Impact of Tobacco Drying Technologies and Fuel-Mixes on Farmer Welfare

A Statistical Analysis of Lombok's Market for the 2011 Season

SUSTAINABLE TRADE & CONSULTING

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Note: In addition to Stata .do and log files the dataset in Microsoft Excel CSV format are available upon request. Please Contact by E-mail: Nick Choy (nchoykm@gmail.com) or Bagus Eka Pratama (guseka@stcresources.com).

Introduction

Background

70%-75% of Indonesia's export-grade Virginia tobacco originates from Lombok Island in the province of Nusa Tenggara Barat, Indonesia. This industry supports approximately 12,000 farming households and employs 80,000 or more part-time workers. In 2008, the Government of Indonesia announced its plan to eliminate subsidized kerosene for industrial purposes by 2010. In the wake of this policy many farmers turned to illegal and/or unsustainable fuelwood as a substitute for unsubsidized kerosene in the drying and curing of tobacco. The resulting deforestation contributes to loss of biodiversity and damage to the Gunung Rinjani watershed (Sustainable Trade & Consulting, 2012). Subsequently, many stakeholders race to find the best tobacco curing system, combination of technology and fuel-mix, which delivers the benefits of subsidized kerosene at a comparable cost.

The nature of Lombok's tobacco industry, which is comprised entirely of smallholder farmers, represents a unique stage for testing the commercial viability of sustainable biomass. Successful research can launch effective solutions into other industries. I present a quantitative analysis of the available technologies and fuel options in Lombok for the 2011 season. 87 ovens, owned by 66 tobacco farmers, were surveyed to determine the impact that various curing systems have on the welfare of farmers. To my knowledge a statistical study of this nature has not yet been conducted for Lombok. The greatest weakness of my research stems from its reliance on farmers' recollection of details from last year. However, I will apply the lessons learned from this study to build a more comprehensive analysis using data for the future seasons.

Objective

This report is intended to function as a roadmap for future research. It covers a range of metrics that influence the welfare of farmers to identify promising areas of development. Quantitative research, drawn from local experiences, creates greater marketing credibility for local consumers. The 2012 season marks a turning point for the industry as farmers and major tobacco companies begin to embrace sustainable biomass. Gasification technology, which optimizes many biomass feedstocks, promises to be a viable replacement for kerosene. However, conventional furnaces represent the largest market segment in Lombok. The promotion of biomass to reduce consumption of unsustainable fuel-types hinges on advocating gasifiers as the best replacement for furnaces as they wear out. But research and development on processing biomass into forms best suited to conventional furnaces will help spearhead this movement.

Overview of Results

Ranking of Furnace Performance on Metrics of Welfare (Best to Worst: 1 to 5)					
	Kerosene	*Liquefied Petroleum Gas*	*Diesel*	*Conventional*	*Gasifiers*
Net-Benefits	3	5	2	4	1
Net-Benefits/kg	1	5	3	4	2
Total Costs	5	1	4	3	2
Total Costs/kg	5	2	3	4	1
High Price	1	4	2	5	3
Energy Efficiency	4	2	3	5	1
Note: Rankings ignore statistical significance.[1] "Per kilogram" is per kg of dried tobacco					

SWOT Analysis of Available Furnace Types					
	Kerosene	*Liquefied Petroleum Gas*	*Diesel*	*Conventional*	*Gasifiers*
Strengths	Highest Net-Benefits per kg Highest Price	Lowest Total Cost	Second Highest Price	Able to Use the Most Fuel-Mixes	Ranked Highest for Net-Benefits Lowest Costs/kg Dried Tobacco Most Energy Efficient
Weaknesses	Highest Costs Highest Cost/kg Dried Tobacco	Ranked Second Lowest for Price	Prohibited by Law	Ranked Lowest for Price	High Investment Costs
Opportunities	R&D Benchmark for Other Technologies	Quality Improvements as Farmers Gain Familiarity Leading to Price Improvements	Limited Because of Prohibition	Most Widely Used by Farmers. Most Versatile for Use with Different Fuel-Mixes R&D Focus: PT Sadhana's Sustainable Wood Program	Marketing Focus: New PT. ELI model requires lower initial investment costs and improve fuel efficiency thereby lowering variable costs. Increase in Supply of Sustainable Fuel: PT. STC's Supply Chain Development of Biomass.
Threats	As R&D and Familiarity with other Technologies Increases, Kerosene Might be Pushed Out of the Market	Lack of focus in R&D as Market Concentrates on other Furnaces and Fuels	If authorities initiate stricter enforcement farmers might not be able to obtain fuel	If authorities initiate stricter enforcement of illegal fuelwood, coupled with shrinking local supplies that raises prices, farmers' net-benefits decrease over time.	Diverse models and brands with varied reputations for performance leave a negative stigma with farmers regarding gasifiers. Performance with biomass is as yet unfamiliar to many farmers.

[1] Note: statistical significance means the probability of discovering a result by chance. The lower the significance value, the less likely the results from the regressions occurred by chance and the more confident we can be in its validity. By convention 10% significance level is considered the maximum threshold.

Theoretical Framework of the Analysis

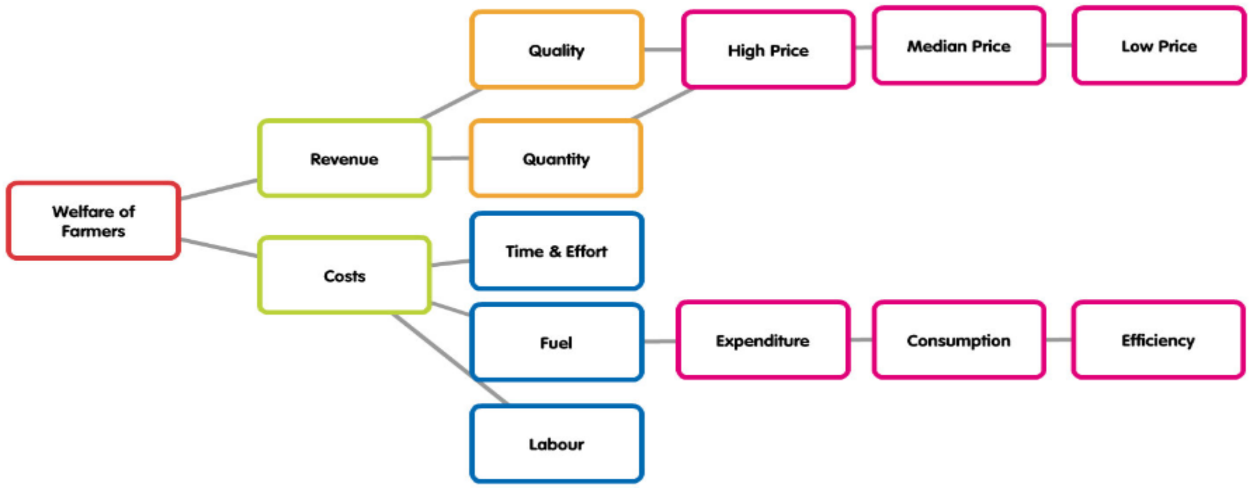

Figure 1: Components of Farmer Welfare from Drying Tobacco

I define farmer welfare as the net-benefits, revenue minus costs, from activities between the sale and drying phases described below. Revenue is determined by the product of price, determined by quality, and the quantity at each grade of dried tobacco sold to companies. Farming factors such as growing techniques, irrigation systems and fertilizers establish the quality of wet leaf inputted into furnaces, but a farmer's curing system plays a critical role in realizing a harvest's full potential.

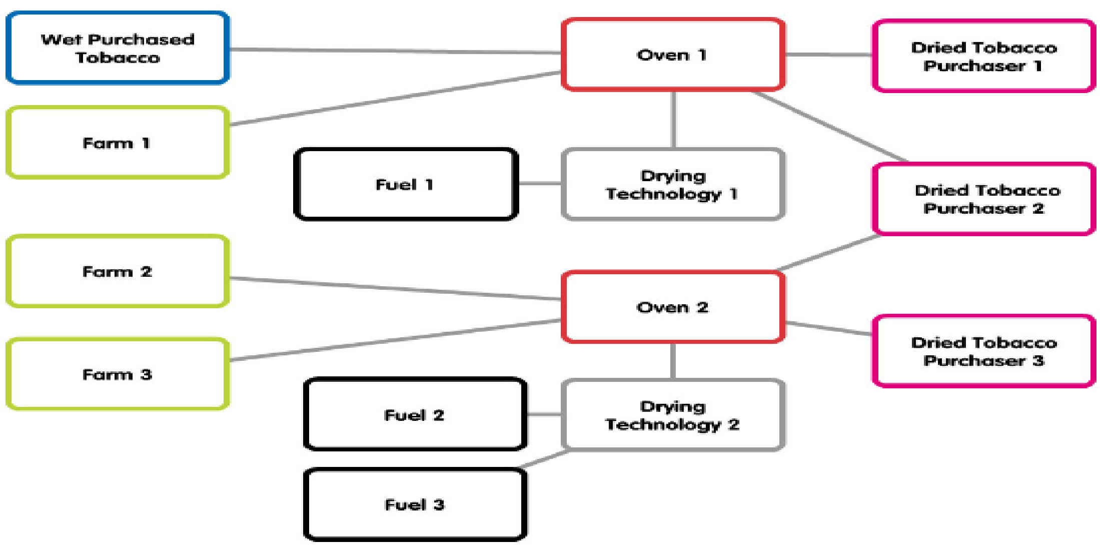

Figure 2: Process Flow of Tobacco from Farm to Purchasing Tobacco Company

Supply Chain: I designed a survey (Appendix I) to track the flow of tobacco throughout the supply chain from farm to sale. Some farmers grew tobacco from multiple locations which was then dried and cured in separate ovens using different technologies and fuel-mixes. Sometimes wet tobacco was purchased and mixed with a farmer's own crop for each session. Also, there were cases where farmers bought and dried wet leaf after they finished their own crops. Often cured tobacco was sold to one or more tobacco companies or independent traders. By breaking down the process I attempted to isolate and control for as many variables that affect the welfare of farmers as possible at each stage. My analysis uses each oven, 87 in total, as an observation.

From Theory to Application: Construction of Variables

Random sampling was conducted to generate a representative picture of the population. A summary of sample statistics can be found in Appendix II. Largely due to gaps in farmers' memories some components from the theoretical design could not be incorporated into the data set. For example farmers would remember what types of fertilizers they used but not the quantities. Also there were misunderstandings by some of the survey team regarding the kind of data the survey questions were designed to collect. Although we tried to fill in the gaps and make corrections by re-visiting farmers, time constraints prevented us from filling in all the missing data. The lessons learned from this experience will be incorporated into preparations for future surveys.

Dependent Variables: Components of Farmer Welfare

Revenue

Price: There are around 25 grades for cured tobacco and each tobacco company employs a different grading scheme. Moreover, almost all farmers did not keep sales records for the 2011 season. To analyze price I created three tiers from the average: *top price (harga tertinggi), median price (harge sedang), and lowest price (harga terendah)* they received for their product. In most cases better quality product should garner higher prices.

Quantity: I also asked farmers the approximate proportion of crop which was sold at each price tier. The harvesting of tobacco begins with the lowest leaf, *daun pertama*, which generally yields lower grade tobacco compared to the top leaf, *daun atas*. But various curing systems can generate differences within a particular section of leaf. Each time curing, *kali kering*, of a harvest takes approximately 4 to 5 days to complete. In the sample, farmers cured an average of 8.6 times for the 2011 season. Unfortunately, many farmers could not recall the quantities sold at each price tier. Including this variable with the missing observations would have reduced my sample size too much and was therefore excluded it from my analysis.

Costs

I define total drying costs as the sum of

1. Fuel Price
2. Cost of labour for *stockers* who load the fuel

Some farmers saved money by stocking the furnaces themselves; the mean cost for stockers in the sample is 2,796,471 RP for each oven. But these farmers bear the full opportunity cost associated with time and effort. Conventional furnaces using wood require almost constant attention over a 24 hour period. If farmers were not stocking the ovens themselves, they could be spending more time with their family or on other revenue generating activities. However, the time component of loading fuel was particularly challenging to accurately record from farmer recall. Many of their estimations for time spent stocking exceeded 24 hours for a single day. Thus I left this variable out of my analysis also.

I approached the fuel-efficiency of each type of curing system by converting the amount and type of fuel used for each curing session into British Thermal Units (BTUs)[2]. All the data were collected from the internet and does not account for variations in fuel quality but should still paint an adequate picture.

Dependent Variables

Variable Name	*Unit*	*Description*
Net-Benefits	RP	Total Revenue minus Total Drying Costs for the entire 2011 season
Net-Benefits/kg	RP	Net-Benefits divided by total quantity of dried tobacco sold
Total Cost for Season	RP	Total Drying Costs: total expenditure on fuel and stockers
Cost/kg	RP	Total Cost divided by total quantity of dried tobacco sold
Harga Tertinggi	RP/kg	Top price received by farmers for dried tobacco
Highprice	0 or 1	Binary variable that takes value 1 if Harga Tertinggi > 35000 RP (median value of harga tertinggi)
KonHighprice	0 or 1	Binary variable that takes value 1 if Harga Tertinggi > 33000 RP (median value for conventional ovens)
BTU/kg	BTU	Total BTUs expended in drying for 2011 season divided by total quantity of dried tobacco sold; measure of energy expended to dry each kg of tobacco

Independent Variables: Determinants of Farmer Welfare

Variables of Interest: The focal point of my research is the effect of curing systems on welfare. These technologies or furnaces (*tungku*) can be categorized into Liquid Petroleum Gas (*LPG*), kerosene

[2] Appendix III describes how BTUs for each fuel-type was derived

(*minyak tanah*), diesel (*solar*), conventional (*konvensional*) and gasifiers (*gasifikasi*). Only the latter two types can employ one or more fuel-types (*bahan bakar*). These include wood (*kayu*), coal (*batu bara*), coal briquettes (*batu bara briket*), candlenut shells (*kulit kemiri*) or a combination of any of the above. The table below indicates that *kayu* in *konvensional* furnaces was the most common curing system.

Summary of Curing Systems in the Sample

Tungku	***Kayu***	***Batu bara***	***Kayu Batu Bara* Briket & *Kulit Kemiri***	**Solar**	**Minyak Tanah**	***Kulit Kemiri***	**LPG**	***Kayu & Batu Bara***	***Kayu & Kulit Kemiri***	***Kulit Kemiri & Batu Bara***	***Kayu, Kulit Kemiri & Batu Bara***	**Total**	*% of Total*
Konvensional	32	1	2	0	0	1	0	11	2	0	2	***51***	*59%*
LPG	0	0	0	0	0	0	4	0	0	0	0	***4***	*5%*
Minyak Tanah	0	0	0	0	11	0	0	0	0	0	0	***11***	*13%*
Solar	0	0	0	9	0	0	0	0	0	0	0	***9***	*10%*
Gasifikasi	0	0	0	0	0	7	0	0	0	2	3	***12***	*14%*
Total	***32***	***1***	***2***	***9***	***11***	***8***	***4***	***11***	***2***	***2***	***5***	***87***	*100%*
% of Total	*37%*	*1%*	*2%*	*10%*	*13%*	*9%*	*5%*	*13%*	*2%*	*2%*	*6%*	*100%*	

Due to perfect collinearity between *LPG*, *minyak tanah* and *solar* as variables of *bahan bakar* and *tungku* I could not interact them in the usual way. As such I manually constructed binary variables that took the value 1 if a set of fuel-mixes intersected with a type of furnace and then grouped these into a single categorical variable. The table below summarizes the number of observations for each curing system.

Constructed Variables for Curing Systems	Number of Observations
Konvensional	
Kayu	32
Batu Bara	1
Kayu, Batu Bara Briket & Kulit Kemiri	2
Kulit Kemiri	1
Kayu & Batu Bara	11
Kayu & Kulit Kemiri	2
Kayu, Kulit Kemiri & Batu Bara	2
Gasifikasi	
Kayu, Kulit Kemiri & Batu Bara	3
Kkulit Kemiri & Batu Bara	2
Kulit Kemiri	7
Minyak Tanah	11
Solar	9
LPG	4

Models of gasifiers were made by Kompor Tembara (7.5%), Rotani (7.5%), Elang Nusa (61.5%), and Export Leaf Indonesia's large, triple-hopper design from 2010 (23%). With only 12 gasifiers in the sample it was not possible to compare performance between the brands.

Control Variables

Control variables are factors that could influence the relationship between the variables of interest and the dependent variables. Including them in each model allows us to remove their influences and isolate the impacts from the variables of interest on the dependent variables. I classify the control variables based on stages along the supply chain: growing, drying and sale.

Growing Phase at the Farm Level:

- Fertilizers (*pupuk*): brand and quantity applied on a per hectare basis affect the quality of tobacco. However since many farmers forgot the exact amounts they used for the 2011 season, I turned *pupuk* into a categorical variable that takes a value other than zero if the farmer used combinations of Pertilla, KNO3, SP36, UREA, NPK, ZA and TSP. In total there were 30 possible combinations.
- Irrigation system (*system pengairan*): categorical variable that takes the value 1 for *subak*, 2 for *teknis* and 3 for a combination of the first two.
- Cost of soil preparation per hectare (*biaya mempersiapkan pembajakan*): this continuous variable, in rupiahs, should have a positive correlation with quality and therefore price.
- Types of pesticides (*jumlah tipe pestisida*): originally I intended to record the amount of each type of pesticide used on a per hectare basis. But many farmers forgot the quantities applied so I used the sum of types-applied as one variable. Implicitly, the more pesticides used the more problems with pests the farmer had which could have a negative correlation with quality and therefore price. The most common brands were Desis, Metindo, Aktara, MRT, LIK, Semptot, Entrakol, Black Crown and Trakol.
- Farmer experience growing tobacco (*pengalaman tembakau*): this continuous variable was used as a proxy for skill in growing tobacco. I created an exponential variable for experience to test if there were diminishing returns to experience (*peng_temb* and *peng_temb*^{2}) but the goodness-of-fit decreased and neither term was statistically significant so I excluded the exponential.
- Company: An independent tobacco trader informed me that tobacco plants are grown for either export or domestic sale. Consumers of the former favour a "strong character" cultivated from growing thicker leaves. Indonesian preferences lean toward milder tastes from plants with thinner leaves. Most tobacco companies will only buy cured tobacco that suits their consumer markets. Thickness of leaf is controlled by the process of "topping" tobacco plants while they are growing. Therefore, the companies a farmer sells his product to affects both quality and price. The survey attempted to record the proportion or quantity of dried tobacco sold to each company to capture this, but many farmers forgot the exact details. Instead I created a categorical variable with 25 combinations drawn from sales to: Export Leaf Indonesia (PT.

ELI), PT. Sadhana Arifnusa, Djarum, Alliance One, EDS, Wismiluk, Trisnowadi, STF and Brokers (independent tobacco traders).
- Location of farm (*daerah*): this categorical variable, coded 1 for "upland," 2 for "lowland," 3 for "midland," and 4 for "dryland" controls for factors like elevation and climate which affects the quality of dried tobacco.

Drying Phase at Oven Level:

- Type of flu (*jenis flu*): affects quality of tobacco, fuel efficiency and therefore cost. This categorical variable is coded 1 for *buntu* (which is synonymous with *biasa* and *besi*), 2 for *kipas* and *putar*, 3 for *bata*, 4 for *minyak tanah* and 5 for *tepong*.
- Oven Volume: is a continuous variable measured in cubic meters generated by multiplying the length by width and number of *tingkat* (or "steps" for height) and assumes each *tingkat* is 1 meter apart.
- The following variables affect fuel efficiency and quality:
  - Age of Oven (*oven umur*): continuous variable that measures how old the oven is.
  - Oven Capacity (*kapasitas*): continuous variable that measures how much wet tobacco leaf a farmer puts into the oven for each time curing.
  - Last time furnace replaced/repaired (*kapan reperbaiki tungku*): continuous variable measured in years.
  - Last time oven was repaired (*kapan reperbaiki oven*): continuous variable measured in years.
  - Frequency flu is repaired (*frekuensi reperbaiki flu*): continuous variable that divides the number of times the flu is repaired by the number of years between repairs. The flu's condition probably affects quality and fuel-efficiency.
- Total number of times curing in a season (*berapa kali kering*): continuous variable measuring the number of times a farmer cured harvests of leaf.
- Location of farm (*daerah*): In general a farm is located close to a farmer's oven(s) and *daerah* was statistically significantly correlated (5% level) with *tungku*. Suggesting type of curing system seems to be clustered by location.

Sale Phase to Companies:

- Company: each company uses its own grading system but an employee of PT. Sadhana Arifnusa estimates a price differential of approximately 5% at each grade.

Excluded Variables

Although the following variables were collected in the survey, they were not used in my analysis because of too many missing variables.

- I operated under the assumption that the number of ovens owned would not have an impact on quality, drying costs and therefore net-benefits. However, in my discussion of results I explore the link between farmer wealth and choice of furnace. Even though number of ovens "owned" was asked, a more appropriate question would have been number of ovens "used" for the season.
- Does a farmer rent or own the farmland was asked as part of the survey but not used in regressions because I thought it would have no impact on quality or net-benefits. A good follow up question to add would be cost of land payments which would partially proxy for farmer wealth.
- Total farmed area was not used in the regressions but would also be a good proxy for wealth.
- Cost of irrigation was not included.
- Proportion of dried tobacco sold to each company was excluded due to too many missing variables.

Manipulation of Variables

In order to mitigate errors arising from farmer recall, I built redundant questions into the survey to approach the same data from different angles. For example, *daun kering* was asked directly but I cross-referenced these responses against the quantity sold at each price tier. Ideally the sum of the latter should equal the former.

- If the farmer had two farms but only one oven, I broke the data into two observations but weighted variables like *daun kering* according to the quantity of wet leaf produced from each farm or the difference in acreage.
- If there was a discrepancy between total tons of dry leaf and the proportions sold at each price tier I used the total tons stated by the farmer.
- If there was a discrepancy between the amount of fuel used per time curing and the total amount of fuel stated by the farmer, I used the season's total divided by *berapa kali kering*.
- If the farmer forgot the last time his oven or furnace was repaired I used the year of construction or purchase.
- If the farmer bought wet leaf after finishing drying his own crop I deducted the revenue he gained from this process from the season's total revenue. Also, I reduced *berapa kali kering* and total quantity of *bahan bakar* by the number of times he cured purchased leaf.
- Some farmers had low crop yields and bought wet leaf to mix thereby allowing the oven to operate at full capacity; I did not modify the data in these cases. This will be corrected in the next analysis with the addition of a dummy variable.

Methodology

I organized my paper into the following format:

1. Separate analysis of fuel-types and furnaces on dependent variables.
2. Analysis of curing systems on dependent variables.
3. Analysis of various fuel-mixes in conventional furnaces on dependent variables.

Statistical Techniques

In addition to data collected from farmer recall, my small sample size presented some challenges. To ensure that the Classical Linear Model assumptions were satisfied I utilized the following techniques after running the regressions using Stata 11. Following every Ordinary Least Square (OLS) regression, Breusch-Pagan/Cook-Weisberg and White's tests for homoskedasticity were conducted in conjunction with visual plots of residuals versus fitted-values. In cases where heteroskedasticity was found outliers were dropped. If heteroskedasticity persisted I ran the regressions with robust standard errors; Davidson and MacKinnon's bias corrections for small-sample robust standard errors (hc2); and the even stricter Angrist and Pischke's version (hc3). Since furnace types in the sample seemed to be clustered by location, I also ran the regressions using robust standard errors clustered by *daerah.* One possible explanation for this clustering is that farmers copy neighbours who are perceived as successful. Or perhaps certain regions have better access to certain fuel-types.

I was concerned with multicollinearity since different observations, counted by ovens, received wet tobacco leaf from the same farm. Variance inflation factor tests were conducted after every regression and none exceeded 10, so multicollinearity was probably not a problem. Finally, because net-benefits can yield negative values reflecting losses, I could not take the logarithm of this dependent variable. All other models, with the exception of those on the price tiers, are in log-log form and coefficients are expressed as constant elasticities; in other words rates of change in percentage terms.

OLS Regressions: The effects of *bahan bakar* and *tungku* on net-benefits, total costs, BTUs expended and the three price tiers were examined using OLS regressions. *Bahan bakar* was not statistically significant when *tungku* was expanded into binary dummy variables using *minyak tanah* or *kayu* as reference categories. All impacts of the other furnaces on each dependent variable are stated in comparison to the reference categories.

Logistic Regressions: On average, compared to *minyak tanah*, all other furnaces produced lower values across all three price tiers: *harga tertingi*, *harga sedang* and *harga terendah*. Visual plots after each OLS regressions exhibited discernable patterns implying violation of the Classical Linear Model assumptions. Likely the error terms are not normally distributed because or clustering around certain prices but can be remedied in the future with a larger sample size. Considering the fact that *minyak tanah* incurred the highest costs but yielded the greatest net-benefits/kg, I decided to make price a focal point of my research. I ran logistic regressions to ascertain the effects specific curing systems had on the probability of obtaining a *high price* (greater than the median price of *harga tertinggi*: 35,000 RP/kg). Logistic regressions on *harga sedang* and *harga terendah* resulted in too many omitted fuel types due to perfectly predicted successes and failures. In other words, certain fuel types always received higher or lower than the median value of each price tier. This prevented them from being included in a logistic regression so I only considered *high price*.

I used likelihood ratio tests (Appendix II, Table 4) to determine if including *tungku* would improve the model. Since neither *tungku* nor the likelihood ratio statistic was statistically significant I excluded *tungku* from the model that expands *bahan bakar*. I also used likelihood ratio tests (Appendix II, Table 5) to decide whether or not to include *bahan bakar* after expanding *tungku*. Because both *bahan bakar* and the likelihood ratio statistic were not statistically significant I excluded *bahan bakar* from the model.

The coefficients for all logistic regression results in Appendix II do not reflect the magnitude each independent variable has on the dependent variable. Marginal effects were separately calculated for each logistic regression and reported as part of the results section. Continuous variables were evaluated at the sample means and categorical variables at observations.

Models and Results

Individual Fuels and Furnaces

OLS Regressions on Net-Benefits (Appendix II, Table 1):

1. Net-Benefits = f(*bahan bakar, tungku, daun kering, control variables: drying, farming, sale*)
2. Net-Benfits/kg = f(*bahan bakar, tungku, control variables: drying, farming, sale*)

The difference between OLS Models 1 and 2 is that for the former, quantity of dried tobacco is used as a control variable. The latter directly incorporates it into the dependent variable by dividing *net-benefits* by the total quantity of dried tobacco sold. Since the quantity of dried tobacco (*daun kering*) was not statistically significant in Model 2 and including it in the model reduced the goodness-of-fit, I excluded it.

Results:

- *Net-Benefits*: using *minyak tanah* as the reference category, only *gasifikasi* was statistically significant at the 10% level, generating approximately 41.5 million RP more net-benefits.
- *Net -Benefits/kg*: none of the other types of furnaces were statistically significant even at the 10% level, but generated fewer benefits than *minyak tanah*.

OLS Regressions on Costs (Appendix II, Table 2):

3. Total Cost = f(*bahan bakar, tungku, daun kering, control variables: drying, sale*)
4. Total Cost/kg = f(*bahan bakar, tungku, control variables: drying, sale*)

Berapa kali kering was excluded from OLS Model 4 because it was not statistically significant and removing it improved the goodness-of-fit. Quantity of dried tobacco is directly incorporated into the dependent variable.

Results:

Results for Total Drying Costs for 2011 Season

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - On average compared to minyak tanah:*
Konvensional	1%	-43.40%	*Konvensional* furnace users had 43.4% less total drying costs
LPG	1%	-58.30%	*LPG* furnace users had 58.3% less total drying costs
Gasifikasi	1%	-46.10%	*Gasifikasi* furnace users had 46.1% less total drying costs

Results for Total Drying Costs per Kilogram of Dried Tobacco for 2011 Season

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
LPG	10%	-77.60%	*LPG* furnace users had 77.6% less total drying costs per kilogram
Gasifikasi	1%	-82.70%	*Gasifikasi* furnace users had 82.7% less total drying costs per kilogram

OLS Regressions on Price Tiers (Appendix II, Table 3):

5. Harga Tertinggi =f(*bahan bakar, tungku, control variables: drying, farming, sale*)
6. Harga Sedang = f(*bahan bakar, tungku, control variables: drying, farming, sale*)
7. Harga Terendah = f(*bahan bakar, tungku, control variables: drying, farming, sale*)

Results:

The results below for the three price tiers might be misleading since a visual plot of residuals versus fitted values show a slight, discernable pattern for *harga tertinggi* and strong patterns for the rest. This suggests the Classical Linear Model assumptions may be violated. But they do indicate that *minyak tanah* users receive higher prices across the entire range compared to almost all other furnaces.

- *Harga tertinggi:* On average, compared to *minyak tanah*, farmers who used *konvensional* and *gasifikasi* furnaces received lower values for their top price: 4,662 RP/kg less (5% significance level) and 3,326 RP/kg less (10% significance level) respectively. The other furnaces were not statistically significant even at the 10% level but also obtained lower prices compared to *minyak tanah.*
- *Harga sedang:* On average, compared to *minyak tanah*, farmers who used *konvensional*, *LPG* and *gasifikasi* furnaces collected lower prices: 3,510 RP/kg (10% significance level), 5,605 RP/kg (5% significance level) and 4,535 RP/kg (5% significance level).
- *Harga Terendah:* On average, compared to *minyak tanah*, farmers who used *LPG* and *gasifikasi* furnaces obtained 8,076 RP/kg (5% significance level) and 6,890 RP/kg (5% significance level) lower prices.

Logistic Regressions of Fuel on High Price (Appendix II, Table 6):

1. High Price = f(*bahan, bakar, control variables: drying, farming, sale*)
   a. *Minyak Tanah* as reference category
   b. With robust standard errors then robust standard errors clustered by *daerah*
2. High Price = f(b*ahan, bakar, control variables: drying, farming, sale*)
   a. *Kayu* as reference category
   b. With robust standard errors then robust standard errors clustered by *daerah*

Results:

Results for Logistic Regression of *Bahan Bakar* on High Price (*Minyak Tanah* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
Kayu	1%, 1%, 5%	-51.95%	51.95% less likely to obtain a high price
Solar	1%, 5%, 1%	-44.23%	44.23% less likely to obtain a high price
Kulit Kemiri	10%, 10%, 1%	-21.44%	21.44% less likely to obtain a high price
LPG	>10%, 5%, 1%	-29.93%	29.93% less likely to obtain a high price
Kayu & Batu Bara	1%, 1%, 1%	-48.90%	48.90% less likely to obtain a high price
Kayu & Kulit Kemiri	5%, 5%, 5%	-53.39%	53.39% less likely to obtain a high price
Kayu, Kulit Kemiri & Batu Bara	>10%, >10%, 5%	18.27%	18.27% more likely to obtain a high price

Note: *Batu Bara* and *Kulit Kemiri & Batu Bara* predicted failure completely so were omitted; *Kayu, Batu Bara Briket & Kulit Kemiri* predicted success completely

Results for Logistic Regression of *Bahan Bakar* on High Price (*Kayu* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to kayu:*
Minyak Tanah	1%, 1%, 5%	51.95%	51.95% more likely to obtain a high price
Kulit Kemiri	5%, 5%, 10%	30.50%	30.50% more likely to obtain a high price
LPG	>10%, 10%, 5%	22.01%	22.01% more likely to obtain a high price
Kayu, Kulit Kemiri & Batu Bara	1%, 5%, 5%	70.22%	70.22% more likely to obtain a high price

Note: *Batu Bara* and *Kulit Kemiri & Batu Bara* predicted failure completely so were omitted; *Kayu, Batu Bara Briket & Kulit Kemiri* predicted success completely

Logistic Regressions of Furnaces on High Price (Appendix II, Table 7):

3. High Price = f(*tunkgu, control variables: drying, farming, sale*)
   a. *Minyak Tanah* as reference category
   b. With robust standard errors then robust standard errors clustered by *daerah*
4. High Price = f(*tunkgu, control variables: drying, farming, sale*)
   a. *Konvensional* as reference category
   b. With robust standard errors then robust standard errors clustered by *daerah*

Results:

Results for Logistic Regression of *Tungku* on High Price (*Minyak Tanah* as Ref. Cat.)

(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
Konvensional	1%, 5%, 1%	-78.68%	78.68% less likely to obtain a high price
LPG	10%, 5%, 10%	-61.63%	61.63% less likely to obtain a high price
Solar	10%, 10%, 1%	-54.73%	54.73% less likely to obtain a high price
Gasifikasi	5%, 10%, 1%	-56.03%	56.03% less likely to obtain a high price

Results for Logistic Regression of *Tungku* on High Price (*Konvensional* as Ref. Cat.)

(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to konvensional:*
Minyak Tanah	1%, 5%, 1%	78.68%	78.68% more likely to obtain a high price

OLS Regressions on Fuel-Efficiency (Appendix II, Table 8):

The first set of regressions with robust standard errors clustered by *daerah*, then hc2 and hc3 robust standard errors.

8. BTU/kg = f(*bahan bakar, tungku, control variables: drying, sale)*
   a. *Minyak Tanah* as the reference category
9. BTU/kg = f(*bahan bakar, tungku, control variables: drying, sale)*
   a. *Konvensional* as the reference category

Results:

Results for BTU/kg (*Minyak Tanah* as Ref. Cat.)

(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
LPG	10%, 1%, 5%	-141.7%	*LPG* furnaces expended 141.7% fewer BTUs to dry each kilogram of tobacco
Solar	>10%, 5%, 10%	-59.3%	*Solar* furnaces expended 59.3% fewer BTUs to dry each kilogram of tobacco
Gasifikasi	>10%, 1%, 1%	-152.7%	*Gasifikasi* furnaces expended 152.7% fewer BTUs to dry each kilogram of tobacco

Various Curing Systems

OLS Regressions (Appendix II, Table 9):

I manually constructed interaction terms between *bahan bakar* and *tungku* using *minyak tanah* as the reference category.

10. Net-Benefits/kg = f(*bahan bakar*tungku, control variables: drying, farming, sale*)
11. Total Costs/kg = f(*bahan bakar*tungku, control variables: drying, sale*)
12. Harga Tertinggi = f(*bahan bakar*tungku, control variables: drying, farming, sale*)
13. BTU/kg = f(*bahan bakar*tungku, control variables: drying, sale*)
    a. With robust standard errors: clustered by *daerah*, hc2 and hc3

Results:

Results for Various Curing Systems on Net-Benefits/kg (*Minyak Tanah* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average, compared to minyak tanah:*
Konvensional *Kayu*	10%	-10,969 RP	*Kayu* in *Konvensional* furnaces yields 10,969 RP less net-benefits per kg of dried tobacco
Kayu & Batu Bara	5%	-17,159 RP	*Kayu & Batu Bara* in *Konvensional* furnaces yield 25,180 RP less net-benefits per kg of dried tobacco
Gasifikasi *Kayu, Kulit Kemiri & Batu Bara*	5%	-26,515 RP	*Kayu, Kulit Kemiri & Batu Bara* in gasifiers yield 26,515 RP less net-benefits per kg of dried tobacco
Kulit Kemiri & Batu Bara	5%	-28,496 RP	*Kulit Kemiri & Batu Bara* in gasifiers yield 28,496 RP less net-benefits per kg of dried tobacco
LPG	10%	-13,535 RP	LPG furnaces yield 26,515 RP less net-benefits per kg of dried tobacco

Results for Various Curing Systems on Costs/kg (*Minyak Tanah* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
Konvensional *Kayu*	1%	-47.40%	*Kayu* in *Konvensional* furnaces generate 47.4% fewer costs per kg of dried tobacco
Kayu & Batu Bara Briket, Kulit Kemiri	10%	36.40%	*Kayu* and *Batu Bara Briket* in *Konvensional* furnaces generate 36.4% more costs per kg of dried tobacco
Kayu & Batu Bara	1%	-35.80%	*Kayu* and *Batu Bara* in *Konvensional* furnaces generate 36.2% fewer costs per kg of dried tobacco
Kayu & Kulit Kemiri	10%	-33.70%	*Kayu* and *Kulit Kemiri* in *Konvensional* furnaces generate 33.70% fewer costs per kg of dried tobacco
Kulit Kemiri	5%	-58.6%	*Kayu* in *Konvensional* furnaces generate 58.6% fewer costs per kg of dried tobacco
Gasifikasi *Kulit Kemiri*	1%	-55.2%	*Kulit Kemiri* in *Gasifikasi* generate 55.2% fewer costs per kg of dried tobacco
LPG	1%	-48.30%	LPG furnaces generate 48.3% fewer costs per kg of dried tobacco

Results for Various Curing Systems on *Harga Tertinggi* (*Minyak Tanah* as Ref. Cat.)

(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
Konvensional			
Kayu	5%	-3,310	*Kayu* in *Konvensional* furnaces receive 3,310 RP less for *Harga Tertinggi*
Batu bara	1%	-14,737	*Batu Bara* in *Konvensional* furnaces obtain 14,737 RP less for *Harga Tertinggi*
Kayu & Batu Bara	1%	-6,528	*Kayu & Batu Bara* in *Konvensional* furnaces generate 6,528 RP less for *Harga Tertinggi*
Gasifikasi			
Kulit Kemiri, Batu bara	5%	-7,354	*Kulit Kemiri & Batu Bara* in gasifiers get 7,354RP less for *Harga Tertinggi*

Results for Various Fuel-Mixes in Various Furnaces on BTU/kg (*Minyak Tanah* as Ref. Cat.)

(Significance Level given for normal Clustered Robust SE, Robust SE (hc2) and (hc3) in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
Konvensional			
Kayu, Batu Bara Briket, & Kulit Kemiri	10%, 5%, >10%	109.20%	*Kayu & Batu Bara Briket* in *Konvensional* furnaces expended 109.2% more BTUs to dry each kilogram of dried tobacco
Kulitk Kemiri	5%, 1%, 1%	-262.10%	*Kulit Kemiri* in *Konvensional* furnaces required 262.1% fewer BTUs to dry each kilogram of dried tobacco
Gasifikasi			
Kulit Kemiri & Batu Bara	>10%, 10%, >10%,	-62.70%	*Kulit Kemiri & Batu Bara in Gasifikasi* furnaces burned 62.7% fewer BTUs to dry each kilogram of dried tobacco
Kulit Kemiri	10%, 1%, 1%	-169.30%	*Kulit Kemiri* in *Gasifikasi* furnaces consumed 169.3% fewer BTUs to dry each kilogram of dried tobacco
Solar	10%, 1%, 5%	-137.80%	*Solar* furnaces needed 137.8% fewer BTUs to dry each kilogram of dried tobacco

Logistic Regressions of Various Curing Systems on High Price (Appendix II, Table10):

5. High Price = f(*bahan bakar*tungku, control variables: drying, farming, sale*)
   a. *Minyak Tanah* as reference category
   b. With robust standard errors then robust standard errors clustered by *daerah*
6. High Price = f(*bahan bakar*tungku, control variables: drying, farming, sale*)
   a. *Kayu* in *konvensional* furnaces as reference category
   b. With robust standard errors then robust standard errors clustered by *daerah*

Results:

Results for Logistic Regression of Various Curing Systems on *High Price* (*Minyak Tanah* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to minyak tanah:*
Konvensional			
Kayu	1%, 1%, 5%	-56.28%	56.28% less likely to obtain a high price
Kayu & Batu Bara	1%, 1%, 1%	-52.93%	52.93% less likely to obtain a high price
Kayu & Kulit Kemiri	5%, 5%, 1%	-51.81%	51.81% less likely to obtain a high price
Gasifikasi			
Kulit Kemiri	10%,10%, 1%	-12.07%	12.07% less likely to obtain a high price
Solar	1%, 10%, 1%	-51.88%	51.88% less likely to obtain a high price
LPG	10%, 5%, 5%	-38.11%	38.11% less likely to obtain a high price

Results for Logistic Regression of Curing Systems on *High Price* (*Kayu* in *Konvensional* furnaces as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to Kayu in Konvensional furnaces:*
Konvensional			
Kayu, Kulit Kemiri & Batu Bara	10%, 1%, 5%	44.22%	44.22% more likely to obtain a high price
Note: *Kayu, Batu Bara Briket, & Kulit Kemiri* and *Kulit Kemiri* predicted success perfectly so were omitted; *Batu Bara* predicted failure perfectly			
Gasifikasi			
Kulit Kemiri	5%, 10%, >10%	30.88%	30.88% more likely to obtain a high price
Note: *Kayu, Kulit Kemiri & Batu Bara* predicted success perfectly so were omitted; *Kulit Kemiri & Batu Bara* predicted failure perfectly			
Minyak Tanah	1%, 1%, 5%	56.29%	56.29% more likely to obtain a high price

Various Fuel-Mixes in Conventional Furnaces

OLS Regressions (Appendix II, Table 11):

The first set of regressions use *kulit kemiri* as the reference category then *kayu*.

14. Net-Benefits/kg = f(*bahan bakar, control variables: drying, farming, sale*)
15. Total Costs = f(*bahan bakar, control variables: drying, sale*)
16. Total Costs/kg = f(*bahan bakar, control variables: drying, sale*) excluding *berapa kali kering*
17. BTU/kg = f(*bahan bakar, control variables: drying, sale*)
18. Harga Tertinggi = f(*bahan bakar, control variables: drying, farming, sale*)
    a. Appendix II, Table 11: first set of regressions use *kulit kemiri* as the reference category then *kayu*

Results:

- *Net-Benefits, Net-Benefits/kg, Total Cost of Drying:* None of the other fuel-mixes had statistically significant effects compared to both *kulit kemiri* and *kayu* as the reference categories.
- *Cost/kg*: *Batu bara* was 212.3% more expensive than *kulit kemiri* and 151.8% more expensive than *kayu*; significant at the 10% and 5% level respectively.
- *BTU/kg:*
    - Compared to *kulit kemiri* all other statistically significant fuels expended more BTUs
        - *Kayu:* 302.2% (significant at 1% level)
        - *Batu bara:* 237% (significant at 10% level)
        - *Batu bara briket, kayu & kulit kemiri* 248.0% (significant at 5% level)
        - *Kayu & batu bara* 285.7% (significant at 1% level)
        - *Kayu & kulit kemiri* 275.2% (significant at 1% level)
    - Compared to *kayu*: *kulit kemiri* expended 302.2% fewer BTUs (significant at 1% level) while all other fuel-mixes were not statistically significant but had negative coefficients also.

Logistic Regressions of Various Fuel-Mixes in Conventional Furnaces on High Price (Appendix II, Table 13):

7. High Price = f(*bahan bakar, control variables: drying, farming, sale*)
    a. *Kulit Kemiri* as reference category
    b. With robust standard errors then robust standard errors clustered by *daerah*
8. High Price = f(*bahan bakar, control variables: drying, farming, sale*)
    a. *Kayu* as reference category
    b. With robust standard errors then robust standard errors clustered by *daerah*

Results:

Results for Logistic Regression of Various Fuel-Mixes in Conventional Furnace on *High Price* (*Kulit Kemiri* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to kayu in konvensional furnaces:*
Kayu	>10%, 1%, 1%	-291.04%	291.04% less likely to obtain a high price
Kayu & Batu Bara	>10%, 1%, 1%	-310.56%	310.56% less likely to obtain a high price
Kayu & Kulit Kemiri	>10%, 1%, 1%	-207.78%	207.78% less likely to obtain a high price

Note: *Batu Bara* predicted failure perfectly; *Kayu, Batu Bara Briket & Kulit Kemiri* predicted success perfectly

Results for Logistic Regression of Various Fuel-Mixes in Conventional Furnace on *High Price* (*Kayu* as Ref. Cat.)
(Significance Level given for normal Standard Errors, Robust SE and Clustered Robust SE in that order; >10% indicates not statistically significant at 10% level)

Statistically Significant Variables	*Significance Level*	*Marginal Effect on Dependent Variable*	*Explanation - on average compared to kayu in konvensional furnaces:*
Kayu & Kulit Kemiri	10%, 10%, >10%	85.45%	85.45% more likely to obtain a high price

Note: *Batu Bara* predicted failure perfectly; *Kayu, Batu Bara Briket & Kulit Kemiri* predicted success perfectly; *Kulit Kemiri* predicted success perfectly

Discussion of Results

Individual Fuels and Furnaces

Following the perceptions of many farmers, I used kerosene as the benchmark to compare other drying technologies and fuels. Only *gasifikasi* furnaces were statistically significant, on average generating 41.5 million RP more net-benefits compared to *minyak tanah*. On a kilogram of dried tobacco basis, all other furnaces produced fewer net-benefits but these results were not statistically significant. *Konvensional*, *LPG* and *gasifikasi* furnaces incurred 43.4%, 58.3% and 46.1% less total drying costs than *minyak tanah*. On a kilogram of dried tobacco basis, the cost savings increased to 77.6% and 82.70% for *LPG* and *gasifikasi* furnaces. On the metric of fuel-efficiency *gasifikasi* furnaces were most efficient followed by *LPG* and *solar*, consuming 152.7%, 141.7% and 59.3% fewer BTUs than *minyak tanah*.

To explore why net-benefits per kilogram, as a dependent variable, yielded no statistically significant results I ran an OLS regression on total net-benefits and interacted *tungku* with *daun kering* (Appendix V, Table 1). Evaluating the latter at the sample percentiles, ceteris paribus, it seems the net-benefits of using *gasifikasi* surpass that of *minyak tanah* when *daun kering* increases from 4 to 5 tons. *LPG* users have greater net-benefits than *minyak tanah* until between 2.1 and 2.93 tons. This suggests that using net-benefits as the dependent variable is probably a better measure of the returns to various furnaces as the costs, or cost-savings, change over increases in quantity of tobacco.

Net-Benefits from Furnaces as we Increase the Quantity of Dried Tobacco Processed

Furnace *(compared to Minyak Tanah)*	*Quantities Evaluated at Percentiles in the Sample:*				
	1 Ton (10%)	*2.1 Ton (25%)*	*2.93 Ton (50%)*	*4 Ton (75%)*	*5 Ton (90%)*
Konvensional	- 68,000,000.00	- 60,190,000.00	- 54,297,000.00	- 46,700,000.00	- 39,600,000.00
LPG	**38,600,000.00**	**5,160,000.00**	- 20,072,000.00	- 52,600,000.00	- 83,000,000.00
Solar	- 73,700,000.00	- 54,450,000.00	- 39,925,000.00	- 21,200,000.00	- 3,700,000.00
Gasifikasi	- 57,900,000.00	- 37,440,000.00	- 22,002,000.00	- 2,100,000.00	**16,500,000.00**

At the sample mean of 3.4 tons of *daun kering*, all other furnaces generated fewer net-benefits than *minyak tanah.* If unsubsidized kerosene is the most expensive curing system, it stands to reason that *minyak tanah* users probably receive higher prices on average. Logistical regressions on *high price* seem to confirm this which implies that *minyak tanah* produces the best quality. An alternate explanation is that farmers with greater wealth can afford to pay the higher costs of using unsubsidized kerosene. Further, there could be a link between wealth and social status. Thus, these factors could contribute to the probability of *minyak tanah* users having a better chance of obtaining a high price compared to their counterparts.

I generated a binary variable, *wealthy*, that takes the value 1 if a farmer owned more than 2 ovens and used more than 3 hectares (the 75th percentile) of farmland in 2011. Controlling for experience growing tobacco and location, w*ealthy* farmers were 37.5 times more likely to use *minyak tanah* (significant at 1% level) and 3.4 times more likely to use *gasifikasi* (almost significant at 10% level) than non-*wealthy* farmers. Non-*wealthy* farmers were 3.97 times more likely to use *konvensional* furnaces (significant at 5% level) than *wealthy* farmers. A successful program aimed at maximizing welfare should tailor marketing strategies towards the financial means of farmers.

Various Curing Systems

Of the statistically significant independent variables, compared to *minyak tanah*, *kayu* in *konvensional* furnaces and *LPG* furnaces generated the least negative returns in net-benefits per kilogram. *Kulit kemiri* in *konvensional* and *gasifikasi* furnaces produced the most cost savings and energy savings per kilogram. *Kayu, batu bara briket & kulit kemiri* in *konvensional* furnaces was the most expensive and energy intensive. The only fuel-mix that was more likely (18.2%) to achieve a *high price* than *minyak tanah* was *kayu, batu bara & kulit kemiri*. However I was unable to attribute this result to a specific technology; there were 2 *konvensional* and 3 *gasifikasi* farmers using this fuel-mix.

Effect of Various Curing Systems on Net-Benefits from as Oven Volume Increases

Fuel-Mix in Furnaces *(Minyak Tanah as Ref. Cat)*	*96 m^3 (10%)*	*112 m^3 (25%)*	*140 m^3 (50%)*	*175 m^3 (75%)*	*210 m^3 (90%)*
Konvensional:					
Kayu	-55510272	-49761984	-39702480	-27128100	-14553720
Kayu, Batu Bara	-110943520	-91267440	-56834300	-13792875	**29248550**
Gasifikasi:					
Kulit Kemiri	-48073984	-24919648	**15600440**	**66250550**	**116900660**
Solar	-76930336	-54585392	-15481740	**33397825**	**82277390**
LPG	-69122592	-63143024	-52678780	-39598475	-26518170

If we evaluate the effect of interacting oven volume and curing systems on net-benefits (Appendix V, Table 2), the comparative benefits of using *minyak tanah* seem to decrease as oven volume increases. At the sample median of 140 m^3 (4 meters by 5 meters by 7 *tingkat*) only *kulit kemiri* in *gasifikasi* furnaces produced greater net-benefits. *Solar* joins in at the 75th percentile and *kayu & batu bara* in *konvensional* furnaces at the 90th percentile. This implies certain systems perform better over different oven volumes. As such, a marketing plan to promote specific systems should account for factors unique to each combination of oven, farmer and furnace.

Various Fuel-Mixes in Conventional Furnaces

Conventional furnaces dominated the sample and farmers who were not *wealthy* were approximately 3 times more likely to use this technology. If our aim is to improve the welfare of the largest number of farmers this is a demographic we cannot ignore. The dissemination of more efficient furnaces is constrained by the rate farmers are willing and able to replace their current units. In the meantime, we can focus on delivering immediate solutions in the form of optimal fuel-mixes.

There were no statistically significant differences for net-benefits or net-benefits per kilogram using either *kulit kemiri* or *kayu* as the reference categories. *Kayu*, *batu bara briket & kulit kemiri* generated 64% more total costs than *kulit kemiri*. On a per kilogram basis, these values increase to 212.3% and 151.8%. In terms of energy-savings, every other statistically significant fuel-mix was more inefficient than *kulit kemiri*, requiring 237.0% (*batu bara*) to 302.2% (*kayu*) more BTUs to cure each kilogram of tobacco. Using *kayu* as the reference category, every other fuel-type was more efficient but only *kulit kemiri* was statistically significant (at 1%) expending 302.2% fewer BTUs.

The potential biases and problems from the small sample size had an even greater impact on my investigation of fuel-mixes in conventional furnaces. I attempted to interact fuel-mix with oven volume and type of flu over a range of dependent variables. Perfect predictions and multicollinearity resulted in too many omitted variables of interest in every case. However the prevalence of this furnace in the market will make gathering a larger sample size, in order to conduct a more comprehensive study, relatively easy.

Conclusion

The multitude of factors which affect the welfare of farmers from drying and curing tobacco create exciting challenges for researchers in the fields of agriculture and energy. In addition to the quantitative results from my analysis, I hope to contribute to future research by improving on this study's methodology. Some recommendations are included in Appendix VI. To build on the broad findings of this report, forthcoming research efforts should focus on:

1. The optimal curing systems for different wealth and social classes
2. The impact of interacting control variables with variables of interest
3. The best fuel-mixes of available feedstocks for use in *konvensional* furnaces
4. The use of new forms of biomass for use in *konvensional* furnaces; e.g. biomass briquettes from agricultural waste and sustainable fuelwood.

This study reveals that *LPG* and *gasifikasi* furnaces reduce costs the most and are the most energy efficient. But *minyak tanah* systems generate the greatest net-benefits per kilogram of dried tobacco; probably due to the higher prices its users receive. Whether this is due to social factors, familiarity of farmers with the technology or superior quality from the curing system itself merits further investigation. Net-benefits from using *solar*, *kulit kemiri* in *gasifikasi*, and *kayu & batu bara* in *konvensional* furnaces seem to exceed those of *minyak tanah* as oven volume increases. Discovering the underlying causes behind this interaction might allow farmers to achieve similar results in smaller ovens.

In *konvensional* furnaces *kayu & kulit kemiri*, as well as *kulit kemiri*, are most likely to obtain a high price; the latter is also the most energy-efficient. This bodes well for raising the demand of sustainable biomass in Lombok. Given the widespread use of *konvensional* furnaces, many farmers can benefit by incorporating *kulit kemiri* into their fuel-mix. The 2012 season heralds the introduction of palm oil kernel shells (*cangkang sawit*) into the market. Growing consumer preference of biomass from agro-forestry waste-streams reflects a mounting awareness of this fuel-type's private benefits to farmers. If obtained from a sustainable source, replacing illegal fuelwood and fossil fuels with biomass also raises social welfare by reducing negative impacts on the environment. Currently stakeholders independently pursue the marketing of gasification technologies and R&D on biomass feedstocks. However, collaborative research at the heart of grassroots marketing programs, *socialisasi*, can encourage consumer acceptance at a synergistic rate.

Appendix I: Survey Untuk Musim 2011

Kami akan menyimpan semua informasi yang Anda berikan sebagai rahasia.

Nama Petani:	HP:
Lokas Rumah:	Nama surveyor:

Berapa areal sawah yang anda punya (musim 2011)? ___________________

Areal #1	**Areal #2**	**Areal #3**	**Areal #4**
Lokas:	Lokas:	Lokas:	Lokas:
Jumlah (hectare):	Jumlah (hectare):	Jumlah (hectare):	Jumlah (hectare):
Tipe: up/low/mid/dry	Tipe: up/low/mid/dry	Tipe: up/low/mid/dry	Tipe: up/low/mid/dry
Apakah anda memiliki atau menyewa areal? (tolong lingkaran satu):			
sewa pribadi	sewa pribadi	sewa pribadi	sewa pribadi
Berapa banyak daun basah untuk setiap areal?			
(jumlah ton):	*(jumlah ton):*	*(jumlah ton):*	*(jumlah ton):*

Berapa oven yang anda memiliki (musim 2011)? _____________

Oven #1	**Oven #2**	**Oven #3**	**Oven #4**
Lokasi:	Lokas:	Lokas:	Lokas:
Ukuran:	Ukuran:	Ukuran:	Ukuran:
Berapa tingkat:	Berapa tingkat:	Berapa tingkat:	Berapa tingkat:
Berapa kapsitas (tons):	Berapa kapsitas (tons):	Berapa kapsitas (tons):	Berapa kapsitas (tons):
Berapa umur (tahun):	Berapa umur (tahun):	Berapa umur (tahun):	Berapa umur (tahun):
Jenis flu:	Jenis flu:	Jenis flu:	Jenis flu:
Berapa tungku juga jenis tipe yang anda memiliki dan mengunakan (musim 2011): *Contoh tipe → konvensional; Gasifikasi: pembda, rotani; LPG; minyak tanah; sina ragung; dll...*			
Tipe tungku: a) b) c)	Tipe tungku: a) b) c)	Tipe tungku: a) b) c)	Tipe tungku: a) b) c)
Berapa banyak setiap tunkgu: a) b) c)	Berapa banyak setiap tunkgu: a) b) c)	Berapa banyak setiap tunkgu: a) b) c)	Berapa banyak setiap tunkgu: a) b) c)

Buat panah untuk menunjutkan aliran daun basah dari setiap areal ke setiap oven. Terus menulis berapa banyak daun kering dari setiap oven **(jumlah musim 2011)**. Contoh:

- Areal #1
- Areal #2
- Areal #3
- Areal #4

15 ton daun basah (atau 75% daun basah)

5 ton daun basah (atau 25% daun basah)

- Oven #1 → berapa ton daun kering 2.25 ton___
- Oven #2 → berapa ton daun kering 7 kwintal____
- Oven #3 → berapa ton daun kering ____________
- Oven #4 → berapa ton daun kering ____________

- Areal #1
- Areal #2
- Areal #3
- Areal #4

- Oven #1 → berapa ton daun kering ____________
- Oven #2 → berapa ton daun kering ____________
- Oven #3 → berapa ton daun kering ____________
- Oven #4 → berapa ton daun kering ____________

Setelah anda menjual tembakau yang anda tanam sendiri, apakah anda membeli daun basah lagi untuk di oven (musim 2011)?
Kalau "yes:"

berapa banyak daun kering yang anda jual dari ini (jumlah ton atau kwintal)? ______________
berapa total pendapatan dari ini? __________________RP
berapa kali anda mengoven untuk ini (jumlah)? ________________ kali

Oven #1	**Oven #2**	**Oven #3**	**Oven #4**
Kapan terakhir anda memperbaiki tungku atau menggantinya (tahun): Oven #1 Oven #2 Oven #3 Oven#4			
Kapan terakhir anda memperbaiki oven: Oven #1 Oven #2 Oven #3 Oven#4			
Kapan terakhir anda memperbaiki atau mengganti flu (tahun): Oven #1 Oven #2 Oven #3 Oven#4			
Seberapa sering anda memperbaiki atau mengganti flu? Oven #1 Oven #2 Oven #3 Oven#4			

Pertanyaan tentang yang *anda tanam sendiri* (musim 2011):

Oven #1	**Oven #2**	**Oven #3**	**Oven #4**
Jenis tipe dan banyak bahan bakar yang anda gunaka untuk setiap oven: [Contoh: a) *kayu* b) *batu bara* c) *kulit kemiri*]			
a) b) c) d) e)	a) b) c) d) e)	a) b) c) d) e)	a) b) c) d) e)
Berapa banyak bahan bakar yang anda gunakan untuk setiap oven. **Kalau karung tolong mengatakan berapa KG per karung**: [Contoh: a) 1 truck b) 20 karung (**1 karung = 80 kg**) c) 1 ton			
Sekali kering: a) b) c) d) e)	***Sekali kering:*** a) b) c) d) e)	***Sekali kering:*** a) b) c) d) e)	***Sekali kering:*** a) b) c) d) e)
Berapa kali pengovenan untuk setiap oven (tanam sendiri, musim 2011):			
Oven #1: Kali	**Oven #2:** Kali	**Oven #3:** Kali	**Oven #4:** Kali
Berapa harga rata-rata anda bayar untuk bahan bakar (harga per unit): [Contoh: a) 2 juta RP/truck b) 65.000RP/karung c) 1,4 juta RP/ton			
a) b)	a) b)	a) b)	a) b)

c) d) e)	c) d) e)	c) d) e)	c) d) e)
Berapa rata-rata jumlah bahan bakar yang anda gunakan untuk setiap oven (jumlah): [Contoh: a) 6 truck b) 400 karung (1 karung = 80 kg) c) 2 ton			
a) b) c) d) e)	a) b) c) d) e)	a) b) c) d) e)	a) b) c) d) e)
Kalau anda meyewa stoker, berapa gaji setiap stoker dan berapa jumlah stoker untuk musim 2011? Contoh: 2 stoker dan 1 stoker 2 juta RP → 2 X 2 juta RP			
Oven #1:	Oven #2:	Oven #3:	Oven #4:

Pertanyaan tentang daun Yang Anda tanam sendiri (musim 2011):

Berapa banyak penghasilan untuk setiap oven (jumlah RP):			
Oven #1:	Oven #2:	Oven #3:	Oven #4:
Berapa rata-rata harga kering yang anda jual: [Contoh: harga tertinggi – 30,000RP/kg atau 3 juta RP/kwintal			
Harga tertinggi: RP	Harga tertinggi: RP	Harga tertinggi: RP	Harga tertinggi: RP
Harga sedang: ____________________RP	Harga sedang: RP	Harga sedang: RP	Harga sedang: RP
Harga terendah: RP	Harga terendah: RP	Harga terendah: RP	Harga terendah: RP
Berapa jumlahnya untuk setiap harga anda jual (kwintal atau ton):			
Harga tertinggi:	Harga tertinggi:	Harga tertinggi:	Harga tertinggi:
Harga sedang:	Harga sedang:	Harga sedang:	Harga sedang:
Harga terendah:	Harga terendah:	Harga terendah:	Harga terendah:

Berapa total biaya untuk mempersiapkan pembajakan (per hectare): ____________________________________

Sistem pengairan seperti apa yang anda punya: *subak* *technis* atau: _________________________________

Berapa biaya pengairan anda untuk sepanjang musim (per hectare): ____________________________________

Jenis Pupuk apa yang anda gunakan untuk tembakau (per hectare): contoh 2 kwintal/ha

Pertilla _________ *KNO3* _________ *SP36* _________ *UREA* _________

NPK _________ *ZA* _________ *Perginia* _________ _________________

_________________ _________________ _________________ _________________

Jenis pestisida apa yang anda gunakan (melingkungi kalau yes):

Desis *Metindo* *Aktara* *MRT* *LIK*

Semptot *Entrakol* *BlackCrown* *Trakol* _________

_________ _________ _________ _________

____

Berapa tahun anda menanam tembakau? __________________ tahun

Untuk mengeringkan tembakau:

- Dalam 24 jam berapa kali anda melakukan pengisian bahan bakar: ________________ kali
- Satu kali pengisian bahan bakar, berapa lama waktu yang di perlukan: ___________ menit/jam
- Contoh:
    - *Kayu*: 4 kali dalam 24 jam. 1 kali perlu 2 jam.

Oven #1	**Oven #2**	**Oven #3**	**Oven #4**
Kepada siapa biasanya anda menjual daun tembakau dan berapa jumlah (ton atau percent): Contoh: BAT 3 ton, Sadhana 2 ton, Broker 1 ton atau BAT 60%, Sadhana 40%, Broker 20%			
BAT/ELI:	BAT/ELI:	BAT/ELI:	BAT/ELI:
Sadhana:	Sadhana:	Sadhana:	Sadhana:
Jarum:	Jarum:	Jarum:	Jarum:
Eliensuan:	Eliensuan:	Eliensuan:	Eliensuan:
EDS:	EDS:	EDS:	EDS:
Wishmiluk:	Wishmiluk:	Wishmiluk:	Wishmiluk:
Broker:	Broker:	Broker:	Broker:

-

Berikan nilai untuk haal di bawa ini berdasarkan yang penting menurut anda (1 yang paling penting):
Hemat bahan bakar: _____________________
Hemat biaya: _____________________
Hemat waktu: _____________________
Harga bahan bakar: _____________________

Contoh:
Hemat bahan bakar: __4__________________
Hemat biaya: _______1______________
Hemat waktu: _______2_____________
Harga bahan bakar: ___3_________________

Appendix II: Survey Sample Statistics

Number of Farmers	66
Number of Ovens (Observations)	87
Total Locations of Farms	45
Proportion of Farms in "Upland"	13%
Proportion of Farms in "Lowland"	19%
Proportion of Farms in "Midland"	45%
Proportion of Farms in "Dryland"	23%
Total Area Farmed (ha)	274.09
Mean Area of Land Farmed per Farmer	3.1
Mean Number of Curings per Farmer	8.6
Mean Oven Volume	145 m^3
Total Dried Tobacco (tons)	279.51
Mean Dried Tobacco Sold per Farmer (tons)	3.4
Total Trucks of Wood	392.5
Total Tons of Coal	77.45
Total Tons of Coal Briquettes	5
Total Drums of Diesel	167.5
Total Drums of Kerosene	220.5
Total Canisters of LPG	189
Total Tons of *kulit kemiri*	117.59
Total British Thermal Units Expended	22,141,904,392.99
Total Expenditure on Fuel (RP)	1,591,628,501.46
Total Expenditure on Stockers (RP)	237,700,000.00
Mean Expenditure on Stockers for the 2011 Season (RP)	2,796,471
Mean Cost of Fuel per Curing (RP)	2,140,569.00
Total Revenue of all Farmers (RP)	7,573,655,000.00
Mean Number of Times Curing	8.6
Mean Revenue of Farmers (RP)	88,065,755.81
Mean of High Price for Tobacco(RP/kg)	34,606.70
Mean of Median Price for Tobacco (RP/kg)	27,845.68
Mean of Low Price for Tobacco (RP/kg)	20,455.56
Mean Price of Wood (RP/Truck)	1,907,849.31
Mean Price of Coal (RP/ton)	1,461,256.20
Mean Price of Coal Briquettes (RP/ton)	1,800,000.00
Mean Price of Diesel (RP/drum)	1,194,444.44
Mean Price of LPG (RP/canister)	487,500.00
Mean Price of Kerosene (RP/drum)	1,320,454.55
Mean Price of *kulit kemiri* (RP/ton)	1,224,801.59
Total Conventional Furnaces	51 (58.6%)
Total LPG Furnaces	4 (5%)
Total Kerosene Furnaces	11 (12.6%)
Total Diesel Furnaces	9 (10.3%)
Total Gasifier Furnaces	12 (13.8%)

Appendix III: Derivation of Calorific Values for Fuel-Types

Fuel Type	Unit	BTUs/Unit
Kerosene (*minyak tanah*)	Drum	7,380,970.62
Coal (*batu bara*)	Ton	5,624,540.80
Coal briquette (*batu bara briket*)	Ton	20,819,750.86
Candlenut Shell (*kulit kemiri*)	Ton	4,784,942.01
Liquefied Petroleum Gas (*LPG*)	Canister	2,347,925.007
Diesel (*Solar*)	Drum	7,480,660.00
Average of Wood (*kayu*):	Truck	44,188,271.71
Log Wood - Air Dried	Truck	23,884,991.43
Sesbania (type of *kayu*)	Truck	64,491,551.99

Assumptions:

- Each drum is 220 litres
- Each ton is 1000 kilogram (kg)
- Each canister is 50 kg
- Each truck is 4 m^3
- 0.453592 kg = 1 pound
- 3.78541 litres = 1 gallon
- 3.96566683 BTUs = 1kilocalories (kcal)
- 947.817120313 BTUs = 1 MegaJoule (MJ)

Calculations:

- Kerosene has 127,000 BTUs/gallon = 33,550 BTUs/litre (SEPEHR REDSTAR CANADA Ltd.)
- Coal has 12,400 BTUs/pound = 5624.541 BTUs/kg (SEPEHR REDSTAR CANADA Ltd.)
- Coal briquettes have 5250 kcal/kg = 20,819.75 BTUs/kg (Agni Group of Companies)
- Candlenut Shells have 10,549 BTUs/pound = 4,784.942 BTUs/kg (Patabang, 2009)
- LPG has 21,300 BTUs/pound = 46,958.5 BTUs/kg (SEPEHR REDSTAR CANADA Ltd.)
- Diesel has 34,003 BTUs/litre (Hofstrand, 2007)
- I took the average of air dried log wood and sesbania to get the average calorific value of wood:
    - Air dried log wood has between 5,200 and 7,400 MJ/m^3 so an average of 6,300 MJ/m^3 (Biomass Energy Centre) = 5971247.86 BTUs/m^3
    - Sesbani has one of the highest calorific values for wood at 4670 kcal/kg and 870 kg/m^3 (Winrock International, 1996) = 16,122,888 BTUs/m^3

Appendix IV: Regression Result Tables

Table 1: OLS Regressions of Furnaces on Net-Benefits

INDEPENDENT VARIABLES *(Minyak Tanah as Reference Category)*	DEPENDENT VARIABLES: Net-Benefits	Net-Benefits/kg
BahanBakar	247,683	-426.3
	(1.860e+06)	(589.8)
Konvensional	6.359e+06	-10,943
	(2.189e+07)	(6,717)
LPG	-1.502e+07	-11,153
	(2.621e+07)	(7,516)
Solar	3.628e+07	-4,572
	(2.474e+07)	(7,594)
Gasifikasi	4.150e+07*	-632.6
	(2.186e+07)	(6,306)
Jenis Flu	-1.182e+07*	-3,549*
	(6.417e+06)	(1,778)
Oven Volume	282,231	132.1**
	(208,325)	(63.16)
Oven Umur	1.481e+06	476.3
	(898,254)	(295.2)
Kapasitas	-1.810e+06	-3,142
	(8.033e+06)	(2,162)
Kapan Reperbaiki Tungku	-9.955e+06**	-3,423**
	(4.902e+06)	(1,402)
Kapan Reperbaiki Oven	1.057e+06	248.8
	(1.558e+06)	(434.4)
Frekuensi Reperbaiki Flu	1.804e+07*	1,621
	(9.564e+06)	(2,479)
Berapa Kali Kering	5.196e+06	333.3
	(3.109e+06)	(834.9)
Daerah	6.268e+06	1,050
	(5.914e+06)	(1,735)
Kwantitas Daun Kering	1.127e+07***	
	(2.649e+06)	
Sistem Pengairan	-6.625e+06	-2,222
	(1.423e+07)	(4,018)
Biaya Mempersiapkan Pembajakan	0.136	5.50e-05
	(0.431)	(0.000125)
Jumlah Tipe Pestisida	8.550e+06	1,282
	(5.118e+06)	(1,554)
Pengalaman Tembakau	-1.996e+06**	-615.8**
	(943,996)	(271.0)
Company	1.382e+06	95.66
	(914,354)	(247.9)
Pupuk	1.381e+06	-311.7
	(960,359)	(276.5)
Constant	-9.679e+07	34,108*
	(6.883e+07)	(19,510)
Observations	75	70
R-squared	0.660	0.387

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: OLS Regressions of Furnaces on Cost

(Cost/kg: Cost per kilogram of dried tobacco)

INDEPENDENT VARIABLES *(Minyak Tanah as Reference Category)*	DEPENDENT VARIABLES: Total Cost for Season	Cost/kg
BahanBakar	0.0151	0.0256
	(0.0126)	(0.0291)
Konvensional	-0.434***	-0.358
	(0.134)	(0.316)
LPG	-0.583***	-0.776*
	(0.185)	(0.404)
Solar	-0.0999	-0.464
	(0.140)	(0.318)
Gasifikasi	-0.461***	-0.827**
	(0.160)	(0.371)
Jenis Flu	0.00471	-0.0481
	(0.0424)	(0.0989)
Oven Volume	0.272	0.595
	(0.229)	(0.544)
Oven Umur	-0.0582	-0.108
	(0.0540)	(0.127)
Kapasitas	-0.273	-1.207***
	(0.205)	(0.442)
Kapan Reperbaiki Tungku	-0.0172	0.126
	(0.0744)	(0.172)
Kapan Reperbaiki Oven	0.00881	0.0120
	(0.0502)	(0.116)
Frekuensi Reperbaiki Flu	0.121*	-0.232
	(0.0698)	(0.154)
Berapa Kali Kering	0.0805***	Not significant
	(0.0193)	so excluded
Daerah	0.0242	-0.0995
	(0.0414)	(0.104)
Kwantitas Daun Kering	0.0168	
	(0.0490)	
Company	0.0924	0.203
	(0.0773)	(0.171)
Pengalaman Tembakau	0.00227	-0.0117
	(0.00535)	(0.0124)
Constant	15.19***	7.745***
	(1.009)	(2.442)
Observations	74	71
R-squared	0.654	0.328

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3: OLS Regression of Furnaces on Price Tiers

	DEPENDENT VARIABLE		
VARIABLES	Harga Tertinggi	Harga Sedang	Harga Terendah
BahanBakar	-81.39	234.3	127.7
	(158.5)	(175.8)	(275.1)
Konvensional	-4,662**	-3,510*	-3,248
(Minyak Tanah as Reference Category)	(1,788)	(1,983)	(3,104)
LPG	-638.7	-5,605**	-8,076**
	(2,171)	(2,409)	(3,770)
Solar	-1,790	-801.0	4,287
	(2,025)	(2,247)	(3,516)
Gasifikasi	-3,326*	-4,535**	-6,890**
	(1,857)	(2,061)	(3,225)
Jenis Flu	140.3	372.7	265.9
	(538.5)	(597.5)	(935.1)
Oven Volume	762.9	6,356*	13,696***
	(2,940)	(3,262)	(5,106)
Oven Umur	-675.4	-644.5	360.0
	(724.2)	(803.5)	(1,257)
Kapasitas	-1,066	-4,006	-9,560**
	(2,461)	(2,731)	(4,274)
Kapan Reperbaiki Tungku	-222.6	-2,931***	-4,934***
	(953.3)	(1,058)	(1,655)
Kapan Reperbaiki Oven	-1,724***	378.9	2,250**
	(628.9)	(697.8)	(1,092)
Frekuensi Reperbaiki Flu	99.63	-1,187	-2,283
	(1,020)	(1,132)	(1,771)
Daerah	-129.9	605.0	-225.6
	(539.2)	(598.2)	(936.2)
Sistem Pengairan	-3,968***	-4,465***	-5,021**
	(1,193)	(1,324)	(2,072)
Biaya Mempersiapkan Pembajakan	-321.1	-293.0	-504.6
	(383.1)	(425.1)	(665.3)
Jumlah Tipe Pestisida	-2,641**	-526.4	1,425
	(1,218)	(1,352)	(2,116)
Pengalaman Tembakau	518.6	3,701***	2,740
	(1,001)	(1,110)	(1,738)
Company	100.8	205.5**	293.6**
	(78.24)	(86.81)	(135.9)
Pupuk	-85.67	144.2	427.3**
	(96.71)	(107.3)	(167.9)
Constant	50,060***	575.9	-36,103
	(15,059)	(16,708)	(26,148)
Observations	72	72	72
R-squared	0.534	0.543	0.513

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Visual plot of residuals versus fitted-values show distinct patterns for *harga sedang* and *harga terendah*, and a slight pattern for *harga tertingi* which implies Classical Linear Model assumptions are violated and results are misleading.

Table 4: Likelihood Ratio Test of Including *Tungku* after Expanding *Bahan Bakar*

Notes for Likelihood Ratio Tests Table 4 and Table 5	INDEPENDENT VARIABLES	DEPENDENT VARIABLES			
		Highprice	Highprice	Highprice	Highprice
Note 1: Likelihood Ratio Tests by excluding Tungku.	*Kayu*	-9.764***	-9.094***	Ref. Cat.	Ref. Cat.
		(3.427)	(3.511)		
	Solar	-8.312***	-9.221**	1.451	-0.127
		(3.131)	(3.625)	(2.430)	(3.732)
	Minyak Tanah	Ref. Cat.	Ref. Cat.	9.764***	9.094***
				(3.427)	(3.511)
Note 2: Omitted Bahan Bakar variables were dropped due to collinearity	*Kulit Kemiri*	-4.031*	-5.028*	5.733**	4.066
		(2.332)	(2.861)	(2.450)	(3.533)
	LPG	-5.627	-5.097	4.137	3.997
		(3.452)	(3.630)	(3.128)	(3.262)
	Kayu & Batu Bara	-9.190***	-8.582**	0.573	0.512
		(3.284)	(3.387)	(1.526)	(1.535)
	Kayu & Kulit Kemiri	-10.04**	-9.637**	-0.272	-0.543
		(4.105)	(4.116)	(2.594)	(2.710)
	Kayu, Kulit Kemiri & Batu Bara	3.434	3.257	13.20***	12.35**
		(3.182)	(3.295)	(5.102)	(5.245)
	tungku	excluded	0.473	excluded	0.473
			(0.839)		(0.839)
	Jenis Flu	1.300*	1.190	1.300*	1.190
		(0.760)	(0.763)	(0.760)	(0.763)
	Oven Volume	0.0463	0.0494	0.0463	0.0494
		(0.0333)	(0.0328)	(0.0333)	(0.0328)
	Oven Umur	-0.176	-0.135	-0.176	-0.135
		(0.117)	(0.125)	(0.117)	(0.125)
	Kapasitas	-2.681**	-2.856**	-2.681**	-2.856**
		(1.149)	(1.202)	(1.149)	(1.202)
	Kapan Reperbaiki Tungku	0.463	0.573	0.463	0.573
		(0.661)	(0.727)	(0.661)	(0.727)
	Kapan Reperbaiki Oven	-2.637**	-2.774**	-2.637**	-2.774**
		(1.272)	(1.336)	(1.272)	(1.336)
	Frekuensi Reperbaiki Flu	2.538**	2.436**	2.538**	2.436**
		(1.101)	(1.078)	(1.101)	(1.078)
	Daerah	1.348	1.395	1.348	1.395
		(0.904)	(0.887)	(0.904)	(0.887)
	Sistem Pengairan	-0.265	0.690	-0.265	0.690
		(2.002)	(2.247)	(2.002)	(2.247)
	Biaya Mempersiapkan Pembajakan	6.18e-08	6.22e-08	6.18e-08	6.22e-08
		(4.23e-08)	(4.15e-08)	(4.23e-08)	(4.15e-08)
	Jumlah Tipe Pestisida	-1.338**	-1.292**	-1.338**	-1.292**
		(0.567)	(0.556)	(0.567)	(0.556)
	Pengalaman Tembakau	0.173	0.120	0.173	0.120
		(0.147)	(0.161)	(0.147)	(0.161)
	Company	-0.587**	-0.606**	-0.587**	-0.606**
		(0.259)	(0.264)	(0.259)	(0.264)
	Pupuk	-0.437**	-0.472**	-0.437**	-0.472**
		(0.181)	(0.197)	(0.181)	(0.197)
	Constant	16.98**	16.41**	7.215	7.320
		(7.461)	(7.245)	(5.838)	(5.762)
	Observations	73	73	73	73

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Likelihood-ratio test for both models, excluding tungku yielded a p-value of 0.5864 so I exclude tungku from the regression.

Table 5: Likelihood Ratio Test of Including *Bahan Bakar* after Expanding *Tunkgu*

INDEPENDENT VARIABLES	DEPENDENT VARIABLES:			
	Highprice	Highprice	Highprice	Highprice
BahanBakar	0.153 (0.123)	excluded	0.153 (0.123)	excluded
Konvensional	-4.304** (1.769)	-4.802*** (1.739)	Ref. Cat.	Ref. Cat.
LPG	-3.796* (2.058)	-3.762* (2.038)	0.508 (1.623)	1.041 (1.556)
Minyak Tanah	Ref. Cat.	Ref. Cat.	4.304** (1.769)	4.802*** (1.739)
Solar	-2.877 (1.786)	-3.341* (1.754)	1.427 (1.248)	1.462 (1.215)
Gasifikasi	-3.765** (1.701)	-3.420** (1.671)	0.539 (1.344)	1.383 (1.159)
Jenis Flu	0.236 (0.479)	0.0611 (0.440)	0.236 (0.479)	0.0611 (0.440)
Oven Volume	0.0430** (0.0196)	0.0388** (0.0187)	0.0430** (0.0196)	0.0388** (0.0187)
Oven Umur	-0.00173 (0.0743)	0.00208 (0.0740)	-0.00173 (0.0743)	0.00208 (0.0740)
Kapasitas	-1.112* (0.577)	-1.081* (0.563)	-1.112* (0.577)	-1.081* (0.563)
Kapan Reperbaiki Tungku	0.226 (0.332)	0.241 (0.335)	0.226 (0.332)	0.241 (0.335)
Kapan Reperbaiki Oven	-1.310** (0.585)	-1.264** (0.577)	-1.310** (0.585)	-1.264** (0.577)
Frekuensi Reperbaiki Flu	0.316 (0.706)	0.414 (0.666)	0.316 (0.706)	0.414 (0.666)
Daerah	-0.105 (0.455)	-0.233 (0.447)	-0.105 (0.455)	-0.233 (0.447)
Sistem Pengairan	-1.703 (1.451)	-1.633 (1.396)	-1.703 (1.451)	-1.633 (1.396)
Biaya Mempersiapkan Pembajakan	3.03e-08 (3.12e-08)	3.50e-08 (3.00e-08)	3.03e-08 (3.12e-08)	3.50e-08 (3.00e-08)
Jumlah Tipe Pestisida	-0.610 (0.393)	-0.645* (0.382)	-0.610 (0.393)	-0.645* (0.382)
Pengalaman Tembakau	0.0683 (0.0814)	0.0537 (0.0790)	0.0683 (0.0814)	0.0537 (0.0790)
Company	-0.00719 (0.0757)	-0.00896 (0.0720)	-0.00719 (0.0757)	-0.00896 (0.0720)
Pupuk	-0.0995 (0.0801)	-0.111 (0.0775)	-0.0995 (0.0801)	-0.111 (0.0775)
Constant	4.803 (4.166)	-3.341* (1.754)	0.499 (3.549)	2.216 (3.318)
Observations	78	78	78	78

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Likelihood-ratio test for both models, excluding Bahan Bakar yields a p-value of 0.2081 so I exclude it.

Table 6: Logistic Regression of *Bahan Bakar* on High Price

High Price is a binary variable which takes the value 1 if harga tertinggi is greater than 35,000RP (median)

INDEPENDENT VARIABLES	DEPENDENT VARIABLES:					
	Highprice	Highprice (Robust SE)	Highprice (Clustered Robust SE)	Highprice	Highprice (Robust SE)	Highprice (Clustered Robust SE)
Kayu	-9.764*** (3.427)	-9.764*** (3.338)	-9.764** (3.977)	Ref. Cat.	Ref. Cat.	Ref. Cat.
Solar	-8.312*** (3.131)	-8.312** (3.441)	-8.312*** (2.637)	1.451 (2.430)	1.451 (2.260)	1.451 (1.843)
Minyak Tanah	Ref. Cat.	Ref. Cat.	Ref. Cat.	9.764*** (3.427)	9.764*** (3.338)	9.764** (3.977)
Kulit Kemiri	-4.031* (2.332)	-4.031* (2.187)	-4.031*** (1.310)	5.733** (2.450)	5.733** (2.518)	5.733* (3.326)
LPG	-5.627 (3.452)	-5.627** (2.234)	-5.627* (3.100)	4.137 (3.128)	4.137* (2.364)	4.137** (1.834)
Kayu & Batu Bara	-9.190*** (3.284)	-9.190*** (2.620)	-9.190*** (1.757)	0.573 (1.526)	0.573 (1.577)	0.573 (3.095)
Kayu & Kulit Kemiri	-10.04** (4.105)	-10.04** (3.977)	-10.04** (3.904)	-0.272 (2.594)	-0.272 (2.926)	-0.272 (4.583)
Kayu, Kulit Kemiri & Batu Bara	3.434 (3.182)	3.434 (3.086)	3.434** (1.360)	13.20*** (5.102)	13.20** (5.377)	13.20** (5.135)
Jenis Flu	1.300* (0.760)	1.300* (0.764)	1.300*** (0.359)	1.300* (0.760)	1.300* (0.764)	1.300*** (0.359)
Oven Volume	0.0463 (0.0333)	0.0463 (0.0317)	0.0463** (0.0216)	0.0463 (0.0333)	0.0463 (0.0317)	0.0463** (0.0216)
Oven Umur	-0.176 (0.117)	-0.176* (0.0925)	-0.176* (0.0900)	-0.176 (0.117)	-0.176* (0.0925)	-0.176* (0.0900)
Kapasitas	-2.681** (1.149)	-2.681** (1.152)	-2.681*** (0.746)	-2.681** (1.149)	-2.681** (1.152)	-2.681*** (0.746)
Kapan Reperbaiki Tungku	0.463 (0.661)	0.463 (0.784)	0.463 (0.697)	0.463 (0.661)	0.463 (0.784)	0.463 (0.697)
Kapan Reperbaiki Oven	-2.637** (1.272)	-2.637** (1.160)	-2.637** (1.278)	-2.637** (1.272)	-2.637** (1.160)	-2.637** (1.278)
Frekuensi Reperbaiki Flu	2.538** (1.101)	2.538*** (0.951)	2.538*** (0.562)	2.538** (1.101)	2.538*** (0.951)	2.538*** (0.562)
Daerah	1.348 (0.904)	1.348* (0.781)	1.348** (0.631)	1.348 (0.904)	1.348* (0.781)	1.348** (0.631)
Sistem Pengairan	-0.265 (2.002)	-0.265 (1.557)	-0.265 (1.199)	-0.265 (2.002)	-0.265 (1.557)	-0.265 (1.199)
Biaya Mempersiapkan Pembajakan	6.18e-08 (4.23e-08)	6.18e-08 (4.16e-08)	6.18e-08 (3.91e-08)	6.18e-08 (4.23e-08)	6.18e-08 (4.16e-08)	6.18e-08 (3.91e-08)
Jumlah Tipe Pestisida	-1.338** (0.567)	-1.338*** (0.454)	-1.338* (0.689)	-1.338** (0.567)	-1.338*** (0.454)	-1.338* (0.689)
Pengalaman Tembakau	0.173 (0.147)	0.173 (0.129)	0.173 (0.163)	0.173 (0.147)	0.173 (0.129)	0.173 (0.163)
Company	-0.587** (0.259)	-0.587** (0.269)	-0.587*** (0.158)	-0.587** (0.259)	-0.587** (0.269)	-0.587*** (0.158)
Pupuk	-0.437** (0.181)	-0.437** (0.186)	-0.437*** (0.133)	-0.437** (0.181)	-0.437** (0.186)	-0.437*** (0.133)
Constant	16.98** (7.461)	16.98** (7.381)	16.98*** (5.917)	7.215 (5.838)	7.215 (5.439)	7.215*** (2.056)
Observations	73	73	73	73	73	73

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: For regressions using Minyak Tanah and *Kayu* as the reference category, 80.82% was of predictions were correctly classified using predictions greater than 0.5.

Table 7: Logistic Regressions of Furnaces on High Price

INDEPENDENT VARIABLES	DEPENDENT VARIABLES: Highprice	Highprice (Robust SE)	Highprice (Clustered Robust SE)	Highprice	Highprice (Robust SE)	Highprice (Clustered Robust SE)
Konvensional	-4.802*** (1.739)	-4.802** (1.897)	-4.802*** (1.664)	Ref. Cat.	Ref. Cat.	Ref. Cat.
LPG	-3.762* (2.038)	-3.762** (1.776)	-3.762* (2.247)	1.041 (1.556)	1.041 (1.048)	1.041 (0.670)
Minyak Tanah	Ref. Cat.	Ref. Cat.	Ref. Cat.	4.802*** (1.739)	4.802** (1.897)	4.802*** (1.664)
Solar	-3.341* (1.754)	-3.341* (2.013)	-3.341*** (1.075)	1.462 (1.215)	1.462 (1.160)	1.462 (0.985)
Gasifikasi	-3.420** (1.671)	-3.420* (2.068)	-3.420*** (0.793)	1.383 (1.159)	1.383 (1.300)	1.383 (1.082)
Jenis Flu	0.0611 (0.440)	0.0611 (0.377)	0.0611 (0.752)	0.0611 (0.440)	0.0611 (0.377)	0.0611 (0.752)
Oven Volume	0.0388** (0.0187)	0.0388* (0.0207)	0.0388** (0.0188)	0.0388** (0.0187)	0.0388* (0.0207)	0.0388** (0.0188)
Oven Umur	0.00208 (0.0740)	0.00208 (0.0614)	0.00208 (0.0701)	0.00208 (0.0740)	0.00208 (0.0614)	0.00208 (0.0701)
Kapasitas	-1.081* (0.563)	-1.081* (0.587)	-1.081*** (0.328)	-1.081* (0.563)	-1.081* (0.587)	-1.081*** (0.328)
Kapan Reperbaiki Tungku	0.241 (0.335)	0.241 (0.288)	0.241 (0.281)	0.241 (0.335)	0.241 (0.288)	0.241 (0.281)
Kapan Reperbaiki Oven	-1.264** (0.577)	-1.264** (0.625)	-1.264** (0.501)	-1.264** (0.577)	-1.264** (0.625)	-1.264** (0.501)
Frekuensi Reperbaiki Flu	0.414 (0.666)	0.414 (0.836)	0.414 (0.861)	0.414 (0.666)	0.414 (0.836)	0.414 (0.861)
Daerah	-0.233 (0.447)	-0.233 (0.541)	-0.233 (0.487)	-0.233 (0.447)	-0.233 (0.541)	-0.233 (0.487)
Sistem Pengairan	-1.633 (1.396)	-1.633 (1.150)	-1.633** (0.744)	-1.633 (1.396)	-1.633 (1.150)	-1.633** (0.744)
Biaya Mempersiapkan Pembajakan	3.50e-08 (3.00e-08)	3.50e-08 (2.73e-08)	3.50e-08* (2.02e-08)	3.50e-08 (3.00e-08)	3.50e-08 (2.73e-08)	3.50e-08* (2.02e-08)
Jumlah Tipe Pestisida	-0.645* (0.382)	-0.645 (0.475)	-0.645 (0.598)	-0.645* (0.382)	-0.645 (0.475)	-0.645 (0.598)
Pengalaman Tembakau	0.0537 (0.0790)	0.0537 (0.0744)	0.0537 (0.102)	0.0537 (0.0790)	0.0537 (0.0744)	0.0537 (0.102)
Company	-0.00896 (0.0720)	-0.00896 (0.0844)	-0.00896 (0.0886)	-0.00896 (0.0720)	-0.00896 (0.0844)	-0.00896 (0.0886)
Pupuk	-0.111 (0.0775)	-0.111 (0.102)	-0.111*** (0.0260)	-0.111 (0.0775)	-0.111 (0.102)	-0.111*** (0.0260)
Constant	7.019* (3.909)	7.019 (4.527)	7.019* (3.945)	2.216 (3.318)	2.216 (3.771)	2.216 (2.851)
Observations	78	78	78	78	78	78

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Note: For regressions using Minyak Tanah and *Kayu* as the reference category, 82.05% was of predictions were correctly classified using predictions greater than 0.5

Table 8: OLS Regressions of Furnaces on BTU/kg

INDEPENDENT VARIABLES	DEPENDENT VARIABLES (total BTU consumed per kg dry tobacco):					
	BTU/kg (Robust SE cluster: Daerah)	BTU/kg Robust SE (hc2)	BTU/kg Robust SE (hc3)	BTU/kg Robust SE (cluster: Daerah)	BTU/kg Robust SE (hc2)	BTU/kg Robust SE (hc3)
BahanBakar	0.0604*	0.0604*	0.0604	0.0395	0.0395	0.0395
	(0.0228)	(0.0345)	(0.0399)	(0.0383)	(0.0390)	(0.0444)
Konvensional	0.310	0.310	0.310	Ref. Cat.	Ref. Cat.	Ref. Cat.
	(0.464)	(0.347)	(0.395)			
LPG	-1.417*	-1.417***	-1.417**	-1.693**	-1.693***	-1.693***
	(0.472)	(0.460)	(0.551)	(0.398)	(0.456)	(0.559)
Minyak Tanah	Ref. Cat.	Ref. Cat.	Ref. Cat.	-0.169	-0.169	-0.169
				(0.539)	(0.387)	(0.436)
Solar	-0.593	-0.593**	-0.593*	-0.810**	-0.810***	-0.810***
	(0.575)	(0.280)	(0.322)	(0.191)	(0.225)	(0.249)
Gasifikasi	-1.527	-1.527***	-1.527***	-1.594**	-1.594***	-1.594***
	(0.660)	(0.362)	(0.416)	(0.395)	(0.374)	(0.419)
Jenis Flu	-0.0223	-0.0223	-0.0223	-0.0628	-0.0628	-0.0628
	(0.0671)	(0.0930)	(0.107)	(0.107)	(0.0999)	(0.113)
Oven Volume	0.0119***	0.0119***	0.0119***	0.0117**	0.0117***	0.0117***
	(0.00190)	(0.00380)	(0.00430)	(0.00251)	(0.00382)	(0.00432)
Oven Umur	-0.00944	-0.00944	-0.00944	-0.00643	-0.00643	-0.00643
	(0.00796)	(0.0213)	(0.0263)	(0.00891)	(0.0228)	(0.0284)
Kapasitas	-0.300	-0.300**	-0.300**	-0.343*	-0.343**	-0.343**
	(0.130)	(0.125)	(0.140)	(0.129)	(0.131)	(0.147)
Kapan Reperbaiki Tungku	-0.0824	-0.0824	-0.0824	-0.0963	-0.0963	-0.0963
	(0.0918)	(0.0633)	(0.0734)	(0.112)	(0.0757)	(0.0883)
Kapan Reperbaiki Oven	-0.224***	-0.224	-0.224	-0.163**	-0.163	-0.163
	(0.0382)	(0.139)	(0.163)	(0.0403)	(0.160)	(0.184)
Frekuensi Reperbaiki Flu	-0.340*	-0.340	-0.340	-0.308*	-0.308	-0.308
	(0.121)	(0.214)	(0.280)	(0.102)	(0.209)	(0.271)
Pengalaman Tembakau	0.00118	0.00118	0.00118	0.0127	0.0127	0.0127
	(0.0135)	(0.0148)	(0.0168)	(0.0260)	(0.0209)	(0.0232)
Constant	11.46***	11.46***	11.46***	11.76***	11.76***	11.76***
	(0.920)	(0.776)	(0.908)	(0.555)	(0.638)	(0.744)
Observations	77	77	77	77	77	77
R-squared	0.584	0.584	0.584	0.472	0.472	0.472

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: OLS Regressions of Various Curing Systems on Dependent Variables

INDEPENDENT VARIABLES *(Minyak Tanah as Ref. Cat.)*	DEPENDENT VARIABLES: Net Ben./kg	Cost/kg	Harga Tertinggi	BTU/Kg Robust SE (cluster: Daerah)	BTU/Kg Robust SE (hc2)	BTU/Kg Robust SE (hc3)
Konvensional: *Kayu*	-10,969* (6,126)	-0.474*** (0.102)	-3,310** (1,610)	0.208 (0.484)	0.208 (0.313)	0.208 (0.352)
Batu bara	-16,997 (13,117)	-0.150 (0.229)	-14,737*** (3,348)	-0.492 (0.635)	-0.492 (0.386)	-0.492 (8.013)
Kayu & Kulit Kemiri, Batu bara Briket	-12,465 (12,612)	0.364* (0.206)	-4,792 (3,313)	1.092* (0.378)	1.092** (0.486)	1.092 (0.661)
kulit kemiri	-15,175 (13,779)	-0.586** (0.224)	131.8 (3,929)	-2.621** (0.526)	-2.621*** (0.391)	-2.621*** (0.478)
Kayu & Batu Bara	-17,159** (8,339)	-0.358*** (0.127)	-6,528*** (1,929)	0.0374 (0.670)	0.0374 (0.466)	0.0374 (0.543)
Kayu & Kulit Kemiri	3,546 (11,310)	-0.337* (0.184)	-5,040 (3,065)	0.679 (0.314)	0.679 (0.431)	0.679 (0.592)
Kayu, Kulit Kemiri & Batu Bara	-12,444 (13,362)	-0.139 (0.265)	-1,910 (2,757)	1.382 (1.178)	1.382 (1.063)	1.382 (1.784)
Gasifikasi: *Kayu, Kulit Kemiri & Batu Bara*	-12,055 (11,064)	0.111 (0.180)	-1,603 (2,759)	-0.493 (0.484)	-0.493 (0.431)	-0.493 (0.537)
kulit kemiri, Batu bara	-8,788 (11,321)	Omitted: collinearity	-7,354** (3,194)	-0.627 (0.392)	-0.627* (0.345)	-0.627 (0.460)
kulit kemiri	1,254 (6,754)	-0.552*** (0.124)	-2,336 (1,837)	-1.693* (0.596)	-1.693*** (0.363)	-1.693*** (0.446)
Solar:	-2,539 (7,806)	-0.168 (0.113)	-1,819 (1,974)	-1.378* (0.494)	-1.378*** (0.434)	-1.378** (0.537)
LPG:	-13,535* (7,489)	-0.483*** (0.141)	-1,042 (2,017)	0.0936 (0.468)	0.0936 (0.344)	0.0936 (0.395)
Jenis Flu	-4,192** (1,969)	0.0769** (0.0344)	159.0 (506.9)	0.0332 (0.0357)	0.0332 (0.109)	0.0332 (0.126)
Oven Volume	176.5** (72.10)	0.265 (0.192)	-1,692 (3,282)	0.0121** (0.00248)	0.0121*** (0.00407)	0.0121** (0.00485)
Oven Umur	478.2 (340.4)	-0.0665 (0.0446)	-811.8 (805.4)	-0.00369 (0.00738)	-0.00369 (0.0208)	-0.00369 (0.0302)
Kapasitas	-3,545 (2,224)	-0.446*** (0.164)	-1,342 (2,510)	-0.379* (0.146)	-0.379*** (0.131)	-0.379** (0.153)
Kapan Reperbaiki Tungku	-4,575** (1,721)	-0.116 (0.0705)	850.2 (1,101)	-0.115 (0.122)	-0.115 (0.0766)	-0.115 (0.0921)
Kapan Reperbaiki Oven	261.0 (468.1)	0.0989** (0.0462)	-2,127*** (681.6)	-0.159 (0.0730)	-0.159 (0.135)	-0.159 (0.165)
Frekuensi Reperbaiki Flu	2,685 (2,934)	0.0551 (0.0568)	908.1 (1,041)	-0.383** (0.0719)	-0.383** (0.146)	-0.383* (0.192)
Daerah	1,428 (1,985)	0.0492 (0.0370)	231.5 (557.1)			
Kwantitas Daun Kering	-336.9 (960.9)	-0.973*** (0.0567)				
Sistem Pengairan	-3,042 (4,409)		-3,760*** (1,164)			
Biaya Mempersiapkan Pembajakan	5.29e-05 (0.000149)		-249.2 (399.8)			
Jumlah Tipe Pestisida	932.0 (1,693)		-2,738** (1,254)			
Pengalaman Tembakau	-284.7 (377.2)	-0.0530 (0.0644)	2,078* (1,123)	-0.00580 (0.0116)	-0.00580 (0.0156)	-0.00580 (0.0181)
Company	322.4 (334.5)	-0.00498 (0.00574)	3.271 (89.14)	-0.00585 (0.0140)	-0.00585 (0.0175)	-0.00585 (0.0256)
Pupuk	-187.5 (284.8)		-129.6 (103.1)			
Berapa Kali Kering		0.0739*** (0.0153)				
Constant	27,878 (17,566)	8.828*** (0.882)	57,355*** (16,996)	12.02*** (0.726)	12.02*** (0.667)	12.02*** (0.850)
Observations	69	70	72	77	77	77
R-squared	0.520	0.949	0.685	0.681	0.681	0.681

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Visual plot of residuals versus fitted values for *harga tertinggi* reveals a distinct pattern which implies Classical Linear Model assumptions are violated and results can be misleading.

Table 10: Logistic Regressions of Various Curing Systems on High Price

INDEPENDENT VARIABLES	DEPENDENT VARIABLES:					
	Highprice	Highprice Robust SE	Highprice Clustered Robust SE	Highprice Robust SE	Highprice	Highprice Clustered Robust SE
***Konvensional*:**						
Kayu	-9.383***	-9.383***	-9.383**	Ref. Cat.	Ref. Cat.	Ref. Cat.
	(3.281)	(3.382)	(3.720)			
Kayu & Batu Bara	-8.823***	-8.823***	-8.823***	0.560	0.560	0.560
	(3.281)	(2.920)	(1.630)	(1.537)	(1.279)	(2.706)
Kayu & Kulit Kemiri	-8.636**	-8.636**	-8.636***	0.747	0.747	0.747
	(3.983)	(3.604)	(2.744)	(2.710)	(3.036)	(4.304)
Kayu, Kulit Kemiri & Batu Bara	-2.012	-2.012	-2.012	7.371*	7.371***	7.371**
	(3.418)	(2.820)	(2.061)	(3.781)	(2.412)	(3.053)
Gasifikasi:						
Kulit Kemiri	-4.236*	-4.236*	-4.236***	5.147**	5.147*	5.147
	(2.428)	(2.186)	(1.553)	(2.267)	(2.729)	(3.616)
Minyak Tanah:	Ref. Cat.	Ref. Cat.	Ref. Cat.	9.383***	9.383***	9.383**
				(3.281)	(3.382)	(3.720)
Solar:	-8.649***	-8.649*	-8.649***	0.734	0.734	0.734
	(3.290)	(4.455)	(2.866)	(2.468)	(2.294)	(1.120)
LPG:	-6.353*	-6.353**	-6.353**	3.030	3.030	3.030
	(3.419)	(2.656)	(3.130)	(2.989)	(2.045)	(2.101)
Jenis Flu	1.255	1.255	1.255*	1.255	1.255	1.255*
	(0.788)	(0.766)	(0.747)	(0.788)	(0.766)	(0.747)
Oven Volume	0.0570*	0.0570**	0.0570**	0.0570*	0.0570**	0.0570**
	(0.0339)	(0.0278)	(0.0236)	(0.0339)	(0.0278)	(0.0236)
Oven Umur	-0.0267	-0.0267	-0.0267	-0.0267	-0.0267	-0.0267
	(0.138)	(0.114)	(0.108)	(0.138)	(0.114)	(0.108)
Kapasitas	-3.093**	-3.093**	-3.093***	-3.093**	-3.093**	-3.093***
	(1.217)	(1.373)	(0.934)	(1.217)	(1.373)	(0.934)
Kapan Reperbaiki Tungku	0.458	0.458	0.458	0.458	0.458	0.458
	(0.710)	(0.962)	(0.869)	(0.710)	(0.962)	(0.869)
Kapan Reperbaiki Oven	-2.113*	-2.113**	-2.113	-2.113*	-2.113**	-2.113
	(1.248)	(1.031)	(1.363)	(1.248)	(1.031)	(1.363)
Kapan Reperbaiki Flu	2.379**	2.379***	2.379***	2.379**	2.379***	2.379***
	(0.995)	(0.628)	(0.330)	(0.995)	(0.628)	(0.330)
Daerah	1.474*	1.474*	1.474**	1.474*	1.474*	1.474**
	(0.882)	(0.803)	(0.594)	(0.882)	(0.803)	(0.594)
Sistem Pengairan	-0.162	-0.162	-0.162	-0.162	-0.162	-0.162
	(2.939)	(2.799)	(2.520)	(2.939)	(2.799)	(2.520)
Biaya Membajakha	6.94e-08	6.94e-08	6.94e-08*	6.94e-08	6.94e-08	6.94e-08*
	(4.22e-08)	(4.50e-08)	(3.85e-08)	(4.22e-08)	(4.50e-08)	(3.85e-08)
Jumlah Tipe Pestisida	-0.956*	-0.956**	-0.956	-0.956*	-0.956**	-0.956
	(0.574)	(0.437)	(0.709)	(0.574)	(0.437)	(0.709)
Pengalaman Tembakau	0.125	0.125	0.125	0.125	0.125	0.125
	(0.178)	(0.159)	(0.222)	(0.178)	(0.159)	(0.222)
Company	-0.577**	-0.577**	-0.577***	-0.577**	-0.577**	-0.577***
	(0.233)	(0.256)	(0.146)	(0.233)	(0.256)	(0.146)
Pupuk	-0.414**	-0.414**	-0.414**	-0.414**	-0.414**	-0.414**
	(0.179)	(0.194)	(0.166)	(0.179)	(0.194)	(0.166)
Constant	13.95**	13.95*	13.95**	4.564	4.564	4.564
	(6.842)	(7.743)	(7.109)	(5.626)	(5.273)	(3.857)
Observations	69	69	69	69	69	69

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: For regressions using Minyak Tanah and *Kayu* as the reference category, 86.96% was of predictions were correctly classified using predictions greater than 0.5.

Table 11: OLS Regressions of Various Fuel-Mixes in Conventional Ovens on Various Dependent Variables

INDEPENDENT VARIABLES	DEPENDENT VARIABLES: Net Ben./kg	Net Ben./kg	Total Cost	Total Cost	Cost/kg	Cost/kg	BTU/kg	BTU/kg
Kayu	-3,444 (16,838)	Ref. Cat.	0.186 (0.265)	Ref. Cat.	0.606 (0.775)	Ref. Cat.	3.022*** (0.690)	Ref. Cat.
Batu bara	-17,162 (24,986)	-13,719 (15,337)	0.514 (0.377)	0.328 (0.251)	2.123* (1.127)	1.518** (0.730)	2.370* (1.158)	-0.652 (0.825)
Batu bara Briket, Kayu & Kulit Kemiri	3,742 (20,522)	7,185 (22,359)	0.640* (0.347)	0.454 (0.347)	1.495 (1.023)	0.889 (1.010)	2.480** (1.030)	-0.542 (0.812)
kulit kemiri	Ref. Cat.	3,444 (16,838)	Ref. Cat.	-0.186 (0.265)	Ref. Cat.	-0.606 (0.775)	Ref. Cat.	-3.022*** (0.690)
Kayu & Batu Bara	-9,635 (18,424)	-6,191 (6,218)	0.237 (0.282)	0.0519 (0.102)	0.690 (0.827)	0.0843 (0.293)	2.857*** (0.740)	-0.166 (0.288)
Kayu & Kulit Kemiri	18,112 (15,122)	21,556 (14,550)	0.293 (0.309)	0.108 (0.218)	0.134 (0.896)	-0.472 (0.622)	2.752*** (0.818)	-0.270 (0.571)
Jenis Flu	-4,493 (4,069)	-4,493 (4,069)	0.145* (0.0795)	0.145* (0.0795)	0.0202 (0.231)	0.0202 (0.231)	0.142 (0.187)	0.142 (0.187)
Oven Volume	206.2* (115.3)	206.2* (115.3)	0.479* (0.261)	0.479* (0.261)	0.449 (0.767)	0.449 (0.767)	0.00535 (0.00510)	0.00535 (0.00510)
Oven Umur	582.6 (601.2)	582.6 (601.2)	-0.0694 (0.0811)	-0.0694 (0.0811)	-0.302 (0.244)	-0.302 (0.244)	-0.0470 (0.0293)	-0.0470 (0.0293)
Kapasitas	-4,861 (5,202)	-4,861 (5,202)	-0.353 (0.264)	-0.353 (0.264)	-0.919 (0.818)	-0.919 (0.818)	-0.386 (0.229)	-0.386 (0.229)
Kapan Reperbaiki Tungku	-7,301* (3,633)	-7,301* (3,633)	0.132 (0.147)	0.132 (0.147)	0.338 (0.422)	0.338 (0.422)	0.260 (0.176)	0.260 (0.176)
Kapan Reperbaiki Oven	-26.45 (868.3)	-26.45 (868.3)	0.131* (0.0757)	0.131* (0.0757)	0.0828 (0.210)	0.0828 (0.210)	-0.315* (0.183)	-0.315* (0.183)
Frekuensi Reperbaiki Flu	2,117 (4,820)	2,117 (4,820)	0.144 (0.125)	0.144 (0.125)	-0.258 (0.345)	-0.258 (0.345)	-0.395* (0.207)	-0.395* (0.207)
Daerah	4,283 (4,476)	4,283 (4,476)	0.0355 (0.0730)	0.0355 (0.0730)	-0.213 (0.206)	-0.213 (0.206)		
Kwantitas Daun Kering	-648.9 (1,200)	-648.9 (1,200)	0.00659 (0.0730)	0.00659 (0.0730)				
Sistem Pengairan	-6,024 (5,714)	-6,024 (5,714)						
Biaya Mempersiapkan Pembajakan	0.000216 (0.000210)	0.000216 (0.000210)						
Jumlah Tipe Pestisida	1,571 (4,239)	1,571 (4,239)						
Pengalaman Tembakau	-42.63 (442.1)	-42.63 (442.1)			-0.0671 (0.270)	-0.0671 (0.270)	0.00444 (0.0275)	0.00444 (0.0275)
Company	306.2 (414.1)	306.2 (414.1)	-0.000718 (0.00821)	-0.000718 (0.00821)	-0.0329 (0.0226)	-0.0329 (0.0226)		
Pupuk	-315.5 (447.9)	-315.5 (447.9)						
Berapa Kali Kering			0.123*** (0.0345)	0.123*** (0.0345)				
Constant	19,830 (21,792)	16,386 (27,457)	13.14*** (1.248)	13.32*** (1.233)	8.247** (3.440)	8.853** (3.377)	9.574*** (1.003)	12.60*** (0.715)
Observations	39	39	41	41	41	41	41	41
R-squared	0.621	0.621	0.639	0.639	0.454	0.454	0.568	0.568

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: OLS Regressions of Various Fuel-Mixes in Conventional Ovens on *Harga Tertinggi*

INDEPENDENT VARIABLES	DEPENDENT VARIABLES: OLS MODEL: Harga Tertinggi	OLS MODEL: Harga Tertinggi
Kayu	-10,246** (4,009)	Ref. Cat.
Batu bara	-23,374*** (5,293)	-13,128*** (2,959)
Kayu & Batu Bara Briket, kulit kemiri	-4,205 (3,808)	6,041 (4,313)
kulit kemiri	Ref. Cat.	10,246** (4,009)
Kayu & Batu Bara	-14,657*** (4,213)	-4,411*** (1,273)
Kayu & Kulit Kemiri	-4,849 (3,440)	5,398 (3,135)
Oven Volume	2,205 (3,698)	2,205 (3,698)
Oven Umur	-316.5 (982.2)	-316.5 (982.2)
Kapasitas	-8,058* (4,039)	-8,058* (4,039)
Kapan Reperbaiki Tungku	-3,576* (1,762)	-3,576* (1,762)
Kapan Reperbaiki Oven	-2,417*** (797.8)	-2,417*** (797.8)
Frekuensi Reperbaiki Flu	1,354 (2,352)	1,354 (2,352)
Daerah	3,122*** (951.0)	3,122*** (951.0)
Sistem Pengairan	-2,544** (1,114)	-2,544** (1,114)
Biaya Mempersiapkan Pembajakan	281.5 (454.7)	281.5 (454.7)
Jumlah Tipe Pestisida	-314.9 (2,394)	-314.9 (2,394)
Pengalaman Tembakau	2,390** (1,057)	2,390** (1,057)
Company	58.78 (104.4)	58.78 (104.4)
Pupuk	87.74 (135.9)	87.74 (135.9)
Constant	31,032* (17,853)	20,786 (19,656)
Observations	39	39
R-squared	0.838	0.838

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Logistic Regressions of Various Fuel-Mixes in Conventional Ovens on High Price

INDEPENDENT VARIABLES	DEPENDENT VARIABLES: KonHighprice	KonHighprice Robust SE	KonHighprice Clustered Robust SE	KonHighprice	KonHighprice Robust SE	KonHighprice Clustered Robust SE
Kayu	-39.33 (6,324)	-39.33*** (9.120)	-39.33*** (6.457)	Ref. Cat.	Ref. Cat.	Ref. Cat.
kulit kemiri	Ref. Cat.	Ref. Cat.	Ref. Cat.	*DROPPED: predicts success perfectly*		
Kayu & Batu Bara	-41.97 (6,324)	-41.97*** (10.06)	-41.97*** (11.04)	-2.638 (3.422)	-2.638 (2.502)	-2.638 (5.329)
Kayu & Kulit Kemiri	-28.08 (6,324)	-28.08*** (7.349)	-28.08*** (5.731)	11.25* (6.025)	11.25* (5.844)	11.25 (8.543)
Jenis Flu	-0.407 (2.370)	-0.407 (1.053)	-0.407 (0.958)	-0.408 (2.371)	-0.408 (1.053)	-0.408 (0.958)
Oven Volume	0.0636 (0.0562)	0.0636* (0.0373)	0.0636 (0.0687)	0.0636 (0.0562)	0.0636* (0.0373)	0.0636 (0.0687)
Oven Umur	0.188 (0.498)	0.188 (0.392)	0.188 (0.541)	0.188 (0.498)	0.188 (0.392)	0.188 (0.541)
Kapasitas	-3.554 (2.397)	-3.554* (1.951)	-3.554* (2.102)	-3.554 (2.397)	-3.554* (1.952)	-3.554* (2.102)
Kapan Reperbaiki Tungku	-4.499** (2.204)	-4.499*** (1.598)	-4.499*** (1.089)	-4.499** (2.204)	-4.499*** (1.599)	-4.499*** (1.089)
Kapan Reperbaiki Oven	0.0589 (3.230)	0.0589 (2.679)	0.0589 (3.761)	0.0589 (3.230)	0.0589 (2.680)	0.0589 (3.761)
Frekuensi Reperbaiki Flu	7.039 (7.728)	7.039 (4.819)	7.039** (3.516)	7.039 (7.728)	7.039 (4.821)	7.039** (3.516)
Daerah	6.721* (3.559)	6.721*** (2.081)	6.721*** (2.581)	6.721* (3.559)	6.721*** (2.082)	6.721*** (2.581)
Sistem Pengairan	-5.545 (6.862)	-5.545* (3.166)	-5.545* (2.969)	-5.545 (6.862)	-5.545* (3.167)	-5.545* (2.968)
Biaya Mempersiapkan Pembajakan	1.96e-07* (1.19e-07)	1.96e-07** (9.08e-08)	1.96e-07* (1.04e-07)	1.96e-07* (1.19e-07)	1.96e-07** (9.08e-08)	1.96e-07* (1.04e-07)
Jumlah Tipe Pestisida	3.813 (4.550)	3.813 (2.612)	3.813*** (0.663)	3.813 (4.551)	3.813 (2.613)	3.813*** (0.663)
Pengalaman Tembakau	-0.200 (0.408)	-0.200 (0.327)	-0.200 (0.199)	-0.200 (0.408)	-0.200 (0.327)	-0.200 (0.199)
Company	-0.525 (0.782)	-0.525 (0.568)	-0.525 (0.598)	-0.525 (0.782)	-0.525 (0.568)	-0.525 (0.598)
Pupuk	0.00378 (0.368)	0.00378 (0.392)	0.00378 (0.648)	0.00377 (0.368)	0.00377 (0.392)	0.00377 (0.648)
Constant	26.50 (6,324)	26.50*** (8.556)	26.50** (12.85)	-12.83 (16.10)	-12.83 (8.807)	-12.83 (17.81)
Observations	39	39	39	38	38	38

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note 1: For regressions using *kulit kemiri* and *Kayu* as the reference category, 92.31% was of predictions were correctly classified using predictions greater than 0.5.

Note 2: For every model Stata predicted 1 failure and 0 successes but there were no missing standard errors so no correction was needed.

Appendix V: Discussion Regression Results

Table 1: Interaction Between Furnaces and Quantity of Dried Tobacco		
Furnace and Interaction with Quantity Tobacco *(Minyak Tanah as Ref. Cat.)*	*Coefficient*	*Statistical Significance*
Konvensional	88,900,000.00	5%
LPG	233,000,000.00	5%
Solar	72,800,000.00	>10%
Gasifikasi	87,500,000.00	5%
Dried Tobacco	45,700,000.00	1%
Konvensional*Dried Tobacco	- 38,600,000.00	1%
LPG*Dried Tobacco	- 76,100,000.00	5%
Solar*Dried Tobacco	- 28,200,000.00	10%
Gasifikasi*Dried Tobacco	- 27,100,000.00	5%
(Constant: baseline comparison to Minyak Tanah)	- 164,000,000.00	5%

Table 2: Interaction Between Fuel-Mixes in Furnaces and Oven Volume			
Fuel-Mix in Furnaces *(Minyak Tanah as Ref. Cat)*		*Coefficient*	*Statistical Significance*
Konvensional:			
	Kayu	-259000000.00	5%
	Kayu, BB	-398000000.00	5%
Gasifikasi:			
	Kemiri	-356000000.00	5%
Solar		-380000000.00	5%
LPG		-274000000.00	10%
Oven Volume		-1613120.00	5%
Konvensional : kayu*Oven Volume		1972388.00	5%
Konvensional: kayu, BB*Oven Volume		2842875.00	5%
Gasifkasi: Kem*Oven Volume		3060266.00	5%
Solar*Oven Volume		3009679.00	5%
LPG*Oven Volume		1986843.00	10%
(Constant: baseline comparison to Minyak Tanah)		169000000.00	10%

Appendix VI: Lessons Learned

Models

- Time series regression to track or control for:
    - weather conditions
    - which harvest of leaf to better control for quality differences which in turn affect price
    - when the tobacco was sold
    - changes in fuel consumption and costs in relation to harvest of leaf
        - quantity of each type of fuel used every week
    - changes in price trends of tobacco and fuel due to market fluctuations
- Interactions between control variables and independent variables of interest
- Comparison between brands of gasifiers

Survey and Sampling

- Larger sample size with weekly data collection for time series
- Wider coverage of areas and locations of farms

Variables to Include

- Dummy variable if farmers purchased and mixed tobacco
    - What proportion was mixed into own crop (per week)
    - Cost of bought tobacco
- Dummy variable if farmers purchased tobacco after curing their own crop
    - Cost of purchased tobacco
- Time spent loading fuel for the last day of the most recent curing in order to gauge time spent stocking for each technology and fuel. This can be translated into dollar terms and incorporated into *total cost of drying*
- Social status and wealth variables:
    - Cost of land rental
    - Number of vehicles owned
    - Number of trips to Mecca
    - Number of paid workers for tobacco season
    - Cost of paid workers for tobacco season
- Frequency of repairs to oven and furnace
- Cost of soil preparation can be expanded to include the type of systems used to prepare soil and whether investments were made for drainage to protect the roots in case of rain
- Where did they learn to grow tobacco
- Dummy variable for formal training
- Costs for fertilizer, pesticides to conduct comprehensive cost-benefit analysis
- Number of years using current furnace
- Number of years using current fuel mix

Marketing Questions

- When will you be replacing your furnace next?

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