg_ext_center	community_coop
nh	0.001335929	0.0042475160	0.001222053	0.00873828	0.01156714	0.01224699
clust	-0.031621422	0.1661421430	-0.008655734	-0.17503417	0.07769240	-0.11008955
ez	-0.101850225	0.2235140465	0.102383520	-0.14460622	0.02956224	-0.10954063
loc2	0.102713237	0.1864903573	0.638069722	0.38437513	0.18215560	0.23567373
loc5	-0.003543185	0.2951817040	0.547003398	0.18555916	0.15871909	0.10421812
profit_per_rope	-0.021213096	-0.0039760849	-0.047849860	0.03417169	-0.01635986	0.05448911
education_max	0.051092539	0.0006943613	-0.006860979	0.12972204	0.03027206	0.05608102
read_max	0.056618146	0.0044172381	-0.010215016	0.10734419	0.02838509	0.05589196
write_max	0.062706735	-0.0025608980	-0.004939149	0.11508944	0.03122107	0.05430967
calc_max	0.052743245	-0.0108583342	-0.010027098	0.12068680	0.03851087	0.04397692
road	0.243845040	0.1121065906	0.674780382	0.55039557	0.23107191	0.23534723
bank	0.448213370	0.0257285430	0.173430978	0.27052271	0.38766039	0.13139253
daily_market	1.000000000	-0.1581821288	0.228635624	0.29806817	0.36647918	0.14400948
periodic_market	-0.158182129	1.0000000000	0.252500914	0.25763709	0.16274399	0.16612265
prim_school	0.228635624	0.2525009136	1.000000000	0.57423691	0.24663181	0.26188613
jss_school	0.298068167	0.2576370878	0.574236914	1.00000000	0.35554353	0.30040390
agg_ext_center	0.366479181	0.1627439895	0.246631812	0.35554353	1.00000000	0.31606068
community_coop	0.144009476	0.1661226518	0.261886131	0.30040390	0.31606068	1.00000000
irrigated_fields	0.097811399	-0.0055348105	0.156850412	0.20270956	0.16625826	0.09436898
sharecroppers	0.204122531	-0.0338278500	0.388746536	0.37850080	0.13029864	0.28003804
farm_mutual_aid	-0.013847151	0.2515403383	0.549556571	0.22836848	0.15929025	0.25967924

	irrigated_fields	sharecroppers	farm_mutual_aid
nh	0.023487763	0.01803881	-0.002679099
clust	0.053159046	-0.25024435	0.094399020
ez	0.009500384	-0.20967930	0.217260336
loc2	0.115845480	0.40035067	0.625561942
loc5	0.094554912	0.15278514	0.625077435
profit_per_rope	-0.018774473	0.09106778	0.050031019
education_max	0.082838576	0.12241989	-0.100416051
read_max	0.065833086	0.10127334	-0.106348363
write_max	0.067599413	0.10031604	-0.099506163
calc_max	0.074019343	0.13038060	-0.090229987
road	0.167284496	0.47686197	0.475824333
bank	0.012305306	0.04716150	-0.085583780
daily_market	0.097811399	0.20412253	-0.013847151
periodic_market	-0.005534810	-0.03382785	0.251540338
prim_school	0.156850412	0.38874654	0.549556571
jss_school	0.202709564	0.37850080	0.228368477
agg_ext_center	0.166258264	0.13029864	0.159290249
community_coop	0.094368978	0.28003804	0.259679239
irrigated_fields	1.000000000	0.18701699	0.098902737
sharecroppers	0.187016990	1.00000000	0.412593006
farm_mutual_aid	0.098902737	0.41259301	1.000000000