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Estimating Cost Efficiencies of Propane use in Broiler Production: Case Study From Savoy, Arkansas and Trnaca Pri Laborci, Slovak Republic

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ESTIMATING COST EFFICIENCIES OF PROPANE USE IN BROILER PRODUCTION: CASE STUDY FROM SAVOY, ARKANSAS AND TRNAVA PRI LABORCI, SLOVAK REPUBLIC

ESTIMATING COST EFFICIENCIES OF PROPANE USE IN BROILER PRODUCTION: CASE STUDY FROM SAVOY, ARKANSAS AND TRNAVA PRI LABORCI, SLOVAK REPUBLIC

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of the requirements for the degree of
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ABSTRACT

This study focuses on analyzing the common practice of U.S. broiler farmers to operate on cash basis instead open credit lines for operating cost of propane gas for heating. Data for analysis were taken over from U.S. ABRF at Savoy and Slovak Farm Univerza at Trnava pri Laborci. Predicting the propane gas usage and propane gas cost was analyzed using the OLS model. It describes impact of selected factors on gas usage and cost. The overall purpose of the thesis is to find out which approach from designed scenarios is more economically efficient for farmer: (a) to pre-purchase propane gas with credit (operating loan) or (b) to continue purchasing propane gas regularly without credit (cash basis).

Key words: broiler production, propane gas usage, propane gas cost, LPG pre-purchase

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DEDICATION

I would like to give my special thanks to my parents whose love, wisdom and financial support enabled me to complete this work.

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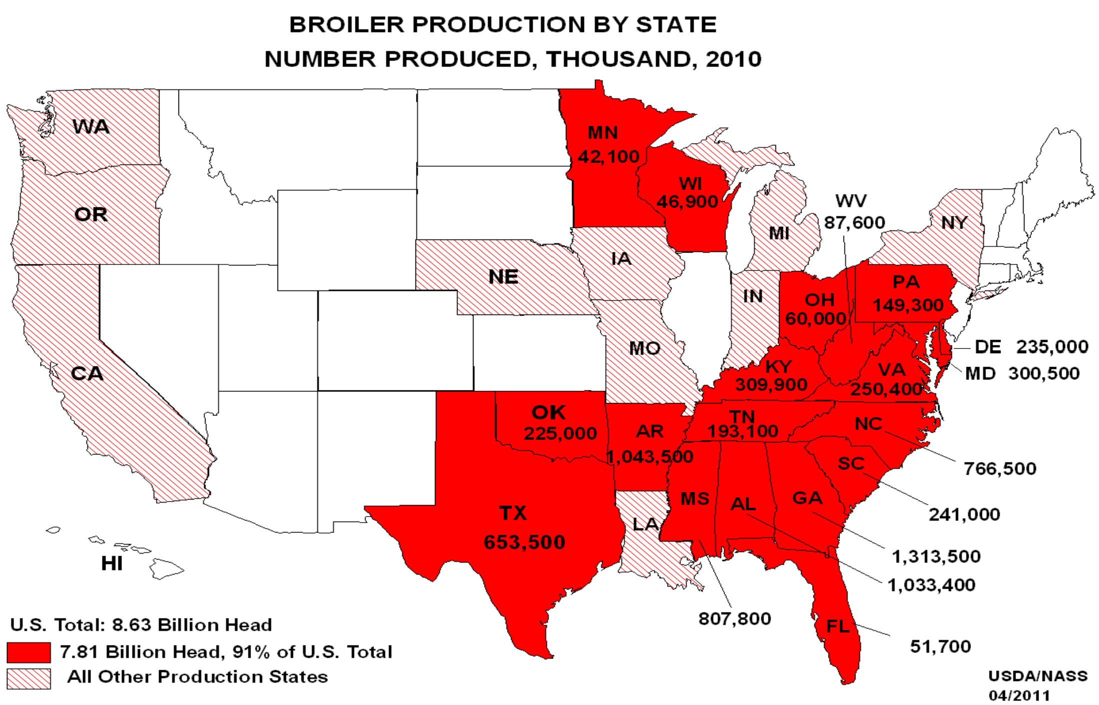
I. INTRODUCTION

The United States (U.S.) is one of the largest poultry producers in the world and the second largest exporter. Industry concentrates on three main segments – broilers, eggs and turkeys. Annually the U.S. produces over 43 billion lbs poultry meat and 18% production is exported to other countries. Over 80% of total production is broiler meat and the rest, 20%, mostly represents turkey meat production and small quantities of other chicken meat. *"The total farm value of U.S. poultry production exceeds $20 billion"* (ERS/USDA, 2009). Almost the entire industry is controlled by a small number of corporations with large scale. On the other hand chicken producers (growers) have a tendency to operate on a small-scale (Greenberg, 2007).

Over the last several decades the poultry industry in USA has significantly changed. Nowadays it is considered as *"the most vertically integrated sector of all of U.S. agriculture and food production"* (Goodwin, 2005). In the 1950`s a grower had to feed a broiler chicken approximately 60 days to produce a 4 lbs bird. At the present it takes just 35 days to produce a 4 lbs broiler with improved feed efficiency and higher percentage of white meat. Slaughter chickens are usually fed from 4 to 8 weeks to achieve average live weight 5.5 lbs. (Donald, 2004).

In the past 50 years, the consumption of chicken meat tripled in the United States of America (USA). In 2006, Americans consumed 86 lbs of chicken meat per person on average. Thanks to increased incomes and a relatively constant price of chicken meat, poultry became the preferred protein choice. Higher consumption resulted in the growth of broiler production that was achieved through production contracts between growers and chicken companies (McDonald, 2008). U.S. broiler production is mostly concentrated in southeast states and along the Atlantic coast (Figure 1.1), the top five broiler producing states, in order, are Georgia, Arkansas, Alabama, Mississippi and North Carolina (ERS/USDA, 2009).

Figure 1.1



Source: NASS/USDA, 2011; Charts and Maps; Broilers: Inventory by State, US; http://www.nass.usda.gov/Charts_and_Maps/Poultry/brlmap.asp

Poultry production in the Slovak Republic is the opposite of the U.S. Slovakia is one of the few countries where poultry production keeps decreasing contrary to other states of the European Union (EU) that are increasing their production. According to Slovak Poultry Producers' Union (Nemec, 2011), the current situation in the Slovak poultry industry is the worst it has been in the last 20 years. Total production of slaughter poultry dropped from 127,187 tons in 2002 to 63,000 tons in 2010, a 40% decline. The main reasons of the decline are: increased competition through large imports from neighboring states (Poland and Hungary) after Slovakia became part of the EU in 2004, policies of retail chains, shortcomings in legislation and nonregistered (illegal) import.

In comparing U.S. poultry consumption with Slovak consumption, Slovak consumption is far behind that of the U.S. even though Slovak consumption has increased over time. According to statistics, Slovaks eat just 19.5 kg (43 lbs) poultry meat per person per year, approximately half of U.S. consumption. But this number is not really accurate because it does not contain unregistered sales are estimated at 6 kg (13.23lbs) per person in Slovakia (Francisiová, 2009). Poultry consumption in Slovakia has gradually increased, but it is still behind pork (32 kg per person), the highest-ranking protein in terms of consumption.

This research is concentrated on analyzing propane, also referred to as liquid propane gas (LPG) usage for heating and electricity usage for cooling necessary for efficient broiler production. Modern era birds are very sensitive to their environment (Donald, 2004). They require appropriate temperature levels, relative humidity and air quality factors as well as proper lighting. All these factors have significant impacts on bird performance. Temperature volatility is unacceptable for modern bird breeds; suitable temperature range has become narrower than it was 20 years ago.

Propane and natural gas are usually used as the source of energy for heating in poultry production. In the last several years, growers have noticed considerable increases in operating costs affected by the increased cost of fuel for heating. Throughout 2008 and

2009, propane prices rose from a low of $1.28 per gallon in 2008 to a high of $2.16 per gallon in 2009 (Table 1.1). The most demanding season for heating in poultry housing is winter. Compared to other seasons, growers use the majority of their purchased fuel in the wintertime. Summertime is demanding on the cooling system, thus electricity. As consumer spending has decreased and operating costs for feed and energy has increased, negative returns for the majority of broiler processors have resulted. Many integrators decided to adapt to these conditions by decreasing *"bird placement and/or bird weight for contract farmers which in turn impacted returns for contract growers".* This in turn had negative results for growers, and for a few growers, there was another negative result – they lost their contracts "*due to company cutbacks in production or closing of processing facilities*". However, a number of companies achieved profit again thanks to production cutbacks (Cunningham and Fairchild, 2009).

Table 1.1: Average Commercial Prices of Natural Gas, LPG and Electricity, Slovakia and U.S. selected years

	Natural Gas		LPG		Eletricity	
Year	SK (€/GJ)	US ($/000cu.ft)	SK (€/l)	US ($/gall)	SK (€/KWH)	U.S. (cents/KWH)
1991	-	4.81	-	0.39	-	-
1997	-	5.8	-	0.51	-	7.59
2004	5,33	9.43	-	0.86	0.0697	8.17
2005	5,08	11.34	-	1.01	0.0694	8.67
2006	7,66	12.00	0.740	1.02	0.0753	9.46
2007	7,99	11.34	0.680	1.32	0.1053	9.65
2008	8,92	12.23	0.660	1.24	0.1283	10.36
2009	11,12	10.06	0.446	1.03	0.1396	10.17
2010	8,74	9.15	0.498	1.36	0.1185	10.26

Source: USDA, EuroStat, Slovak Gas Industry (SPP), Statistical Office of the Slovak Republic (SO SR)

This thesis concentrates on analyzing the common practice of U.S. broiler farmers to operate on a cash basis instead of on open credit lines for operating cost of energy, especially propane gas for heating. Growers currently purchase energy as it is needed with cash during the season rather than alternative purchase strategies that may be more economically efficient, such as pre-season purchases using credit.

The overall objective of this study is to find out if it is economically efficient to pre-purchase energy (LPG) with credit or to continue purchasing energy regularly – usually when farmers LPG reserve drop below 25% – without credit.

Specific objectives are:

1. Identify relationships among production performance, season and price parameters.

2. Estimate energy usage based upon various production and seasonality parameters.

3. Estimate energy cost based upon various production, economical and seasonality parameters.

4. Estimate energy cost savings utilizing advanced purchase, with and without credit lines.

II. LITERATURE REVIEW

2.1 U.S Poultry production

Poultry production in U.S. developed over decades into the largest poultry industry in the world. In the beginning of the 20th century, the majority of production was operated on small scale farms, basically family farms concentrated on production of two outcomes – egg and meat. In the 1930`s, both egg and meat production started to commercialize as a result of increasing urban population. Mechanization enabled the size of farms to significantly increase, resulting in the number of farms decreasing (Table 2.1). *"In the 1940`s, most business along the value chain from farm to consumer remained independent".* The majority of the poultry industry (farms, hatcheries, processing facilities and feed mills) was concentrated in the east and south of the country where crop production was concentrated (Greenberg, 2007).

Table 2.1: Structural changes in U.S. Agriculture

	1900	1930	1945	1970	2000
Number of farms (Mil.)	5.7	6.3	5.9	2.9	2.1
Av. farm size (Ac.)	146	151	195	376	441
Av. Number of commodities per farm	5.1	4.5	4.6	2.7	1.3

Source: Dimitri, C. and Effland, A., 2005, Milestones in U.S. Farming and Farm Policy, http://www.ers.usda.gov/amberwaves/june05/pdf/DataFeatureJune05.pdf

According to and Greenberg, (2007) in the second half of the 20th century, poultry production took another key step. This period is characterized by *"the specialization in genetics that divided the industry into meat and egg sectors"*. Poultry breeding companies begin to aim specifically on breeding birds for production of meat resulting in standardization of poultry meat. Poultry businesses wanted to control all phases of production and processing to reduce production and marketing risks, increase production and economic efficiency and provide a more uniform product. To achieve this, they began to acquire links of the vertical integration of the broiler industry.

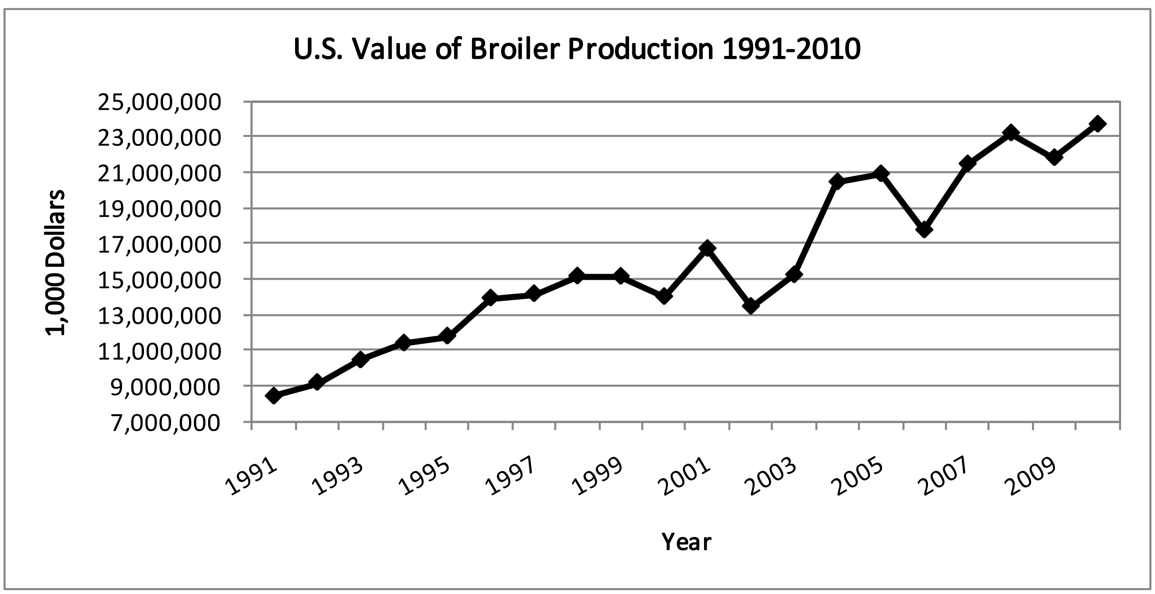
According to H.L. Goodwin (2005), in the past 50 years the number of firms operating in the broiler industry reduced from 250 to less than 50 companies. It means that approximately 95% of broiler production is part of the vertically integrated companies through either contracting or ownership. Most of broiler producers (88%) are under contract with broiler companies. Vertically integrated poultry industry has several stages: *"the breeder farm, hatchery, feed mill, broiler grow-out farm, processing plant, wholesale and retail market"* (Goodwin, 2005).

Integrators own processing plants, feed mills and hatcheries and contract with farmers who raise integrators' broilers to a specified marketed weight. According to the contract the broiler grower is paid a base contract price plus or minus a performance payment on the basis of comparison of the farmer`s performance with other growers (MacDonald, 2008).

Growers and processors have different tasks in production. Objectives for the processor are to supply the grower/farmer with broiler chicks, feed and veterinary service (medicine). He also provides labor for live haul and transportation of the birds from farm to processing plant. The farmer/grower usually operates broiler houses and supplies production with water, cooling, heating and necessary employees to run broiler house (ERS/USDA, 2009).

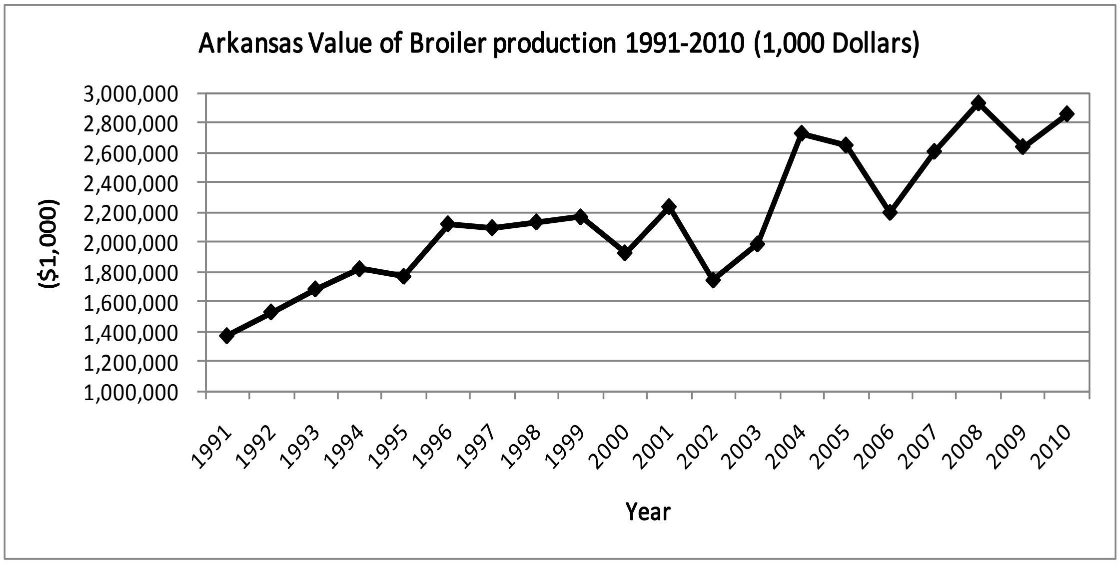
Location of poultry production depends on few factors. The first factor, feed, corresponds to the majority of production cost. It is representing about 60 to 70% of operation cost. Because of this it is assumed that most of the birds are situated in the areas where corn and soybean crops are produces. The second factor is land. Poultry farmers and processors usually operate on small acreage because growing and processing birds does not require quality land or a large land holding. It means that poultry producers are situated in regions with land improper for large-scale crop production, lower quality land that results in lower price per acre. *"Employment alternatives and educational levels in the same regions translated into adequate supplies of relatively low-cost-labor"* (Goodwin, 2005).

Figure 2.1: U.S. Value of Broiler Production



Source: USDA

Figure 2.2: Arkansas Value of Broiler Production

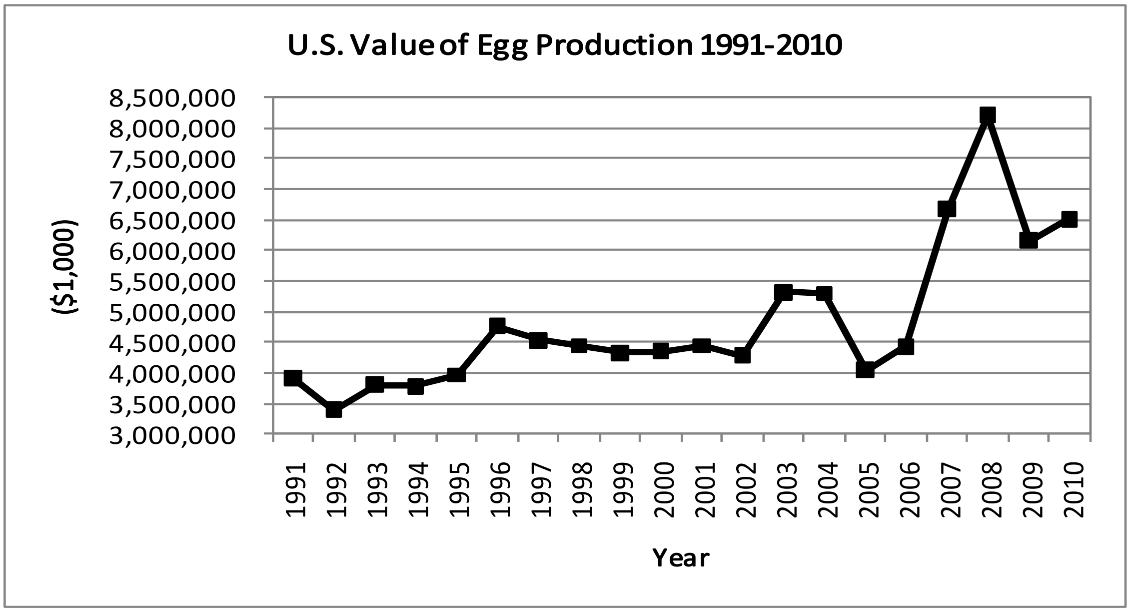


Source: USDA

Every year the U.S. produces approximately 250 million turkeys with average live weight of 25 lbs. per bird. It is also the largest production in the world. And although most of the turkey production is exported, domestic turkey consumption per capita is higher than others countries. The main states where turkey production is located in US in order from largest production are Minnesota, North Carolina, Arkansas and Virginia (ERS/USDA, 2009).

The third sector of poultry industry is eggs. Annual production fluctuates around 90 billion eggs. Most of the production is for consumption and the rest, one-third, is for the hatching market. Americans consume on average 250 eggs per capita every year. The majority of egg production is located in Iowa, Ohio, Pennsylvania, Indiana and Texas (ERS/USDA, 2009).

Figure 2.3: U.S. Value of Egg Production 1991-2010



Source: USDA

Table 2.2: U.S. Poultry Production

Year	Broiler				Eggs			Turkey			
	Number Produced	Lbs Produced	Price per Lb	Value of Production	Egg Produced	Price per Dozen	Value of Production	Number Produced	Lbs Produced	Price per Lb	Value of Production
	1,000 Head	1,000 Lbs	Dollars	1,000 Dollars	Million	Dollars	1,000 Dollars	1,000 Head	1,000 Lbs	Dollars	1,000 Dollars
1991	6,137,150	27,202,862	0.308	8,383,046	69,196	0.678	3,908,730	285,110	6,110,660	0.380	2,344,742
1992	6,388,990	28,772,172	0.318	9,155,992	70,528	0.577	3,389,070	288,980	6,332,533	0.380	2,385,779
1993	6,694,310	30,617,600	0.340	10,416,962	71,936	0.634	3,800,237	287,650	6,432,577	0.390	2,509,127
1994	7,017,540	32,528,500	0.350	11,371,723	74,911	0.614	3,780,377	286,605	6,540,877	0.404	2,643,765
1995	7,325,670	34,222,000	0.344	11,762,222	74,268	0.640	3,958,976	292,626	6,774,577	0.410	2,774,301
1996	7,597,600	36,483,050	0.381	13,904,924	76,281	0.749	4,762,131	302,708	7,233,074	0.433	3,128,814
1997	7,760,260	37,523,400	0.377	14,152,519	77,401	0.702	4,530,522	300,620	7,215,704	0.399	2,880,461
1998	7,934,280	38,553,600	0.393	15,144,551	79,754	0.668	4,439,446	285,204	7,050,944	0.380	2,679,301
1999	8,146,010	40,829,800	0.371	15,128,840	82,711	0.627	4,322,589	272,994	6,947,156	0.408	2,835,389
2000	8,284,000	41,623,100	0.336	13,988,434	84,386	0.618	4,345,382	269,969	6,942,809	0.407	2,822,736
2001	8,389,100	42,445,900	0.393	16,693,569	85,702	0.622	4,444,864	272,059	7,154,781	0.390	2,790,317
2002	8,591,080	44,058,700	0.305	13,437,345	87,252	0.589	4,281,416	275,477	7,494,861	0.365	2,732,481
2003	8,492,850	43,958,200	0.346	15,214,947	87,196	0.731	5,315,311	274,348	7,549,333	0.360	2,720,180
2004	8,740,650	45,796,250	0.446	20,446,086	89,091	0.714	5,299,185	263,207	7,278,413	0.420	3,054,329
2005	8,870,350	47,908,100	0.436	20,901,939	89,960	0.539	4,042,282	256,270	7,206,560	0.449	3,232,576
2006	8,867,800	48,829,900	0.363	17,739,234	91,328	0.582	4,431,745	262,460	7,463,885	0.479	3,573,690
2007	8,898,200	49,208,400	0.436	21,460,211	90,581	0.885	6,678,147	271,689	7,869,224	0.472	3,710,846
2008	9,009,300	50,441,600	-	23,203,136	90,040	1.090	8,215,999	273,088	7,922,087	0.565	4,477,054
2009	8,550,500	47,726,500	-	21,811,013	90,359	0.817	6,155,825	247,359	7,149,942	0.500	3,573,637
2010	8,625,200	49,162,100	-	23,696,132	91,398	-	6,517,823	244,188	7,107,282	-	4,371,400

Source: USDA

Table 2.3: Arkansas Poultry Production

Year	Broiler				Eggs			Turkey			
	Number Produced	Lbs Produced	Price per Lb	Value of Production	Egg Produced	Price per Dozen	Value of Production	Number Produced	Lbs Produced	Price per Lbs	Value of Production
	1,000 Head	1,000 Lbs	Dollars	1,000 Dollars	Million	Dollars	1,000 Dollars	1,000 Head	1,000 Lbs	Dollars	1,000 Dollars
1991	980,200	4,214,860	0.325	1,369,830	3,737	0.918	285,881	24,000	489,600	0.380	186,048
1992	1,022,500	4,499,000	0.340	1,529,660	3,601	0.883	264,974	25,000	517,500	0.380	196,650
1993	1,048,800	4,614,700	0.365	1,684,366	3,645	0.941	285,829	25,000	512,500	0.400	205,000
1994	1,078,600	4,853,700	0.375	1,820,138	3,803	1.040	329,593	25,000	510,000	0.440	224,400
1995	1,107,300	4,982,900	0.355	1,768,930	3,608	0.979	294,353	26,000	535,600	0.450	241,020
1996	1,155,000	5,659,500	0.375	2,122,313	3,433	1.050	300,388	28,000	526,400	0.440	231,616
1997	1,164,600	5,590,100	0.375	2,096,288	3,215	1.030	275,954	30,000	525,000	0.410	215,250
1998	1,170,600	5,618,900	0.380	2,135,182	3,233	1.140	307,135	28,000	495,600	0.400	198,240
1999	1,196,200	5,861,400	0.370	2,168,718	3,458	1.110	319,865	27,000	491,400	0.440	216,216
2000	1,191,700	5,839,300	0.330	1,926,969	3,559	1.060	314,378	28,000	498,400	0.440	219,296
2001	1,170,900	5,737,400	0.390	2,237,586	3,427	1.060	302,718	27,000	472,500	0.400	189,000
2002	1,186,300	5,812,900	0.300	1,743,870	3,333	1.070	297,193	29,500	522,150	0.380	198,417
2003	1,192,400	5,842,800	0.340	1,986,552	3,384	1.220	344,040	26,500	477,000	0.370	176,490
2004	1,241,500	6,207,500	0.440	2,731,300	3,526	1.220	287,956	28,500	527,250	0.430	226,718
2005	1,214,300	6,314,400	0.420	2,652,048	3,416	1.240	281,595	29,000	565,500	0.460	260,130
2006	1,185,400	6,282,600	0.350	2,198,910	3,267	1.230	335,499	30,000	585,000	0.520	304,200
2007	1,172,300	6,213,200	0.420	2,609,544	3,288	1.360	371,857	31,000	601,400	0.520	312,728
2008	1,160,000	6,380,000	-	2,934,800	3,139	1.600	418,062	31,000	610,700	0.570	348,099
2009	1,050,900	5,780,000	-	2,641,460	2,935	1.480	362,727	29,000	568,400	0.500	284,200
2010	1,043,500	5,937,500	-	2,861,875	2,894	-	356,273	28,000	548,800	-	340,256

Source: USDA

2.2 Ventilation and Heating Performance in Poultry Production

Over the last decade the industry changed considerably; change is most obvious in broiler houses. Use of systems such as tunnel ventilation, fogging pads and radiant brooders enable a more controlled environment necessary for birds genetically selected for high performance; therefore, this equipment became necessary in production. Without them it is impossible to grow broiler birds as efficiently as possible. Until now, the primary ventilation system in poultry house was side-wall curtains, today used *"just in case of a power outage or to air out the houses between growouts"* (Czarick and Lacy, 1998).

Extremes in weather have a significant impact on broiler production. Birds produce heat when they are digesting/processing feed. During the hot summer, it is a problem for birds to get rid of the added heat. Naturally birds have two methods of ridding themselves of heat: (1) during respiration, when it evaporates water from system or (2) "*by giving off heat to the air moving over and around its body*". If temperature is too high these ways do not help birds enough, they suffer and their condition show in lower growth rate (Czarick and Lacy, 1998).

To achieve profitability in poultry production, farmers must have appropriate ventilation systems in their houses. Broiler houses are ventilated for five prime purposes:

(1) to reduce heat,

(2) to eliminate added moisture,

(3) to reduce odors and dust,

(4) to minimize harmful gases – ammonia, carbon dioxide,

(5) to supply oxygen for respiration (Bucklin et all., 2008).

Reducing heat and moisture are the main and most important purposes for ventilation (Bucklin et all., 1998). Good air quality is a result of accurately utilizing the ventilation system. The main undesirable air components created in broiler houses are ammonia, dust, carbon dioxide, added water vapor and carbon monoxide. When these contaminants exceed preferred rates they have a harmful effect on bird performance and they cause damage to the respiratory tract of birds. Remaining exposure to toxins in the air results in chronic respiratory diseases. With the aid of correct ventilation, contaminated air is removed from broiler houses and is replaced with good air quality (ROSS Breeder).

Table 2.4: Common Air Contaminants in Broiler House

Ammonia	**May be detected by smell at 15 ppm or above.** **>10 ppm will damage the lung surface** **>20 ppm will increase susceptibility to respiratory diseases. Prolonged exposure may increase susceptibility to blindness.** **>50 ppm will reduce growth rate**
Carbon Dioxide	>0.35% causes ascites. Fatal at high levels.
Carbon Monoxide	100 ppm reduces oxygen binding. Fatal at high levels
Dust	Damage to respiratory track lining. Increased susceptibility to disease.
Humidity	Effects vary with temperature. At >84%°F (29°C) and >70% RH, growth will be affected. Litter qualitz is poor at high level, which will increase down/grading at processing

Source: ROSS Breeders, Broiler Management Guide

Cold weather and high energy prices lead growers to reduce fuel consumption to lower operating cost. They may set temperature and ventilation settings in poultry houses on minimum sometime. The outcome is mostly negative. Lower temperature results in cold birds, insufficient ventilation in aggravated air quality, lack of fresh air and higher levels of contaminants such as ammonia and wet litter (Donald, 2001).

As birds grow they produce more heat. In summer excess heat has negative influence on birds, resulting in lowered feed consumption, slower growth and increased mortality. Proper use of cooling and ventilation helps to regulate or prevent these problems by removing excess heat concentrated in poultry house from solar radiation and bird metabolism. Market weight broilers produce a larger quantity of heat than do smaller broilers. According to Bucklin et al. (2008), *"a flock of 25,000 four lbs. chicken broiler can give off 1,000,000 BTU per hour of heat*". In the winter season a bigger problem in poultry house is moisture. Moisture is caused by the additional heat in cold weather and usually has a negative effect on birds, especially chicks. Appropriate use of ventilation helps to remove additional moisture. For instance *"a flock of 25,000 4 lbs. chickens give off about 40 gallons of moisture per hour"* (Bucklin et al., 1998).

As poultry production expanded and broiler growth rates increased faster than several years ago, it became necessary for farmers to have sufficient ventilation systems if they wanted to achieve good results in production (ROSS Breeders). According to ROSS there exist two kinds of ventilation systems: (1) power ventilation, consisting of subsystems – minimum, transitional and tunnel ventilation, or (2) natural (curtain) that is divided into mechanical and non-mechanical assisted system.

Tunnel ventilation is very important during warm to hot weather especially for grown market weight birds (ROSS Breeders). This system is composed of fans and inlets. On one end of a poultry house are two large fans and on the other end are air inlets. Fans create a wind chill that has a cooling effect by pulling the air through the house and removing heat from the house (MacDonald, 2008). Tunnel ventilation helps birds to stay comfortable by applying the cooling effect of high-speed air flow. This system generates wind chill that have a cooling effect on birds and maximal exchange of air. "*Each 48 in (122cm) fan for birds under 4 weeks will generate wind chill of 2.5F° (1.4°C)*". If birds are older than 4 weeks this number decreases to 1 to 1.5F° (0.6-0.8°C) (ROSS Breeders).

There are four important requirements for minimum ventilation with fuel and energy savings:

1. Quality insulation in tight broiler house (without cracks or leaks),
2. Must prevent cold air flow directly onto birds,
3. Accurate ventilation rate adjusted in consideration of bird age,
4. Every 5 minutes ventilation on-off timing have to be controlled by timer or *"by a controller set for no longer than 5 minutes for a complete on-off cycle"*(Donald, 2001)

Today as energy prices increase, especially propane and natural gas for heating, it becomes more important for growers to invest in solid, insulated sidewalls for purposes of reducing costs. According to Van Wicklen, to achieve profit, growers must make sure that broiler housing has a tight insulation without leakages or cracks that are common in houses with curtains walls. "*Fuel conservation is one important advantage of tight housing, but without tight housing a grower has little control over where ventilation air* *enters a house in winter as well as summer*". Solid sidewall houses give a grower better control to target ventilation air through the house.

Value of insulation in broiler houses is very important in reducing the amount of heating fuel the farmer has to burn during winter. Insulation is also of benefit during warm months because quality, tight insulation keeps heat of the sun out of the broiler house. One of many insulation advantages is that insulation keeps warmer temperatures inside the house. This heat helps decrease water condensation that concentrates inside. Condensation has a negative impact on birds but also on building structure. Good insulation may prolong the life of the structure (Donald, Eckman, and Simpson 2001).

2.3 Open Credit Lines for Farmers

"The U.S. Department of Agriculture's Farm Service Agency (FSA) makes and guarantees loans to family farmers and ranchers to promote, build and sustain family farms in support of a thriving agricultural economy" (USDA/FSA, 2011). Farmers can apply for farm operating loans which can be used for operating expenses such as feed and energy, purchasing or repairing machinery and equipment, repairing of real estate improvements and refinancing debt. A borrower can obtain direct loans with which he/she can incur debts up to a $300,000 maximum, and *"guaranteed loans for up to a maximum indebtedness of $1,119,000".* The repayment term is usually planned for up to seven years for intermediate-term purposes, but the term can vary. When an applicant obtains an annual operating loan, he/she typically repays it within 12 months or after a farmer sells their production (USDA/FSA, 2011)..

Phillip, Peterson and Mitchell (2009) in their work mention that a farmer has to consider several aspects (type of production, type of farming operations, capital requirements, etc.) before he/she decides to take credit for funding operations. There are several types of loans for farmers. The first loan type is a real estate or farm ownership (FO) loan, which is usually secured by a mortgage on real estate. It is a loan the farmer uses to fund the purchase or improvement of land used for growing crops. Repayment of the loan is arranged for a number of years and is paid on an annual or more frequent basis. The FSA's Direct Farm Ownership Down Payment Loan Program is a particular kind of real estate loan that is meant for ranchers and farmers who are starting their business.

The second loan type, which is one of the most common loan types in the agricultural sector, is the operating loan. It is "a loan that is tied to the production cycle of a farm commodity". Generally a farmer takes this type of credit before the production cycle starts but also perhaps during the cycle. Repayment of the credit has a short term, typically by the end of the production cycle (one year maximum). Unlike other loan arrangements, an operating loan requires interest in additional security because at the beginning of the cycle, the value of the production is very low and the outcome (value of the production commodity) is not guaranteed due to unexpected weather conditions, for instance.

The third loan type is an intermediate term loan.. The loan is typically used for purchasing livestock and equipment. Payment period is shorter than credit for real estate property but can be longer than for an operating loan. Sources for the mentioned loan types are commercial banks, Farm Credit System (FCS), FSA and *"the financing arms of equipment manufacturing companies*" (Phillips, 2009).

According to USDA/FSA, The Consolidated Farm and Rural Development Act of 1961 authorized lines of credits for farmers and ranchers through the Farm Loan Program (FLP). A line of credit is a particular kind of operating loan. A line of credit is similar to an annual operating loan and intermediate term loan, except the farmer only draws upon the line of credit as he/she needs the funds as long as the total amount withdrawn does not exceed the maximum amount of the line of credit. A revolving line of credit loan is similar except that the loan amount outstanding at any given time cannot exceed the maximum amount of the line of credit. The revolving line of credit allows the borrower to withdraw funds, then repay, then withdraw, then repay, etc.

The fourth type of loan is an emergency loan and is available from FSA. An emergency loan is intended for farmers that incur losses from quarantines or unexpected weather conditions.

Loans available for farmers and ranchers from FSA’s Farm Loan Program are limited to:

- Direct operating loan – $300,000
- Direct operating loan for youth – $5,000
- Direct farm ownership – $300,000
- Direct farm ownership down payment – $100,000
- Guaranteed operating loan and farm ownership – $1,119,000
- Emergency loan – $500,000 (USDA/FSA)

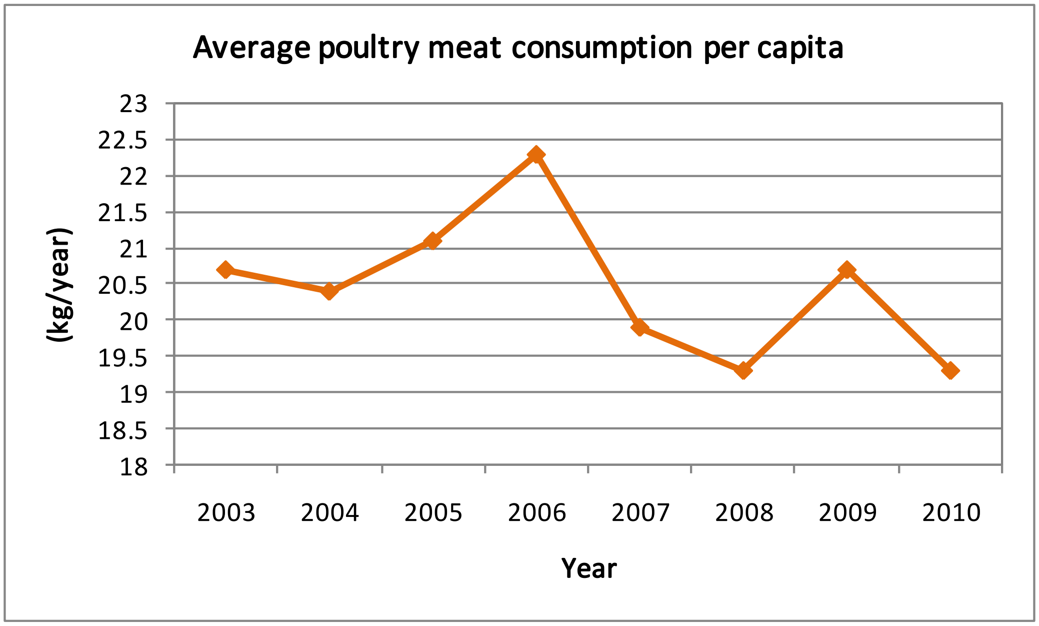
2.4 Slovak Poultry Production

In Slovakia, the poultry industry is one of the youngest food sectors. It began to develop in 1957. After 50 years it is a modern and well-operated part of agriculture (Benková and Bašteková, 2000). According to Mates (2008), poultry production is a part of agriculture that has a short production cycle with minimal impact on environment in comparison with other kinds of livestock.

In the 1980`s, production of slaughter poultry and the poultry industry as a whole were well developed and comparable with poultry industries in developed countries. In the beginning of 1990`s, the privatization of state assets brought changes in production and trade links that had negative impact on the whole agricultural sector. From the end of 1980`s until 1993, poultry production and consumption had dropped sharply. For example the consumption of broiler meat declined 11.8 kg per capita. The situation in the poultry industry had not stabilized until 1997 due to implementation of The Concept of Poultry Production Development that was approved in 1993. The main purpose of the Concept was to create the conditions to maintain self-sufficiency in poultry production. In 1998, poultry production and consumption of poultry products began to gradually increase and consumption reached level of 16.7 kg per capita (Benková and Bašteková, 2000).

The total meat consumption per capita has had an increasing trend that contributes to stabilization of agriculture in Slovakia. Current proportion of meat consumption is 25% of total consumption (Francisciová, 2009). According to Jamborová (2010), poultry meat consumption per capita in Slovakia reached 22.3 kg in 2006 but in 2010 it decreased slightly to 19.3 kg (Figure 2.4), second after pork meat consumption (32.8 kg in 2009). Third place belongs to beef meat (4.4 kg in 2009). The average consumer price of chicken meat in the first half of 2010 was 2.26 €/kg.

Figure 2.4: Slovak Poultry Consumption 2003-2010



Source: VUEPP

In Slovakia the main impact on development of the poultry industry for the future is feed prices in particular, which will depend on the supply of cereals in the domestic and foreign markets. As long as cereal production is decreasing, feed prices will increase (Jamborová, 2009).

According to Jamborová (2010), the Slovak poultry structure consists of chickens, hens, turkeys, geese and ducks. Slaughter chickens comprised the majority of production (92.2%), followed by hens (6.7%), turkeys (1.1%) and geese and ducks with only 0.3%. In 2010 Slovakia produced approximately 15.6 million birds with an average weight of 2.05 kg.

Table 2.5: Slovak Poultry Production in 1,000 head, 2000-2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chicken	1122	-	897	786	767	1109	1195	1429	1121	1358	1627.8
Chicken-broiler	6018	7004	6134	6689	6699	6767	5549	5071	4054	6852	4625.3
Hen	5846	5143	6213	6127	5647	5591	5702	5773	5556	6252	6266.2
Turkey	211	349	285	163	167	180	164	160	126	123	116
Goose	40	38	34	36	36	35	33	37	29	32	32.3
Duck	246	248	253	251	249	250	239	240	194	179	179.2

2010 – estimated
Source: VUEPP

Table 2.6: Selected Prices of Poultry Products in Slovakia, 2006-2010

Price	Unit	2006	2007	2008	2009	2010
Producer Price of Slaughter Broiler-chicken	€/t	-	-	975.57	798.68	788.41
Producer Price of Slaughter Broiler-turkey	€/t	-	-	1511.98	1318.09	1,282.67
Producer Price of Consumption Eggs [1]	€/100pcs	6.67	6.83	7.01	6.69	6.41
Purchase price of Slaughter Broiler-chicken* [1]	€/kg	0.82	0.9	0.97	0.78	0.78
Processor price of Drawn Chicken** [1]	€/kg	1.75	1.81	1.87	1.74	1.72
Consumer price of Drawn Chicken** [2]	€/kg	2.17	2.33	2.51	2.29	2.24

*chicken in live weight
**chicken without offal
[1]without tax
[2]with tax
Source: VUEPP

Poultry meat is consumed worldwide, and the primary reasons for growth in poultry meat consumption according to Haščík (2009) are:

- Elasticity of supply and demand
- Relative low prices
- A short production cycle
- Dietary attributes/qualities of chicken and poultry meat
- Wide range of poultry products
- Consumption without religions restrictions
- Easy preparation.

Poultry production (meat and eggs) make a significant contribution to food security of the country. Intensity of production in Slovakia is 900 pieces per 100 ha of arable land, representing 41.9% of EU poultry production intensity (2150 pieces per 100 ha) (Jamborová, 2009). According to Pliešovský (2009), in 2009 there were 263 approved poultry producers in Slovakia. The majority of them (227) were broiler chicken farms, 179 farms specialized in slaughter broiler production, 30 farms have been registered as breeding farms, and 18 as hatcheries.

In Slovakia, poultry production takes place in vertical integration that is linked by capital or contract. Components/parts of vertical integration are growers, service suppliers, processors and the trade network. To assure high broiler production, it is necessary for the poultry farmer to grow chickens from superior genetic pools and to adapt to technological progress by investing in costly housing over time (Benková and Bašteková, 2000).

The government provides subsidies for poultry producers. Growers can apply for support from the Rural Development Programme. Support is provided for breeding and sustaining endangered species of chickens, geese and bronze turkey and also support for improving animal welfare according to Government decree no. 499/2008, Coll. This program also supports investments to construction, restructuring and modernization of poultry housing, hatcheries and feed stores. Since 2007, producers can draw financial support from the Rural Development Programme for activities aimed at establishing and operating sales businesses whose members are individuals or entities who undertake agriculture in Slovakia and produce poultry and eggs (Jamborová, 2010). The condition for obtaining non-refundable funds is to maintain the number of birds for the following 5 years. Any increase in the number of birds results in a decrease of funds because support is calculated and paid in relation to the amount of livestock units (LU) per area. This calculation is not favorable for poultry producers because Council directive no. 2007/43/ES obliges growers to decrease production density (Teichmanová, 2010).

In 2004, Slovakia joined the European Union and opened markets to other countries. Slovakia was not prepared for large imports from neighboring states and poultry started to face new problems. For instance in 2010 total production of slaughter poultry declined to 63,000 tons from 127,187 tons in 2002. This is the largest decrease in the last 20 years. Growers and processors can hardly compete with the lower prices of imported broiler meat. Also policies of retail chains and shortcomings in legislation make worse conditions for participants during the production cycle. In the last 4 years, production of poultry meat dropped about 20% in Slovakia while in other states of the EU it increased about 39% (Nemec, 2010).

In 2005, slaughter broiler chicken production achieved the following performance parameters:

- 37 days of average length of feeding of slaughter chicken,
- Average weight 1.97 kg per bird at removal day,
- 1.95 kg feed consumption for 1 kg of weight gain,
- Mortality of 4.2%.

By 2013 Slovak growers aim is to achieve 35 days of average length of feeding, average weight of 2 kg per bird at removal day, a maximum of 1.9 kg feed consumption for 1kg of weight gain and to keep mortality under 3.5% (MRPS - Ministry of Agriculture and Rural Development of Slovak Republic, 2006).

In Slovakia, two kinds of housing systems are used. This cage system is mostly used for breeding hens and the deep litter system is more frequently used for breeding slaughter chickens (Brestenský, 2002). Quality of litter material in the chicken house has a significant impact on well-being and health of chickens. Wet and poor quality litter material increases level of ammonia, occurrence of respiratory diseases and dermatitis on the feet of birds. Well-managed environment in the house and proper nutrition of birds help to keep litter dry and loose/mellow (Lichovníková, 2010). Appropriate material for a deep litter system is, for instance, shavings from softwood because it has a good absorption capability (Brestenský, 2002).

With regard to Skalka (2010), factors that cause wet litter are:

- Leaking drinking systems (drinking points are too low or water pressure is too high),
- Cold air flowing on litter,

- Low air speed at air inlets,
- Low amount of total air exchange,
- Low temperature in chicken house,
- Height and type of litter material,
- Incorrect use of air-condition system or incorrect location of fog nozzles,
- Excess salt in feed,
- Excess of nitrogen substances in feed or using poor quality fats and oils,
- Too high density of birds with regard to house technology,
- Infectious diseases causing enteritis.

Room for movement of birds in a poultry house depends on its density per unit area. The measurement for chicken concentration most frequently used is unit kg per m^2. The density expressed like this increases with age of chickens and space available for movement decreases. The greatest limitation for movement of birds occurs in the last week of feeding. In the EU current recommended maximal density per unit area in the end of the breeding period is from 33 to 42 kg per m^2 (Lichovníková, 2010).

III. DATA AND METHODS

3.1 U.S Data Sources and Characteristics

Data utilized in this study come from The Arkansas Broiler Research Farm (ABFR) at Savoy of the Agricultural Experiment Station University of Arkansas for the study duration 1991-2010. ABRF operates production in four broiler houses; in our analysis we include time-series, cross-sectional data from 113 flocks per house for the observed time period. Farm personnel records and retains detailed energy, production and economic reports on a daily and weekly basis and on a house and flock basis. Energy information is kept on a weekly basis and contains data about propane usage in gallons and electricity usage in KwH. The production data includes average weekly mortality in days, feed usage in pounds and water usage in gallons. On a flock basis there are variables that include total liveweight and net liveweight of broiler chickens in pounds, average weight in pounds per bird at pickup day and number of head placed separately for every house. For analysis needs, we calculated average daily propane, electricity, feed and water usage data by dividing the corresponding weekly data by number of days in a given week. The economic reports contained expenditures on weekly propane and electricity in dollars, cost of electricity per KwH, cost of propane gas per gallon and information on gross pay and net pay in dollars per flock and gross pay for broilers in cents per pound. Average daily propane gas expenditures were generated from multiplying weekly propane gas usage and cost of gas per gallon and dividing by number of days in a given week. As for average daily electricity cost, average daily electricity cost was calculated by multiplying weekly electricity usage in KwH and electricity cost per KwH and dividing by number of days in the given week. Additional data sources adapted to our study were from the National Weather Service (NWS) and National Climatic Data Centre (NCDC).

The dataset contains 43 numerical and categorical variables. Most of them (24) were taken from ABRF reports, and 19 variables were created or adjusted in consideration of data reports and additional data. Variable, average high and average low weekly temperatures were calculated from maximum and minimum daily temperatures obtained from NWS and NCDC. They are expressed in Fahrenheit (°F).

To facilitate our analysis, nine new categorical variables with regard to a farm`s information were created (Season, Qtr_in, Qtr_out, Week, Drop_ceiling, Steel_high_ceiling, Wood_low_ceiling, Simmons, House). In the next section, each of them is explained and identified.

Season (categorical) variables are generated from combination of two dummy variables (Qtr_in and Qtr_out). Qtr_in means quarter of the year when a flock was placed in the house and Qtr_out is quarter of the year when a flock was picked up from the house. Both of the variables are identified where 1 refers to spring, 2 to summer, 3 to autumn and 4 to winter. Season variables were developed to identify in which quarter of the year the flock was placed and picked up, as follows:

- 11 (WtrWtr) – flock placed in winter, picked up in winter,
- 12 (WtrSprg) – flock placed in winter, picked up in spring.
- 22 (SprgSprg) – flock placed in spring, picked up in spring,
- 23 (SprgSmmr) - flock placed in spring, picked up in summer,
- 33 (SmmrSmmr) - flock placed in summer, picked up in summer, omitted because the constant term is used,

- 34 (SmmrFall) - flock placed in summer, picked up in fall,
- 44 (FallFall) - flock placed in fall, picked up in fall
- 41 (FallWrt) – flock placer in fall, picked up in winter,

The table represents frequency of the season variables in dataset. The highest season occurrence has category spring/summer (492 observations from 3189) which represents 51.36%. The lowest frequency has season category winter/winter (10.72%).

Table 3.1: Frequency of the Season Variables

Season	Frequency	Percent	Cumulative Frequency	Cumulative Percent
11	342	10.72	342	10.72
12	413	12.95	755	23.68
22	391	12.26	1146	35.94
23	492	15.43	1638	51.36
33	416	13.04	2054	64.41
34	336	10.54	2390	74.95
41	413	12.95	2803	87.9
44	386	12.1	3189	100

In the dataset, the longest duration flocks were held was nine weeks. The length of feeding depends on the decision of the processor to pick up the broilers and varies from 6 to 9 weeks. For analysis use, we created the categorical variable Week which is recognized as week of data, age of flock. It was created because there is an association between input data, such as feed and propane usage, and number of weeks the flock were held. For a better understanding, we refer to the example of feed consumption, which is significantly higher in the last weeks of production than in the first weeks when broilers are small chicks, or, for instance, in the first weeks of production when the farmer has higher energy (gas) usage because chicks have greater difficulty maintaining their body temperature than broilers before pick up date. Because of these relationships we created Week variable that consist of 9 classes, weeks 1 to 9. Week 4 is in the constant terml.

The farm consists of four broiler houses where each of them has different construction characteristics. In 2006, all four houses were retrofitted. With reference to this reconstruction we created one categorical (House) and one dummy variable (drop_ceiling,).

To recognize differences in flock production quality we generated categorical variable house with four classes (house_1, house_2, house_3, house_4). A value of 1 indicates in which house the specific flock was placed. In the regression interpretation, category house_4 was omitted (intercept).

We created the dummy variable Drop_ceiling. Prior to flock 87, there were two houses with steel frames and high ceilings and two houses with wood frames and low ceilings. After flock 86, all four houses have a retrofitted drop ceiling due to the reconstruction in 2006. A value of 1 indicates that the flock was grown in a house with either a retrofitted drop ceiling or a wood low ceiling and value 0 indicates that the flock was grown in a house with high ceilings. Frequencies are shown in Table 3.2.

Table 3.2: Frequency of the Drop Ceiling Variable

Drop_ceiling	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1203	37.72	1203	37.72
1	1986	62.27	3189	100

Based upon the integrator contracting with ABRF, a dummy variable Firm was created. Flocks 1 to 34 were produced for Tyson and it has a value 0; the rest of the flocks (from 35 to 113) were produced for Simmons and has a value 1 (Table 3.3).

Table 3.3: Frequency of Firm Integrator Variable

Firm	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	982	30.79	982	30.79
1	2207	69.21	3189	100

In total, there were 3189 usable observations (weeks and houses with complete data) covered in the analysis for the period from 1991 to 2010. To avoid biases and distorted results we excluded flock number 20 in house 2 from the dataset because the whole flock, 18,800 birds, were smothered in the fifth week due to a technical (air-handling) malfunction. Occurrence of missing data caused an adjustment of 11 observations and removal of 25 observations. Eleven observations had inputs but did not have average daily mortality because the day(s) of production mortality was (were) missing (Table 3.4). To make this data usable we applied average daily mortality from the previous week and applied calculated mortality to missing data.

The next 25 observations had mortality data but did not have average input information. The problem occurs just in the last flock week of production and if there are only two days of input. Missing observations occur in the last week (Table 3.5).

Table 3.4: Observations Missing Average Daily Mortality

Flock	House	Week	Missing days
25	4	7	1
49	1	9	1
49	2	9	1
49	3	9	1
49	4	9	1
52	1	8	1
52	3	8	1
52	4	8	1
68	4	7	2
94	4	9	3
103	1	7	1

Table 3.5: Observations Missing Average Input Data

Flock	House	Week	Missing days
4	1	9	1
4	2	9	1
4	3	9	1
4	4	9	1
11	1	9	1
11	2	9	1
11	3	9	1
11	4	9	1
12	3	9	1
12	4	9	1
13	1	9	1
13	2	9	1
13	3	9	1
13	4	9	1
33	3	7	1
42	1	8	2
42	2	8	2
42	3	8	2
42	4	8	2
72	2	7	1
95	1	9	1
95	2	9	1
95	3	9	1
107	1	8	1
107	2	8	1

Table 3.6 demonstrates descriptive statistic (mean, standard deviation, maximum and minimum) of selected variables. The ABRF farm produced broilers in four houses with an average weight 5.24 lbs. Over the study period, flock placements averaged 16,300 to 25,519 head with an average daily mortality 22 head per day. Higher placement occurred after retrofitting in 2006. Average daily propane gas usage varied from 0 (occurs in summer time) to 161.65 gallons with average cost of 0.88 cents per gallon. Average expenses for propane gas were $14.93 per day and for electricity $19.41 per day.

Table 3.6: Statistical Characteristics of Selected Variables of ABRF (U.S.)

Variable	Unit	N	Mean	Standard Deviation	Minimum	Maximum
Head_Placed	Heads	3,189	20,646.800	2,059.280	16,300	25,519
Avg_Wt	lb/head	3,189	5.244	1.090	3.11	8.26
Gross_Pay_cent_Lb	cents/lb	3,189	4.461	1.213	-12.890	6.66
Feed_lb_daily	lb	3,189	4,296.530	2,319.010	506.571	27,164
water_gal_daily	gal	3,189	928.046	481.465	91.286	5,020
gas_gal_daily	gal	3,189	16.773	24.450	0.000	161.695
gas_cost_daily	$	3,189	14.932	24.564	0.000	204.512
Gas_Cost_Gal	$/gal	3,189	0.883	0.440	0.520	2.100
Dollar_KWH	$/KWH	3,189	0.060	0.006	0.040	0.070
fan_kwh_daily	KWH	3,189	54.895	54.748	0.286	283.333
fan_cost_daily	$	3,189	3.380	3.473	0.017	19.437
light_kwh_daily	KWH	3,189	16.122	15.455	0.000	132.000
electric_kwh_daily	KWH	3,189	83.644	59.550	7.714	439.571
electric_cost_daily	$/KWH	3,189	19.416	21.329	0.069	162.000
avglow	°F	3,189	46.226	16.231	5	72
avghigh	°F	3,189	69.850	16.723	26	103
mortality_daily_avg	Heads	3,189	22.088	24.355	2.0	646.6

ABRF at Savoy

ABRF at Savoy was established in 1990. Funds for building the ABRF's facilities and houses were obtained from the federal government. It operates on 10 acres of land owned by University of Arkansas. ABRF began to operate in November 1990 when the first flock was placed. At first the farm grew chickens for Tyson (flocks 1-34) and after 10 years switched to Simmons. ABRF does not own chickens, but it does own the facilities (buildings, land, etc.). The company/integrator owns chickens. Farmer contracts with integrators to grow broilers generally allow the integrator to determine how many chickens will be placed in the house, the duration of the flock staying, when the flock will be picked up. ABRF does not have control over these decisions. Flocks are usually fed from 6 to 8 weeks (49-60 days). Between flocks there is a period of 10-14 days when houses are empty and prepared for the next flock. The company/integrator supplies chickens and provides feed and veterinary service but ABRF has to pay for medication (vaccination). All four houses are automated and connected to the computer that downloads detailed information (for instance electricity usage, gas usage, feed intake, water intake, etc.). ABRF has used an automated system for collection data from the beginning of production.

ABRF grows chickens in 4 houses that are the same size (40 feet wide and 400 feet long) but have different construction. At the beginning the chicken houses had curtain walls instead of current solid walls. House 1 and 2 have steel high ceiling. House 3 and 4 have wood low ceiling. In 2006, houses were renovated to make them more energy efficient. Now all 4 have retrofitted drop ceilings. Every house has two lines of feeders and four lines of nipple drinkers.

Houses also differ in the type of ventilation system. Two of the houses used conventional style ventilation and two others used tunnel style ventilation. Nowadays it is more common and efficient to have tunnel vents in poultry houses. ABRF has to follow guidelines for producing broilers given by the company/integrator.

3.2 Slovak Data Sources and Characteristics

Slovak data were collected from the farm called Univerza Inc. at Trnava pri Laborci established in 1997. This farm has 7 houses, but only 3 of them are in use due to technological inadequacy. Flock capacity for 3 houses is 65,000 birds. Data were taken from annual summary reports for the last 3 years (2008-2010). Only three years of data are used because earlier reports had inadequate information (missing and inaccurate data). In the study we include 18 flocks per house. Overall, the dataset consists of 57 observations that are identified by 21 numerical and categorical variables, kept on both a flock and house basis (Table 3.7). The farm produced COOP 500 and ROSS 308 broiler chickens with an average weight of 2.28 kg per bird. Length of production (feeding) varies between 37 and 44 days. On average, the farm utilized 2,801.33 m^3 of natural gas, 230,598 kg of feed and 200,301.56 l of water per house per flock. An average 13,046 birds were placed in the every house.

Additional data sources adapted to our analysis were from the Slovak Gas Industry ojsc. (SPP) website. The Gas_KWH variable is cost of natural gas in euro per KWH. It was taken from quarterly SPP reports. Gas_KWH for 2008 had to be adjusted because the Euro currency was adopted in Slovakia beginning January 1, 2009. Gas_KWH from Slovak koruna (Skk)/KWH to Euro/KWH was calculated by applying

Table 3.7: Statistical Characteristics of Selected Data of Slovak Farm

Variable	Unit	N	Mean	Std Dev	Minimum	Maximum
Cost_KWH	€/KWH	54	0.04031	0.00428	0.03640	0.04890
Gass_usage_m3_	m^3	54	2,801.33	2,071.61	406.00	8,187.00
Water_Farm	l	54	200,301.56	31,355.95	147,825.00	246,269.00
Feed_kg	kg	54	230,598.56	30,935.82	162,220.00	274,310.00
Head_placed_Farm	Heads	54	39,138.33	1,619.43	37,200.00	43,500.00
Head_pickup_Farm	Heads	54	36,597.22	1,609.46	34,020.00	41,207.00
Mortality_pct_Farm	%	54	6.49	1.47	4.72	10.03
Water_L	l	54	66,767.19	15,971.09	22,444.00	100,744.00
Age_days	days	54	41.22	1.27	39.00	44.00
Av_weight_Date_in_kg	kg/head	54	0.0409	0.0021	0.0370	0.0460
Av_weight_kg_	kg/head	54	2.2881	0.1688	2.0000	2.5500
Head_placed	Heads	54	13,046.11	541.90	12,400.00	14,500.00
Head_pickup	Heads	54	12,199.07	543.97	11,261.00	13,849.00
Mortality_Pct	%	54	6.49	1.62	4.03	11.27

the quarterly euro exchange rate. The category House was created and consists of the three variables House_1, House_2 and House_3. The Season variables were created in the same way as for the U.S. data. Tables 3.8 and 3.9 show frequencies of the House and Season variables.

Table 3.8: Frequency of Categorical House Variables, Slovak Farm

House	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	18	33.33	18	33.33
2	18	33.33	36	66.67
3	18	33.33	54	100

Univerza at Trnava pri Laborci

All three of the farm's houses are insulated and the inside temperature is effectively controlled by an automated system. Each house is 80 m long, 14 m wide and 4 m high. There is 1,120 m^2 of space in each house. Ventilation inlets are installed in the sidewall at 80 cm height from floor level and the front sidewall. Their size is 60 x 25 cm and their opening is operated by an automated system. Their purpose is to bring fresh air

Table 3.9: Frequency of Categorical Season Variables, Slovak Farm

Season	Frequency	Percent	Cumulative Frequency	Cumulative Percent
11	6	11.11	6	11.11
12	9	16.67	15	27.78
22	9	16.67	24	44.44
23	3	5.56	27	50
33	9	16.67	36	66.67
34	9	16.67	45	83.33
41	3	5.56	48	88.89
44	6	11.11	54	100

inside and adjust temperature. There are 12 inlets on each sidewall. Every inlet is secured with netting to prevent entry of birds and insects to the feeding space. An automated system evaluates data from a humidity meter and a thermometer located in the middle of the house above bird level. According to the current microclimate inside each house, it regulates the opening and closing of vents and the running of fans. The system is secured with an alarm in case of failure. Ventilation in the house is based on a negative pressure tunnel ventilation system. In each house there is one pair of fans (diameter 120 cm) and two pairs of smaller fans (diameter 60 cm) with 900 rpm and performance power of 11,750 m^3 flows of air per hour.

In each house there are five lights with performance power 350W that are set in a checkerboard pattern. The farm uses natural gas for heating. There are two heater units on opposite sides at the end of each house. Equipment for broiler feeding consists of three lines of bowl feeders and four lines of nipple drinkers. It is possible to adjust the height of the drinkers and feeders according to the age of birds. Lines of feeders and drinkers are ordered in turns.

The farm uses straw as deep litter material in every house because it has good moisture absorption and aids in maintaining cleanliness, comfort, a low volume of dust; it should be without pathogens. In the past, farmers used wood shaving but because of reduced availability, they have switched to straw. The litter is spread to a height of 8 cm.

Houses are usually empty between flocks. During this period houses are prepared for the next flock. Preparation includes mechanical removal of litter, cleaning the house with water, disinfection and spreading of new litter material.

During the first five days of each placed flock the house is divided by a curtain and chicks are placed only in half of the house for energy savings. During the first week of the flock, the farm starts to heat the house at 32°C. Five days after placement, the curtain is removed/rolled and fastened to the ceiling. Production continues according to a particular technological process. On removal day, broilers are manually loaded to the box loaders to take to processing.

3.3 Model Specification and Methodology

Regression

To investigate our objectives in the study we use the analytical tool Regression analysis. Regression analysis is a statistical method used to examine relationships among variables. Generally the regression is applied to determine *"the causal effect of one variable upon another"* (Sykes, 1992). In other words researchers seek for prediction of one variable from others. In regression analysis, the researcher estimates a predictive model from the data and after uses an adjusted model to estimate the value of the dependent variable from one independent variable (single regression) or more independent variables (multiple regression). Simple regression attempts to estimate an outcome (dependent variable (Y)) from only one predictor (independent variable X). The researcher fits the data to the model plus error (ε) (Field, 2005).

Simple regression equation:

$$Y_i = (b_0 + b_1 Xi) + \varepsilon_i$$

Multiple regression is used to estimate outcomes from more than one independent variable, the effect of each independent variable can be predicted (Field, 2005; Sykes, 1992). A multiple regression equation is:

$$Y_i = (b_0 + b_1 Xi + b_2 X_2 + ... + b_n X_n) + \varepsilon_i$$

Linear regression indicates the model the researcher fits to the data is linear (a straight line). To estimate (1) energy usage and (2) energy cost in our analysis we use an OLS (Ordinary Least Squares or Linear Least Squares) method. It is a technique to find the line that goes through or as close to, as many of the data points as possible. It is impossible that all points could go through the line (Field, 2005). In the first model we seek to predict energy (gas) usage from selected variables. We assume that the selected (independent) variables have impact on gas usage for heating in poultry house.

(1) Gas_gal_daily = b0 + b1*Gas_cost_gal + b2*Dollar_KWH + b3*Head_placed + b4*Net_wt + b5*Mortality_daily_avg + b6*avglow + b7*Drop_ceiling + b8*Simmons + houseb1*House_1 + houseb2*House_2 + houseb3*House_3 + weekb1*Week_1 + weekb2*Week_2 + weekb3*Week_3 + weekb5*Week_5 + weekb6*Week_6 + weekb7*Week_7 + weekb8*Week_8 + weekb9*Week_9 + ε

Where Gas_gal_daily represents the dependent variable, average daily propane gas usage calculated from weekly usage. Gas_cost_gal stands for expenditure for one gallon of propane given in dollars, Dollar_KWH corresponds to cost of electricity per KWH in dollars, Head_places implies the number of chicks placed in a broiler house on placement date, Net_wt is a variable equal to total weight of flock on pickup date minus condemnation (Dead on arrival – birds that died or were injured during pickup and transport from farm to processor), Mortality_daily_avg represents average number of birds that died per day and avglow is the average weekly minimum temperature. Next Drop_ceiling is binary variable that correspond to houses that were retrofitted and from 2006 have a drop ceiling. Simmons, also a binary variable, stands for flocks fed for Simmons, a processor company. House_1, House_2 and House_3 represent where each flock was placed. Interpretations of House estimators are relative to House_4 category variable it was omitted from the estimated model. Week_1 to 9 are categorical variables too. Week_4 is omitted from the estimated model because in the fourth week occurs significant changes in consumption and energy usage. Birds start to consume considerably larger amounts of feed and water, and also, if we do not consider outside temperature, gas usage drops because birds are capable to maintain their body temperature. b_0 is the intercept in the regression model, the estimated value equal to the predicted dependent variable (gas_gal_daily) when all independent variables are zero.

Equation of the second OLS model (2) is similar to the first model but in this case we estimate average daily cost of propane gas (Gas_cost_daily) as the dependent variable with same independent variables except one. Instead of the categorical variable Week that refers to the age of bird, we selected categorical variable season to estimate trend of increased usage of gas during the year. Season variable consist of 8 categories and each category is a combination of season of placement date and pickup date. Category SmmrSmmr, flock placed in summer and picked up in summer, was left to intercept. In this season combination we expect significantly lower gas usage. In the model are included two new variables - Feed_lb_daily is average amount of feed consumed by broilers per day, and Water_daily_gal stand for amount of water in gallon drunk by birds per day in average.

(2) $Gas\_cost\_daily_i$ = b0 + b1*Gas_cost_gal + b2*Dollar_KWH + b3*Head_placed + b4*Net_wt + b5*Mortality_daily_avg + b6*avglow + b7*Drop_ceiling + b8*Simmons + b9*Feed_lb_daily + b10*Water_gal_daily + houseb1*House_1 + houseb2*House_2 + houseb3*House_3 + WtrWtrb1*WtrWtr + WtrSprgb2*WtrSprg + SprgSprgb3*SprgSPrg + SprgSmmrb4*SprgSmmr + SmmrFallb5*SmmrFall + FallFallb6*FallFall + FallWtrb7*FallWtr + ε

Information available from U.S and Slovak farms varies considerably. We utilized OLS model from Slovak dataset with fewer variables compared to U.S. data. We estimate that natural gas usage measured in m3 (Gass_usage_m3_) (3) is influenced by selected variables:

(3) Gass_usage_m3_ = b0 + b1*Cost_KWH + b3*Feed_kg + b4*Water_l + b5*Age_days + b6*Av_weight_kg + b7*Head_placed + b8*Mortality_Pct + houseb1*House_1 + houseb2*House_2 + WtrWtrb1*WtrWtr + WtrSprgb2* WtrSprg + SprgSprgb3*SprgSprg + SprgSmmrb4*SprgSmmr + SmmrFallb5*SmmrFall + FallFallb6*FallFall + FallWtrb7*FallWtr + ε

Cost_KWH symbolizes expenditures per KWH of natural gas in euro currency, Feed_kg represent feed consumption per flock per farm in kilograms, Water_l is water consumed by birds per flock in litres, Age_days variable stand for length of flock production in days, Head_placed implies to number of chicks places to broiler house on placement date and House, categorical variable, refers to house where the flock was placed. In interpretation of House_1 and House_2, we refer to House_3 which is left in intercept. The Season, second categorical variable, created as combination of binary variables (qtr_in and qtr_out), combination of quarter of the year when flock was placed in and quarter of the year when flock was picked up from house what results in 8 season classes WinterWinter,WinterSpring, SpringSpring SummerSummer, SummerFall, FallFall and FallWinter. Due to lowest usage of Natural gas in summer season we decided to place variable SmmrSmmr in intercept

Correlation

In the study we tested the correlation of variables in Model I, Model II and Model III. It is a useful tool that predicts relationships between each dependent variable and each independent variable but also among independent variables. Field (2005) recognizes correlation "as a measure of the linear relationship between variables". Correlation may result in three types of associations: (1) variables are positively related, when predictor variable increase outcome or other selected predictor increase too; (2) variables are negatively related, when one variable increase, the other variable decrease; and (3) variables are not related, when increase or decrease of one variable does not have impact on the another variable. Value of correlation coefficients varies between -1 to +1. Variables are perfectly correlated when coefficient is equal +1 whicht implies that "as one variable increases the other variable increases by a proportionate amount”, and on the other hand -1 indicates a perfect negative relationship “as one variable increases the other decreases by a proportionate amount”. Value 0 implies there is no linear association between variables at all (Field, 2005).

Heteroskedasticity

Besides correlation we also tested the model for heteroskedasticity. It is a typical problem in analyzing of cross-section data. According to Field (2005) “at each level of the predicted variable, the variance of the residual terms should be constant” this refers to homoskedasticity across the data. When this is not true and the variance of the error term is not constant but very unequal, it implies to heteroskedasticity. Problem of heteroskedasticity does not have an impact on the estimated parameters but correction of variance disturbance in the model results in a change of t-values and standard errors. To test heteroscedasticity in our models we used White’s test of Heteroscedasticity; the result is that in each regressed model heteroskedasticity occurred.

IV. EMPIRICAL RESULTS

Results of the linear regression analysis of the various models specified in the previous chapter are presented in this section. Parameter estimates of the LPG usage, LPG cost and Natural Gas usage models are interpreted. Models are measured by R^2, t-tests of the variables, and F-test. In search for models with best estimators we tested several specifications mentioned in Appendix B.

For running multiple regression models, estimating parameters, testing Pearson Correlation Coefficients and White's test of Heteroskedasticity we used the Statistical Analysis System (SAS, Version 9.1). The advantage of the SAS program is easy utilization through a number of commands and adaptable data organization.

4.1 Multiple Linear Regression Models

The following linear models were selected for interpretation according to theoretical basis and consideration and empirical results from testing.

I. Gas_gal_daily = f(Gas_cost_gal, Dollar_KWH, Head_placed, Net_wt, Mortality_daily_avg, Avglow, Drop_ceiling, Firm, Feed_lb._daily, Water_gal._daily, House, Week) for ABRF,

II. Gas_cost_daily = f(Gas_cost_gal, Dollar_KWH, Head_placed, Net_wt, Mortality_daily_avg, Avglow, Drop_ceiling, Simmons, Feed_lb_daily, Water_gal_daily, House, Season) for ABRF,

III. Gas_usage_m3 = f(Cost_KWH, Fees_kg, Water_l, Age_days, Av_weight_kg, Head_placed, Mortality_Pct, House, Season) for the Slovak Farm.

4.1.1 Fitted Average Daily LPG Usage for U.S. Farm ABRF

The first model, estimated LPG daily usage as function of the independent variables (LPG cost per gallon, electricity cost per KWH, number of head placed in the house, net weight in lbs, average daily mortality, average minimum weekly temperature, drop ceiling as type of house construction, Firm integrator, avg. daily feed consumption, avg. daily water consumption, House_1, House_2, House_3, Week – Week_1, Week_2, Week_3, Week_5, Week_6, Week_7, Week_8, Week_9) is presented in Table 4.1. Results of the Pearson's Correlation Coefficient appear in Appendix A. On the basis of the results, the parameters estimated in the model mostly are not associated except several cases as between the independent variables Gas_cost_gal and Drop_ceiling that we do not know how to explain because Gas_cost_gal is an exogenous variable and should not have a relationship to Drop_ceiling; correlation was also found between Dollar_KWH and Drop_ceiling Again, Dollar_KWH is an exogenous variable; we offer no explanation for this association. Variables Net_wt and Drop_ceiling are also positively correlated.

The White's test of heteroskedasticity (Table 4.1) indicates that model (I) has heteroskedasticity with <0.0001 significance. Thus, the linear regression model is corrected by using the ACOV command in SAS. After correction, the model is homoskedastic. Estimated parameters after correction stayed the same but t-values and standard errors changed.

With reference to the table 4.1, F = 0.0001, which implies we are more than 99% confident that model is significant, so far as predicted values and explanatory values are related. The adjusted R^2 is 0.610, meaning that 61.03% of total variability of predicted LPG usage (Gas_gal_daily) is explained by the independent variables. On average, estimated LPG usage differs from predicated usage by 15.31 gallons (RMSE – Root Mean Squared Standard Error). On the basis of the results of the p-values, majority of explanatory variables are significant at the <0.05 level as well as intercept term (b_0) is significant at the <0.0001 level. On the other hand variables – Net_wt, Mortality_daily_avg and House_1 have p-values higher than 0,05 level, and thus are not statistically significant variables.

Estimated parameters in the fitted model for LPG usage equation appear as the following:

Fitted: Gas_gal_daily = 59.40 + 1.93*Gas_cost_gal –141.74*Dollar_KWH + 0.00007*Head_placed -0.00008*Net_wt + 0.007*Mortality_daily_avg - 0.86*Avglow – 2.35*Drop_ceiling + 3.29*Firm – 0.006*Feed_lb_daily + 0.036*Water_gal_daily - 1.02*House_1 – 4.84*House_2 –1.83*House_3 + 32.46*Week_1 + 23.91*Week_2 + 12.85*Week_3 – 5.29*Week_5 – 8.72*Week_6 – 7.98*Week_7 – 8.12*Week_8 + 4.64*Week_9.

If we assume that the rest of the explanatory variables except intercept (59.40) would equal 0, average daily LPG usage would be 59.40 gallons. The variable LPG cost per gallon “Gas_cost_gal” has a positive relationship to LPG usage. This means that when the market price of propane gas increases, propane usage for heating in broiler production increases too. This is caused by seasonality of utilizing LPG in broiler production. Farmers use the highest amount of propane gas in Fall/Winter season (Figure 4.1). In this quarter of the year, LPG price usually reaches the highest level. The parameter estimate for avglow (b_6) as an explanatory variable to clarify the variability in LPG usage demonstrate that average daily propane usage increases by 0.86 gallons when weekly average minimum outside temperature decreases by 1°F. The parameter estimate (b_7) for dummy variable Drop_ceiling indicates that if chicken house has retrofitted drop ceiling the daily propane usage decrease by 2.35 gallons. The next dummy variable "Firm" and its parameter (b_8) shows that farmers use on average 3.28 gallons more of propane gas per day when feeding broilers for Simmons. Although Firm was shown to have a statistically significant parameter estimate, we cannot dispute the fact that the genetic make-up broilers have changed over the timeframe of this study and this may have impacted the sign of the variable. In addition, changes in the temperature requirements and housing structures, which were increasingly able to reduce the variability in housing environment due to computer-controlled systems, may have also influenced the results.

There are considerable differences in gas usage among houses. House_2 and House_3 average daily LPG usage are lower by about 4.84 and 1.83 gallons, respectively, in comparison to House_4. Houses 1 and 4 are exterior houses in the farm plan, whereas houses 2 and 3 are interior houses, thus explaining the similarity in results for houses 1 and 4 and houses 2 and 3. The parameter estimates for the categorical variable "Week" is significant at the > 0.05 level for every week. The highest impact on gas usage in poultry house was the first three weeks compared to Week_4. In Week_1 average daily gas usage is about 32.46 gallons higher than in Week_4, in Week_2, the amount of daily propane usage is 23.91 gallons higher than in Week_4. Figure 4.1 presents differences is LPG usage for different flock age (weeks). It indicates that the highest gas usage was usually during first three to four weeks of each flock.

4.1.2 Fitted Average Daily LPG Cost for U.S. Farm ABRF

In the second model, the predicted values of the average daily LPG cost as a function of the explanatory variables (LPG cost per gallon, electricity cost per KWH, number of heads placed in the house, net weight in lbs., average daily mortality, average minimum weekly temperature, drop ceiling as type of house construction, Firm integrator, House_1, House_2, House_3, Season – WtrWtr, WtrSprg, SprgSprg, SprgSmmr, SmmrFall, FallFall, FallWtr) is shown in Table 4.2 On the basis of the results from the Pearson Correlation Coefficient we found out that correlation occur in between same variables as previously and one extra case. According to the Table in Appendix A, Feed_lb_daily and Water_gal_daily variables are highly positively associated, with an increase of average daily feed consumption average daily water consumption also increases. In second model heteroskedasticity is also present at with a 0.0001 level of significance. As previously the model was corrected, t-values and standard errors were replaced (Table 4.2).

Table 4.1: Model 1 Parameter Estimates, Average daily LPG usage model, Uncorrected and Corrected for Heteroskedasticity.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent Standard Error	Heteroscedasticity Consistent t Value	Heteroscedasticity Consistent Pr > |t|
Intercept	1	59.3971	5.16	11.52	<.0001	5.18513	11.46	<.0001
Gas_Cost_Gal	1	1.9320	0.95	2.04	0.0418	0.82245	2.35	0.0189
Dollar_KWH	1	-141.7453	54.22	-2.61	0.0090	49.84499	-2.84	0.0045
Head_Placed	1	0.0001	0.00	0.43	0.6667	0.00022018	0.33	0.7438
Net_wt	1	-0.0001	0.00	-3.46	0.0006	0.00002673	-3.15	0.0017
mortality_daily_avg	1	0.0070	0.01	0.52	0.6006	0.01268	0.55	0.5793
avglow	1	-0.8646	0.02	-47.59	<.0001	0.02315	-37.35	<.0001
Drop_ceiling	1	-2.3536	1.16	-2.03	0.0421	1.06022	-2.22	0.0265
Firm	1	3.2876	0.72	4.6	<.0001	0.72859	4.51	<.0001
Feed_lb_daily	1	-0.0065	0.00	-9.85	<.0001	0.00077409	-8.45	<.0001
water_gal_daily	1	0.0362	0.00	10.73	<.0001	0.00332	10.91	<.0001
House_1	1	-1.0211	1.17	-0.87	0.3819	1.07991	-0.95	0.3445
House_2	1	-4.8443	1.17	-4.15	<.0001	1.03073	-4.7	<.0001
House_3	1	-1.8332	0.77	-2.39	0.0169	0.78581	-2.33	0.0197
Week_1	1	32.4634	1.80	18	<.0001	2.86042	11.35	<.0001
Week_2	1	23.9058	1.44	16.65	<.0001	2.25235	10.61	<.0001
Week_3	1	12.8479	1.15	11.2	<.0001	1.39919	9.18	<.0001
Week_5	1	-5.2921	1.12	-4.71	<.0001	1.1962	-4.42	<.0001
Week_6	1	-8.7157	1.23	-7.07	<.0001	1.50763	-5.78	<.0001
Week_7	1	-7.9837	1.42	-5.63	<.0001	1.63044	-4.9	<.0001
Week_8	1	-8.1171	1.64	-4.94	<.0001	1.81621	-4.47	<.0001
Week_9	1	4.6374	4.64	1	0.3174	2.04347	2.27	0.0233

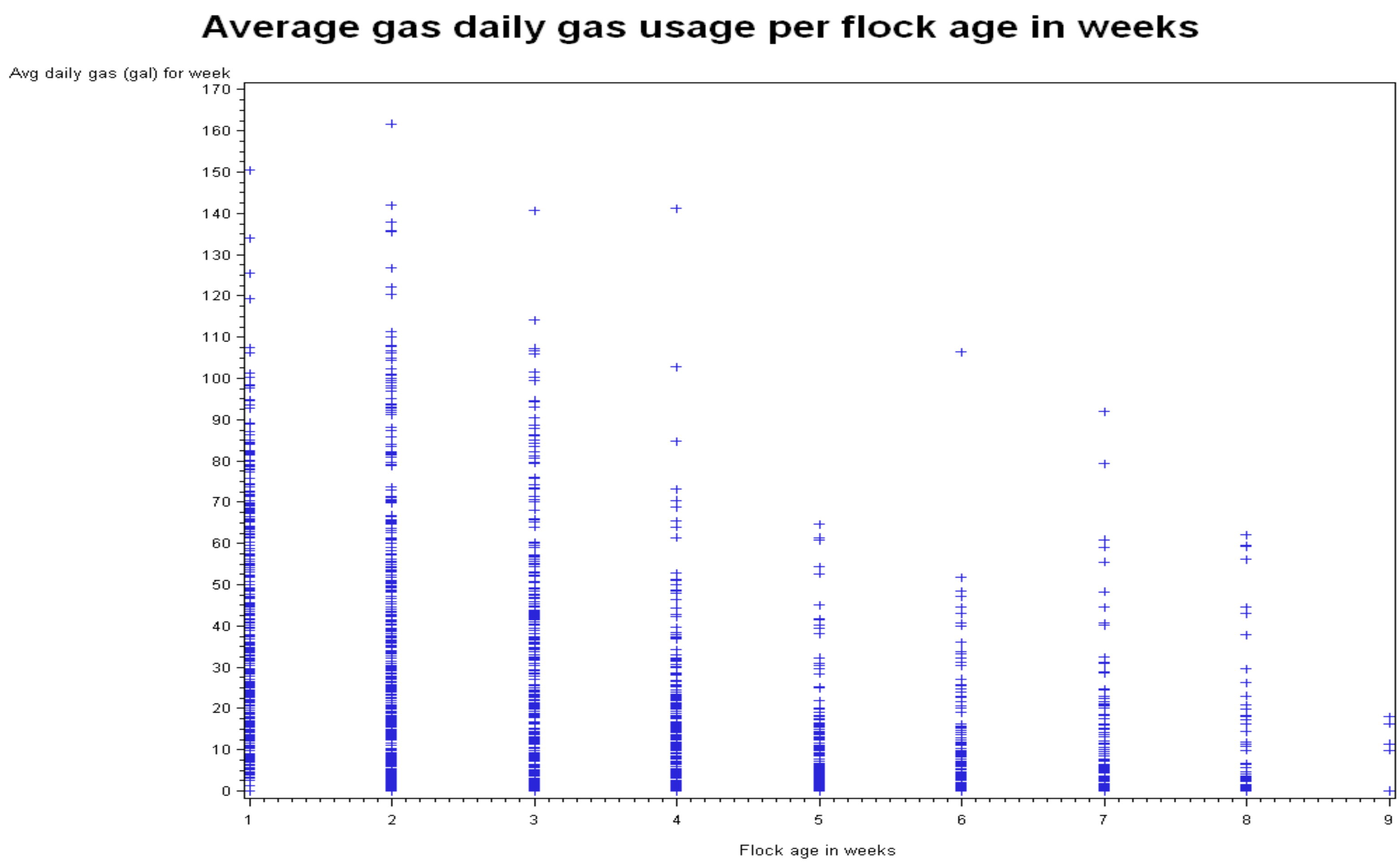
SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	1163196	55390	236.2	<.0001
Error	3167	742674	234.504		
Corrected Total	3188	1905871			

R-Square	0.6103
Adj R-Sq	0.6077
RMSE	15.31352
Dependent Mean	16.77291
Coeff Var	91.29914

Test	White`s Test of Heteroskedasticity
Statistic	904.8
DF	203
Pr > ChiSq	<.0001
Variables	Cross of all vars

Figure 4.1


Average gas daily gas usage per flock age in weeks
Avg daily gas (gal) for week
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
Flock age in weeks

The fitted equation of model (II), average daily LPG cost, with parameter estimates is presented following:

Fitted Gas_cost_daily = 25.04 +17.25*Gas_cost_gal + 81.18*Dollar_KWH + 0.00088*Head_placed + 0.000029*Net_wt - 0.024*Mortality_daily_avg – 0.68*Avglow – 3.59*Drop_ceiling + 4.46*Firm – 0.0086*Feed_lb_daily + 0.018*Water_gal_daily - 2.34*House_1 – 5.87*House_2 - 1.06*House_3 + 4.49*WtrWtr + 3.84*WtrSprg + 1.9*SprgSprg + 2.36*SprgSmmr – 3.69*SmmrFall – 0.13*FallFall + 8.57*FallWtr

On the basis of the results in Table 4.2, we are 99% confident that the model, to estimate predicted average daily LPG cost, is significant (F = 0.0001). The value of R^2 (0.5411) means that 54.11% of the total variability of predicted average daily propane gas cost is explained by explanatory (independent) variables. RMSE (16.69) expresses that our estimated model, average daily propane cost, differs by $16.69 from predicted value of propane cost. When propane gas cost per gallon increases by 1 cent the average daily propane cost increases by $17.25. This explanatory variable is highly significantly positive at the 0.0001 level of confidence. Electricity usage relates to the ventilation and lighting in the poultry house. According to our parameter estimate results, the independent variable, electricity cost per KWH "Dollar_KWH" is not significant. LPG cost is negatively related to average daily mortality and exogenous variable average weekly minimum outside temperature. Parameter estimates for the variables are significantly different at 0.02 and <0.0001 level; an increase in mortality by one bird decreases daily gas cost by 2,4 cents. Drop_ceiling, also has a negative relationship to the dependent variable, significant at the 98% confidence level; type of house construction affects the daily gas usage. Houses that have retrofitted drop ceilings have lower propane cost by about $3.59 per day. Houses with drop ceilings use less propane, thus daily propane cost decrease. The next dummy variable, Firm, is positively related to the gas cost per day and significant at <0.0001 level. This would indicate that chickens fed for Simmons have higher a average daily LPG cost ($4.46) than for Tyson. However, as mentioned in discussion of the first model results for average gas usage, the researchers did not expect such a difference and attribute this occurrence to the same genetic and technological factors as previously explained.

The parameters estimates for average daily feed consumption as an explanatory variable illustrate the variability in daily LPG cost and demonstrate that daily propane cost increase as feed consumption decrease. Chickens with higher consumption of feed produce more body heat, which implies lower gas usage due to higher temperature inside the house, thus lower daily gas expenditures. With the <0.0001 level of significance we are sure that average daily feed consumption are related. Next explanatory variable is also highly significant (<0.0001) but contrary to feed consumption, water consumption is positively associated to dependent variable, meaning that water consumption increases daily gas cost. Higher temperatures in houses convince birds to drink more water to cool down their body temperature. From the categorical variable House, only House_2 shows significance (<0.0001) that the variable is positively related to predicted daily gas cost – flock produced in House_2 has about $5.58 higher daily gas expenditures than in House_4.

Figure 4.2 represents seasonality of gas usage over time at ABRF. Finally, categorical variable ”season” intends to show in which period of the year the propane usage thus, daily propane cost, rise considerably. According to the table 4.2, only FallFall has an insignificant relationship to the daily gas cost. The rest of the season variables are significant at <0.03 level. The highest significance shows periods FallWtr,WtrSprg, and SmmrFall. Flocks fed during the FallWtr period of the year require higher expenditures for heating ($8.57) than during the SmmrSmmr. Figure 4.2 represents LPG usage per week per house for each observation separately. As result from regression also figure of LPG usage shows that highest gas usage was usually in Fall/Winter period. According to regression results another interesting finding is Summer/Fall season, it indicates flocks placed in summer and picked up in fall have even lower gas cost expenditures than in Summer/Summer season.

Table 4.2: Model 2 Parameter Estimates, Average Daily LPG Cost Model, Uncorrected and Corrected for Heteroskedasticity.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent Standard Error	Heteroscedasticity Consistent t Value	Heteroscedasticity Consistent Pr > |t|
Intercept	1	25.04	6.16698	4.0600	<.0001	5.76434	4.34	<.0001
Gas_Cost_Gal	1	17.25	1.04852	16.4500	<.0001	1.42001	12.15	<.0001
Dollar_KWH	1	81.18	60.90271	1.3300	0.1827	52.2431	1.55	0.1203
Head_Placed	1	0.00	0.0001676	5.2500	<.0001	0.00020872	4.21	<.0001
Net_wt	1	0.00	2.662E-05	1.0800	0.2803	0.00002626	1.09	0.2737
mortality_daily_avg	1	-0.02	0.01237	-1.9700	0.049	0.01139	-2.14	0.0324
avglow	1	-0.68	0.03898	-17.3600	<.0001	0.04073	-16.61	<.0001
Drop_ceiling	1	-3.59	1.26299	-2.8400	0.0045	1.54604	-2.32	0.0203
Firm	1	4.46	0.7753	5.7600	<.0001	0.66024	6.76	<.0001
Feed_lb_daily	1	-0.01	0.0006804	-12.6300	<.0001	0.00105	-8.15	<.0001
water_gal_daily	1	0.02	0.0033	5.4200	<.0001	0.00425	4.21	<.0001
House_1	1	-2.34	1.27488	-1.8400	0.0666	1.66028	-1.41	0.1589
House_2	1	-5.87	1.27374	-4.6100	<.0001	1.49478	-3.93	<.0001
House_3	1	-1.06	0.83572	-1.2700	0.2054	0.86029	-1.23	0.2187
WtrWtr	1	4.49	1.86708	2.4000	0.0163	1.75341	2.56	0.0105
WtrSprg	1	3.84	1.5086	2.5400	0.0111	1.25671	3.05	0.0023
SprgSprg	1	1.90	1.27176	1.5000	0.1345	0.85782	2.22	0.0265
SprgSmmr	1	2.36	1.11859	2.1100	0.0349	0.68501	3.45	0.0006
SmmrFall	1	-3.69	1.33161	-2.7700	0.0057	0.88586	-4.16	<.0001
FallFall	1	-0.13	1.61828	-0.0800	0.9351	1.50442	-0.09	0.9302
FallWtr	1	8.57	1.902	4.5000	<.0001	2.12283	4.04	<.0001

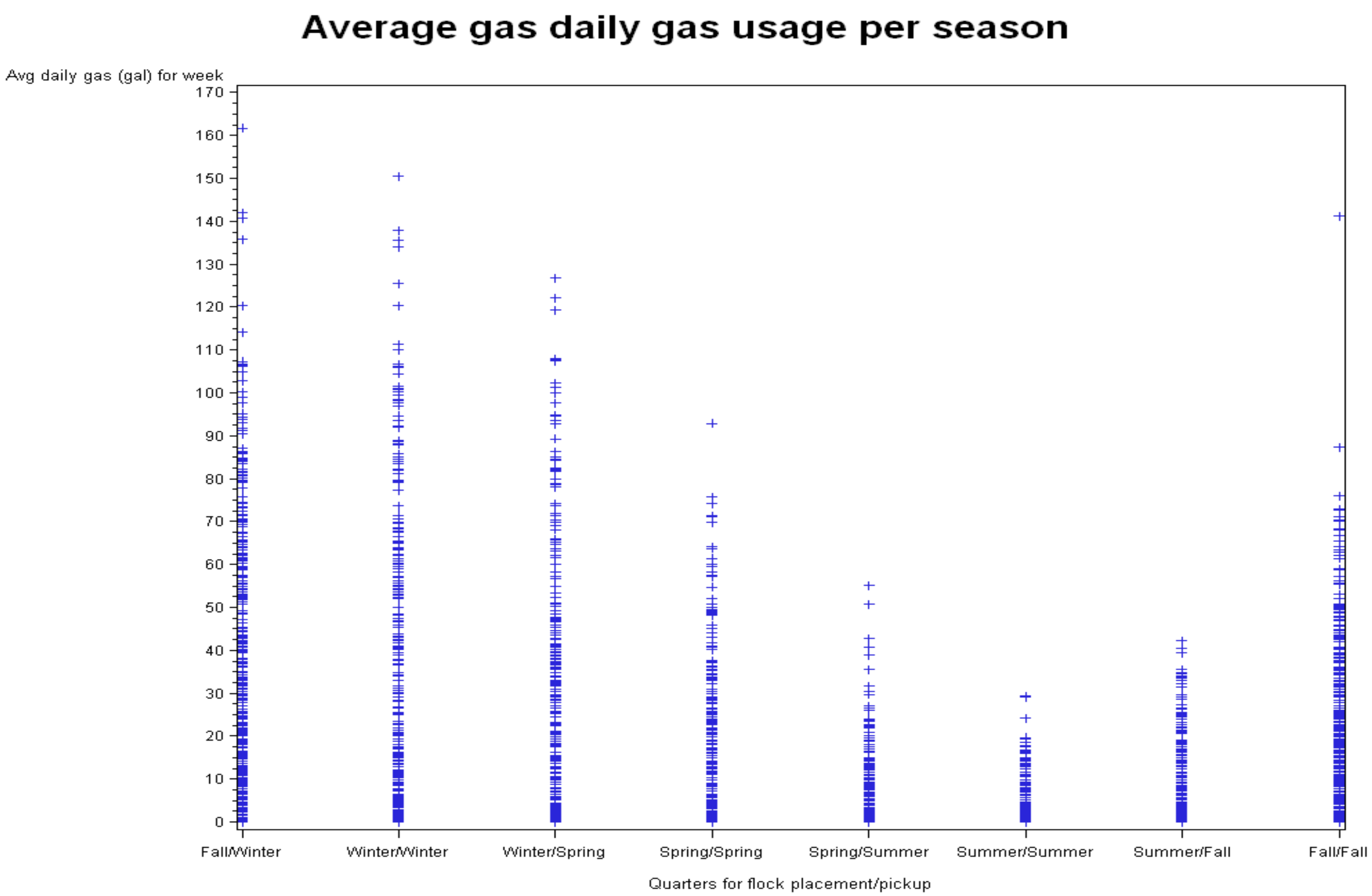
SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	1040863	52043	186.79	<.0001
Error	3168	882669	278.62011		
Corrected Total	3188	1923532			

R-Square	0.5411
Adj R-Sq	0.5382
RMSE	16.69192
Dependent Mean	14.93168
Coeff Var	111.78859

Test	White`s Test of Heteroskedasticity
Statistic	1655
DF	191
Pr > ChiSq	<.0001
Variables	Cross of all vars

Figure 4.2


Average gas daily gas usage per season
Avg daily gas (gal) for week
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Fall/Winter
Winter/Winter
Winter/Spring
Spring/Spring
Spring/Summer
Summer/Summer
Summer/Fall
Fall/Fall
Quarters for flock placement/pickup

4.1.3 Fitted Average Flock Natural Gas Usage for Slovak Farm

Table 4.3 presents regression output of the third model. According to the result, 99.6% total variability of predicted Gas_usage_m3_ is explained by the explanatory variables (Cost_KWH, Feed_kg, Water_l, Age_days, Av_weight_kg, Head_placed, Mortality_Pcs, House_1, House_2, Winter/Winter, Winter/Spring, Spring/Spring, Spring/Summer, Summer/Fall, Fall/Fall, Fall/Winter). We are 99% confident (<0.01) that predicted gas_usage_m3_ and explanatory variables are related. RMSE implies that on average, estimated actual gas usage differs 158.13 m^3 from predicted gas usage. Variable Age_days, indicating age of flock, is significant at <0.01 level. If average flock age (Age_days) would increase by an additional day the gas usage would increase by 225.33 m^3 per flock. Also, Av_weight_kg is significant at the (<0.01) level. An additional kilogram per bird would increase gas usage by 1,465.81 m^3 per flock per house. Electricity expenditure has a negative association to natural gas usage, based on results it indicates that an increase in electricity cost by one euro results in gas usage decrease by 54,616.55 m^3. We cannot really explain this, as Cost_KWH is an exogenous variable and does not show logical association to natural gas usage.

According to regression output variables Water_l, Head_placed, Mortality_pct, and House categories are not significant at 0.1, 0.05, or 0.01 levels; they do not have a significant impact on predicted natural gas usage. On the other hand every season category shows a high level of statistical significance (<0.01). In contrary with previous models, the highest impact on average natural gas usage is season WtrWtr (WinterWinter) as would be suspected in models I. and II. When a flock is placed in winter and picked up in winter, farmers used about 6,643.12 m^3 of natural gas more for heating than in summer/summer period. In the spring/summer period farmer used only 577.99 m^3 of gas more than in summer/summer period.

The fitted equation of the model (III.), Natural gas usage per flock, with parameter estimates is presented following:

Gas_usage_m3 = -7,145.97 – 54,616.55*Cost_KWH – 0.0056*Feed_kg + 0.00033*Water_l + 225.33*Age_days + 1,465.81*Av_weight_kg – 0.098*Head_placed – 21.49*Mortality_Pct + 53.75*house_1 + 23.42*house_2 + 2,797.81*Fall/Fall + 4,744.46*FallWinter + 1,333.06*Spring/Spring + 577.99*Spring/Smmer + 768.87*Summer/Fall + 2,742.67*Winter/Spring + 6,643.12*Winter/Winter

Table 4.3: Model 3 Parameter Estimates, Average flock Natural Gas usage model

Variable		Estimate	Standard Error	t Value	Pr > |t|
Intercept		-7,145.966	1,441.904	-4.96	<.0001
Cost_KWH		-54,616.550	6,648.245	-8.22	<.0001
Feed_kg		-0.006	0.002	-2.93	0.01
Water_L		0.000	0.002	0.19	0.85
Age_days		225.332	19.831	11.36	<.0001
Av_weight_kg_		1,465.812	244.211	6.00	<.0001
Head_placed		-0.098	0.071	-1.38	0.18
Mortality_Pct		-21.492	22.841	-0.94	0.35
House	1	53.747	53.995	1.00	0.33
House	2	23.416	56.976	0.41	0.68
Season	Fall/Fall	2,797.806	102.596	27.27	<.0001
Season	Fall/Winter	4,744.457	127.179	37.31	<.0001
Season	Spring/Spring	1,333.062	115.295	11.56	<.0001
Season	Spring/Summer	577.999	129.202	4.47	<.0001
Season	Summer/Fall	768.868	94.047	8.18	<.0001
Season	Winter/Spring	2,742.671	96.415	28.45	<.0001
Season	Winter/Winter	6,643.125	155.095	42.83	<.0001

SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	226,527,122	14,157,945	566.20	<.0001
Error	37	925,186	25,005		
Corrected Total	53	227,452,308			

R-Square	0.9959
Coeff Var	5.6448
RMSE	158.130
Gass_usage_m3_ Mean	2,801.33

4.2 Estimated Propane Cost under Various Scenarios

The overall purpose of the thesis is to find out which approach is more economically efficient for farmers: (a) to pre-purchase propane gas with credit (operating loan) or (b) to continue purchasing propane gas regularly without credit (cash, or spot market, basis). To assess that we need to structure several scenarios to enable us to evaluate strategies farmers might use. We developed two sets of data covering the period 2006-2010, meaning we consider flocks 87-113. The first used actual propane consumption and the second used average propane consumption, to analyze four alternative strategies. This decision was made because all four houses were renovated on same type of housing in 2006 whereby we avoid the occurrence of biases based on the results from previous regression analyses for estimated daily gas usage. Results indicated that there is a significant relationship between daily gas usage and the categorical variable House. This relationship is not accounted for in the scenarios, as this process is intended to provide a general 'rule of thumb' decision tool.

4.2.1 Scenarios Using Actual Propane Consumption

Data for analyzing alternatives used actual propane consumption and costs based on the dataset used previously in estimating daily gas usage and daily gas cost. This incorporates the association with selected variables and summary propane flock reports from ABRF. In this section we present two scenarios:

- *Actual Consumption, Actual Purchase Pattern*

Typically, a farmer buys LPG when reserves drop below 25%. Table 4.4 presents flock data that indicates the ABRF farm purchased propane gas every flock. Table 4.4 contains propane cost per gallon, total real (actual) propane consumption and total propane cost per flock. Total propane cost was calculated by multiplying the variable propane price per gallon and real propane usage per flock. According to results, the farm had very high LPG usage and cost expenditures for flock 91 in 2007 during the winter season but again in 2008 (flock 96). Variable usage per flock implies that LPG consumption has a seasonal trend; in the winter season consumption reached the highest levels and in summer time the usage dropped considerably.

Table 4.4: Actual Propane Usage and Actual Purchase Pattern

Flock No.	Placement and sales dates	LPG price ($/gal)	Total flock LPG cost ($)	Usage per flock (gal)*
87	4/11/06-5/19/06	$1.52	3,605	6,225**
88	6/5/06-7/13/06	$1.37	794	580
89	8/1/06-9/21/06	$1.37	209	153
90	10/6/06-11/24/06	$1.31	6,361	4,856
91	12/21/06-2/7/07	$1.32	16,534	12,526
92	2/26/07-4/20/07	$1.34	6,179	4,611
93	5/15/07-7/10/07	$1.34	2,012	1,501
94	7/27/07-9/24/07	$1.34	333	249
95	10/08/07-12/3/07	$1.94	6,045	3,116
96	12/14/07-2/6/08	$2.04	16,338	8,009
97	2/21/08-4/11/08	$2.10	10,872	5,177
98	4/25/08-6/13/08	$2.04	4,204	2,061
99	6/26/08-8/14/08	$2.04	692	339
100	8/22/08-10/10/08	$2.04	1,219	598
101	11/3/08-12/22/08	$1.87	8,720	4,663
102	1/12/09-2/23/09	$0.90	4,899	5,443
103	3/12/09-4/24/09	$0.97	3,446	3,553
104	5/15/09-6/29/09	$0.95	956	1,006
105	7/16/09-9/2/09	$0.95	434	457
106	9/15/09-11/2/09	$0.95	1,656	1,743
107	11/15/09-1/5/10	$1.32	6,688	5,067
108	1/15/10-3/5/10	$1.52	7,150	4,704
109	3/25/10-5/11/10	$1.60	3,565	2,228
110	5/31/10-7/16/10	$1.60	318	199
111	6/23/10-9/10/10	$1.60	275	172
112	9/20/10-11/5/10	$1.60	2,397	1,498
113	11/18/10-1/3/11	$1.47	8,445	5,745

*For this table, this column represent both the gallons bought of LPG and the gallon LPG used during each flock. The actual gallons left (on hand) are not known. In the structural scenarios 2-4, the gallons left, gallons bought and gallons used are all known.

**Beginning inventory of propane on ABRF. The amount of gas that was in the tanks when ABRF stopped production in September 2005 to renovate and the amount that was in the tanks when they started production again in April, 2006. There was 2562 gallons in September and they bought 3663 gallons in April to bring the amount up to 6225 for the total ABRF.

- *Actual Consumption with Decision Rule*

In this scenario we calculated assumed propane gas purchase on the basis of a decision rule with real (actual) gas usage and price per gallon undertaken from ABRF's energy flock report for years 2006-2010. The decision rule is based on the fact that the farm can store 10,000 gallons of propane. Every time the LPG reserves drop below 25% (2,500 gallons) the farm buys to increase the reserves up to 10,000 gallons. We assume the first LPG purchase would have been realized in April 2006 because the first flock was placed on 4/11/2006 after the renovation. Table 4.5 presents results when the farmer was supposed to purchase LPG and how many gallons. Table 4.5 indicates in 2007 and 2008, winter flocks 91 and 96, that total purchase costs would have been the highest. During the summer and early fall the farm would not have had to buy any LPG. The column designated 'LPG Left' shows how many gallons of LPG the farm has in stock at the end of the flock, the column designated 'LPG Bought' relates how many gallons LPG would have had to be purchased and 'LPG Cost' reveals how much the farm would have had to pay for purchased gas calculated by multiplying 'Bought LPG' and 'LPG cost per gal'. The purchase rule with actual gas usage shows the farm would have to buy propane in 2006 during April and November; in 2007 during January and the end of March or in April; in 2008 as previously in January and April and in 2009 the farm would have to purchase and fill up tanks in February and December. Based on the decision rule, the farm would buy propane only in October and in the end of flock 113 would still have 4255 gallons of gas in stock for the next flock.

Table 4.5: Purchase Rule with Actual Propane Usage

Flock No.	Placement and sales dates	LPG price ($/gal)	Usage per flock (gal)	Left LPG (gal)	Bought LPG (gal)	LPG cost ($)
87	**4/11/06-5/19/06**	**$1.52**	**2,372**	**3853***		
88	6/5/06-7/13/06	$1.37	580	3,273		
89	8/1/06-9/21/06	$1.37	153	3,121		
90	**10/6/06-11/24/06**	**$1.31**	**4,856**	**10,000**	**11,735**	**$15,372.85**
91	**12/21/06-2/7/07**	**$1.32**	**12,526**	**10,000**	**12,526**	**$16,534.32**
92	2/26/07-4/20/07	$1.34	4,611	5,389		
93	5/15/07-7/10/07	$1.34	1,501	3,887		
94	7/27/07-9/24/07	$1.34	249	3,639		
95	**10/08/07-12/3/07**	**$1.94**	**3,116**	**10,000**	**9,477**	**$18,385.38**
96	**12/14/07-2/6/08**	**$2.04**	**8,009**	**10,000**	**8,009**	**$16,338.36**
97	2/21/08-4/11/08	$2.10	5,177	4,823		
98	4/25/08-6/13/08	$2.04	2,061	2,762		
99	6/26/08-8/14/08	$2.04	339	2,423		
100	**8/22/08-10/10/08**	**$2.04**	**598**	**10,000**	**8,175**	**$16,677.00**
101	11/3/08-12/22/08	$1.87	4,663	5,337		
102	**1/12/09-2/23/09**	**$0.90**	**5,443**	**10,000**	**10,106**	**$9,095.40**
103	3/12/09-4/24/09	$0.97	3,553	6,447		
104	5/15/09-6/29/09	$0.95	1,006	5,441		
105	7/16/09-9/2/09	$0.95	457	4,984		
106	9/15/09-11/2/09	$0.95	1,743	3,241		
107	**11/15/09-1/5/10**	**$1.32**	**5,067**	**10,000**	**11,826**	**$15,609.29**
108	1/15/10-3/5/10	$1.52	4,704	5,296		
109	3/25/10-5/11/10	$1.60	2,228	3,068		
110	5/31/10-7/16/10	$1.60	199	2,869		
111	6/23/10-9/10/10	$1.60	172	2,697		
112	**9/20/10-11/5/10**	**$1.60**	**1,498**	**10,000**	**11,199**	**$17,919.90**
113	11/18/10-1/3/11	$1.47	5,745	4,255		

* Beginning inventory of propane on ABRF (6225 gallons) minus actual usage of flock 87 (2372 gallons)

4.2.2 Scenarios Using 5-year Average Monthly Propane Consumption

Data used to calculate purchase patterns with average propane consumption were generated from the dataset used in the analysis of regressed models I and II. Actual LPG usage was calculated from average monthly consumption of gas from average daily gas usage, (daily_gas_gal) for years 2006-2010 by multiplying the number of days in a given week, creating weekly gas usage. Next, weeks were generated for each month separately, summed and the average gas consumption for each month was calculated. Monthly LPG price per gallon was taken from prior scenarios.

- *Propane Purchased on Spot Market*

This calculation is generated in the same way as prior scenarios. "LPG Left' indicates gas stored at the farm at the end of the month, 'LPG Bought' is the amount of propane purchased in a given month and 'LPG Cost' shows farm expenditures for gas is at the month of purchase. Our decision rule is that the farm purchases the first 10,000 gallons of gas in July when the price is supposed to be the lowest but it is delivered in September 2006 when consumption starts to increase. We assume the farm both buys and refills propane when reserves drop below 25% (2,500 gallons). Results (Table 4.6) show that under the decision rule with average gas consumption, the farm should buy propane to fill up the reserves up to 10,000 gallon two times per year usually in March and December in 2007-2010 with same amount, 8,009 gallons in March and 9,576 gallons in December. In 2006 the first purchase would be realized in July and the next in December. Table 4.6 explains in detail when, how many gallons and at what cost to purchase LPG.

Table 4.6: Purchase Rule with Average Propane Consumption

Year	Month	Avg. LPG usage (gal)	LPG price ($/gal)	Left LPG (gal)	Bought LPG (gal)	LPG cost($)
2006	**Apr-06**	**941.71**	**$1.52**	**5283***		
	May-06	832.15	$1.52	4,450.85		
	Jun-06	168.42	$1.37	4,282.43		
	Jul-06	198.30	$1.37	4,084.13		
	Aug-06	130.39	$1.37	3,953.73		
	Sep-06	565.03	$1.37	3,389		
	Oct-06	**1,380.88**	**$1.31**	**10,000**	**7992**	**$10,469.52**
	Nov-06	2,059.09	$1.31	7,941		
	Dec-06	3,299.62	$1.32	4,641		
2007	**Jan-07**	**4,204.89**	**$1.32**	**10,000**	**9,564**	**$12,624.48**
	Feb-07	1,649.13	$1.32	8,351		
	Mar-07	2,155.08	$1.34	6,196		
	Apr-07	941.71	$1.34	5,254		
	May-07	832.15	$1.34	4,422		
	Jun-07	168.42	$1.34	4,254		
	Jul-07	198.30	$1.34	4,055		
	Aug-07	130.39	$1.34	3,925		
	Sep-07	565.03	$1.34	3,360		
	Oct-07	**1,380.88**	**$1.94**	**10,000**	**8021**	**$15,560.74**
	Nov-07	2,059.09	$1.94	7,941		
	Dec-07	3,299.62	$2.04	4,641		
2008	**Jan-08**	**4,204.89**	**$2.04**	**10,000**	**9564**	**$19,510.56**
	Feb-08	1,649.13	$2.10	8,351		
	Mar-08	2,155.08	$2.10	6,196		
	Apr-08	941.71	$2.04	5,254		
	May-08	832.15	$2.04	4,422		
	Jun-08	168.42	$2.04	4,254		
	Jul-08	198.30	$2.04	4,055		
	Aug-08	130.39	$2.04	3,925		
	Sep-08	565.03	$2.04	3,360		
	Oct-08	**1,380.88**	**$2.04**	**10,000**	**8021**	**$16,362.84**
	Nov-08	2,059.09	$1.87	7,941		
	Dec-08	3,299.62	$1.87	4,641		

Year	Month	Avg. LPG usage (gal)	LPG price ($/gal)	Left LPG (gal)	Bought LPG (gal)	LPG cost($)
2009	**Jan-09**	**4,204.89**	**$0.90**	**10,000**	**9564**	**$8,607.60**
	Feb-09	1,649.13	$0.90	8,351		
	Mar-09	2,155.08	$0.97	6,196		
	Apr-09	941.71	$0.97	5,254		
	May-09	832.15	$0.95	4,422		
	Jun-09	168.42	$0.95	4,254		
	Jul-09	198.30	$0.95	4,055		
	Aug-09	130.39	$0.95	3,925		
	Sep-09	565.03	$0.95	3,360		
	Oct-09	**1,380.88**	**$0.95**	**10,000**	**8021**	**$7,619.95**
	Nov-09	2,059.09	$1.32	7,941		
	Dec-09	3,299.62	$1.32	4,641		
2010	**Jan-10**	**4,204.89**	**$1.52**	**10,000**	**9564**	**$14,537.28**
	Feb-10	1,649.13	$1.52	8,351		
	Mar-10	2,155.08	$1.60	6,196		
	Apr-10	941.71	$1.60	5,254		
	May-10	832.15	$1.60	4,422		
	Jun-10	168.42	$1.60	4,254		
	Jul-10	198.30	$1.60	4,055		
	Aug-10	130.39	$1.60	3,925		
	Sep-10	565.03	$1.60	3,360		
	Oct-10	**1,380.88**	**$1.60**	**10,000**	**8021**	**$12,833.60**
	Nov-10	2,059.09	$1.47	7,941		
	Dec-10	3,299.62	$1.47	4,641		

* Beginning inventory of propane on ABRF (6225 gallons) minus average propane consumption in April 2006 (941.71 gallons)

- *Propane Pre-Purchased*

The scenario Propane Pre-Purchased used the same data as the scenario Propane Purchased on Spot Market, the difference being based on monthly average consumption, we calculated average yearly propane consumption that we assume is the same every year from 2006 to 2010. We assume when the farm pre-purchases propane for one year he has to take an operating loan. On the basis of our calculation, the farm would buy 17,585 gallons LPG to satisfy average yearly requirements for heating in broiler production. Next we assume the farmer would pre-purchase propane every year in July when the LPG price is assumed to be the lowest. If propane demands exceeded the pre-purchase amount, additional propane would be obtained on the spot market; this cannot be modeled and is a source of potential risk management error. Of course, the reverse is also true, in which case extra pre-purchased propane would be carried forward as inventory into the next year. We estimate that the interest rate of commercial banks would be 7.5%. Table 4.7 presents yearly expenditures for pre-purchasing propane in 2006-2010.

Table 4.7: Propane Pre-purchased Cost

Year	July LPG Price ($/gal)	IR	LPG Usage (gal)	LPG Cost ($)
2006	$1.37	7.50%	17,585	$10,458
2007	$1.34	7.50%	17,585	$25,652
2008	$2.04	7.50%	17,585	$31,075
2009	$0.95	7.50%	17,585	$29,619
2010	$1.60	7.50%	17,585	$23,292

Table 4.8 presents in detail the delivery and purchasing rule. In 2006 farmer would farmer pre-purchase the first amount of gas in July but delivery of first 10,000 gallons would be realized in September due to low gas consumption in the summer.

When we summarize all four scenarios (Table 4.9 and Figure 4.3) farm expenditures for propane under various scenarios differ substantially. It seems that for years 2006 and 2008, the best scenario is propane pre-purchasing. For years 2007 and 2010, the best scenario was the decision rule with actual propane consumption, with actual usage and purchase being the best scenario for 2009. The scenario Propane Pre-Purchased has the best result over other alternatives in 2009 when LPG cost per gallon was at its lowest in July. We believe this scenario can save considerable funds for the farmer when he pre-purchases propane on the market, but he has to have good knowledge of the market prices (not only energy but also factors that can have an impact on energy prices) to predict the best time to pre-purchase LPG. Overall, however, the cumulative costs for the Scenarios 1 through 4 are, respectively: $124,346; $111,227; $118,127 and $119,646. This suggests that the current practice is the most economically inefficient and scenario 2 is most efficient.

Table 4.8: Propane Pre-purchased with Average Consumption

Year	Month	Avg. LPG usage (gal)	LPG price ($/gal)	Left LPG (gal)	Delivered LPG (gal)	LPG cost($)
2006	**Apr-06**	**941.71**	**$1.52**	**5283***		
	May-06	832.15	$1.52	4,450.85		
	Jun-06	168.42	$1.37	4,282.43		
	Jul-06	198.30	**$1.37**	4,084.13		**$10,457.65**
	Aug-06	130.39	$1.37	3,953.73		
	Sep-06	565.03	$1.37	3,389		
	Oct-06	**1,380.88**	**$1.31**	**10,000**	**7992**	
	Nov-06	2,059.09	$1.31	7,941		
	Dec-06	3,299.62	$1.32	4,641		
2007	**Jan-07**	**4,204.89**	**$1.32**	**10,000**	**9,564**	
	Feb-07	1,649.13	$1.32	8,351		
	Mar-07	2,155.08	$1.34	6,196		
	Apr-07	941.71	$1.34	5,254		
	May-07	832.15	$1.34	4,422		
	Jun-07	168.42	$1.34	4,254		
	Jul-07	198.30	**$1.34**	4,055		**$25,651.70**
	Aug-07	130.39	$1.34	3,925		
	Sep-07	565.03	$1.34	3,360		
	Oct-07	**1,380.88**	**$1.94**	**10,000**	**8021**	
	Nov-07	2,059.09	$1.94	7,941		
	Dec-07	3,299.62	$2.04	4,641		
2008	**Jan-08**	**4,204.89**	**$2.04**	**10,000**	**9564**	
	Feb-08	1,649.13	$2.10	8,351		
	Mar-08	2,155.08	$2.10	6,196		
	Apr-08	941.71	$2.04	5,254		
	May-08	832.15	$2.04	4,422		
	Jun-08	168.42	$2.04	4,254		
	Jul-08	198.30	**$2.04**	4,055		**$31,074.84**
	Aug-08	130.39	$2.04	3,925		
	Sep-08	565.03	$2.04	3,360		
	Oct-08	**1,380.88**	**$2.04**	**10,000**	**8021**	
	Nov-08	2,059.09	$1.87	7,941		
	Dec-08	3,299.62	$1.87	4,641		

Year	Month	Avg. LPG usage (gal)	LPG price ($/gal)	Left LPG (gal)	Delivered LPG (gal)	LPG cost($)
2009	**Jan-09**	**4,204.89**	**$0.90**	**10,000**	**9564**	
	Feb-09	1,649.13	$0.90	8,351		
	Mar-09	2,155.08	$0.97	6,196		
	Apr-09	941.71	$0.97	5,254		
	May-09	832.15	$0.95	4,422		
	Jun-09	168.42	$0.95	4,254		
	Jul-09	198.30	**$0.95**	4,055		**$29,618.91**
	Aug-09	130.39	$0.95	3,925		
	Sep-09	565.03	$0.95	3,360		
	Oct-09	**1,380.88**	**$0.95**	**10,000**	**8021**	
	Nov-09	2,059.09	$1.32	7,941		
	Dec-09	3,299.62	$1.32	4,641		
2010	**Jan-10**	**4,204.89**	**$1.52**	**10,000**	**9564**	
	Feb-10	1,649.13	$1.52	8,351		
	Mar-10	2,155.08	$1.60	6,196		
	Apr-10	941.71	$1.60	5,254		
	May-10	832.15	$1.60	4,422		
	Jun-10	168.42	$1.60	4,254		
	Jul-10	198.30	**$1.60**	4,055		**$23,292.16**
	Aug-10	130.39	$1.60	3,925		
	Sep-10	565.03	$1.60	3,360		
	Oct-10	**1,380.88**	**$1.60**	**10,000**	**8021**	
	Nov-10	2,059.09	$1.47	7,941		
	Dec-10	3,299.62	$1.47	4,641		

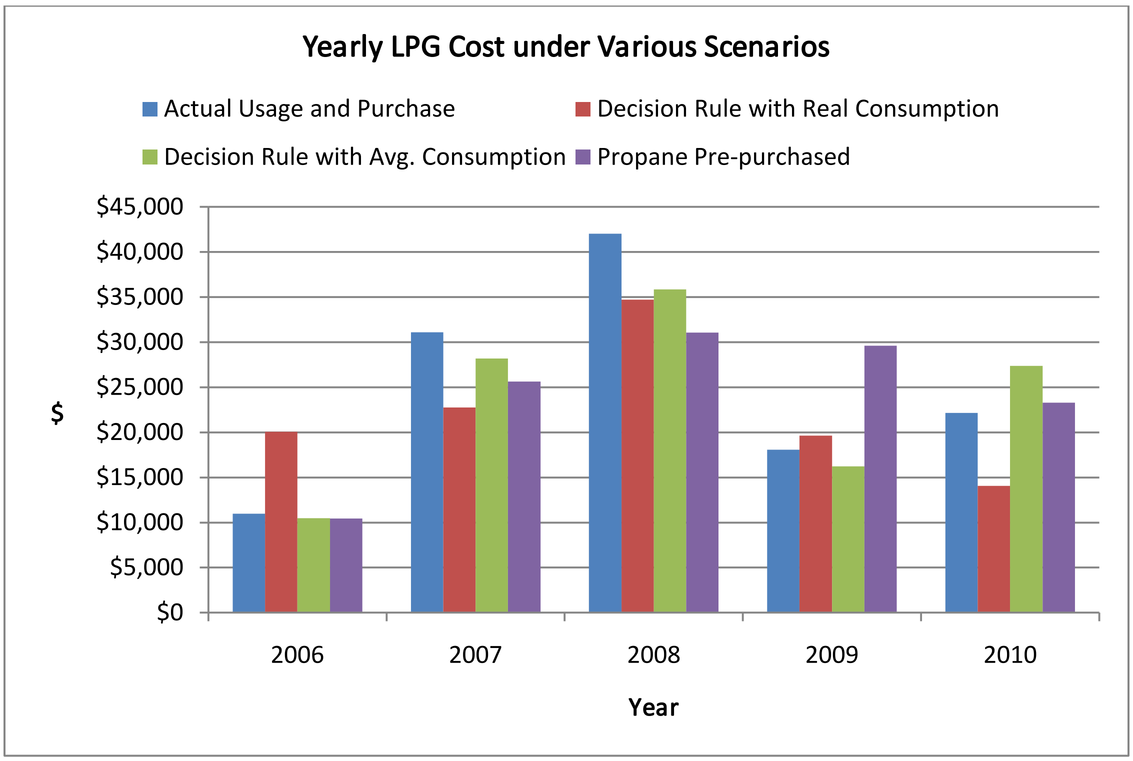
*Beginning inventory of propane on ABRF (6225 gallons) minus average propane consumption in April 2006 (941.71 gallons)

Table 4.9: Summary of Yearly Cost and Usage under Various Scenarios

Year	Actual Usage and Purchase		Decision Rule with Real Consumption		Decision Rule with Avg. Consumption		Propane Pre-purchased	
	Cost ($)	Usage (gal)	Cost ($)	Usage (gal)	Cost ($)	Usage (gal)	Cost ($)	Usage (gal)
2006*	$10,969	7,960	$20,059	7,960	$10,470	9,576	$10,458	9,576
2007	$31,103	22,003	$22,764	22,003	$28,185	17,585	$25,652	17,585
2008	$42,045	20,847	$34,725	20,847	$35,873	17,585	$31,075	17,585
2009	$18,079	17,269	$19,646	17,269	$16,228	17,585	$29,619	17,585
2010	$22,150	14,546	$14,083	14,546	$27,371	17,585	$23,292	17,585

*Recall that 2006 usage, purchases and deliveries cover the period April-December only.

Figure 4.3



V. SUMMARY AND CONCLUSION

5.1 Summary

Over the last several years, energy market prices have become very unstable. This is reflected in increased farmers' expenditures for propane gas used in poultry houses for heating. This situation has led us to analyze the common practices for U.S and Slovak broiler farmers. We selected two farms, U.S. Savoy ABRF and Slovak Trnava pri Laborci Univerza, to quantify relationships among production, performance, season and price parameters. We designed three models to investigate the association among the selected variables and their impact on estimated/predicted variables.

In the first model we estimated propane usage. We hypothesized that propane gas usage in poultry house is affected by propane cost, electricity cost, number of birds placed in the house, total net weight of birds, mortality, average minimum temperature, type of the house construction, firm where birds are processed, house where birds were placed and age of the birds measured by weeks. On the basis of OLS analysis results corrected for heteroskedasticity, we concluded that most of the selected variables were statistically significant in explaining gas usage.. Results indicate that cost of electricity, mortality and total net weight do not have considerable impact on gas usage in poultry houses. On the other hand, model results indicate that as propane cost increase gas usage also increases, largely explained by the convergence of seasonality of higher gas prices gas usage in broiler production. In the winter, when farmers have the highest gas usage for heating, propane market prices typically reach their maximum. Contrariwise, in the summer prices usually drop considerably because interest in purchasing decreases. The type of house construction, Drop_Ceiling, indicates that farmer can decrease gas consumption when houses are retrofitted. Usage can decrease about 4.5 gallons per day. More birds generate more heat, resulting in moderated gas usage; colder temperatures outside require higher gas usage inside the house. Outcomes from regression analysis imply that the company processing the birds has considerable impact on propane usage. It indicates that birds harvested for Simmons company demand more gas usage than can be explained by differences in technological and production requirements among processors. The variable week confirms the first 3-4 weeks of the flock require higher propane usage for heating because of inability of chicks to generate body heat. Results shown that after the fourth week, usage decreases substantially.

Regression results for the estimated propane gas cost indicate that the majority of selected variables are statistically significant and have an impact on the cost expenditures for LPG, except variables House_1 and House_3, season FallFall and also the intercept. Most of the results were not surprising; they confirmed already known impacts on average daily gas cost. For instance, feed usage has a negative impact on total gas cost, indicating that higher feed consumption decreases total propane cost, because birds generate more heat with higher feed consumption, resulting in decreased LPG usage and thus total LPG cost. Propane cost per gallon confirmed the impact on farmers' expenditures for LPG, as well type of housing (retrofitted drop ceiling) clearly indicates that renovation of houses led to decreasing gas usage and decreasing expenditures. An interesting finding was that the season FallWinter has an almost double impact on total gas cost compared to WinterWinter. We believe this coincides with date of placement and pick-up of birds and variation in outside temperature. We suspect that FallWinter season is highly significant because a considerable number of flocks were placed at the end of fall when temperature is very close to that of winter, which would explain higher energy expenditures in this period.

Slovak broiler growers use natural gas instead of propane for heating in poultry houses. Natural gas is much easier access than LPG. During the 1980's, Slovakia built a considerable network of gas pipelines. Results from the Slovak model are most probably not accurate due to lack of data and the short time range (only three years) of analysis. Our model results appear to be too good to be true. Results of selected variables have similar impact on natural gas consumption as in the U.S. models. But in contrary with U.S. models, average daily gas cost indicate that WinterWinter season have significant impact on natural gas usage, confirming common knowledge, But it is difficult to compare two countries whose climate is markedly different. The independent variable Age of birds (in days), implies that more natural gas is used when the birds are older, the reverse of what is expected because older birds have lower requirements for heat.

5.2 Conclusion

Analyzing the three models helped us to better understand and evaluate the impacts on gas usage and its cost and led us to proceed in designing gas purchasing scenarios farmers might use. We designed two sets of alternatives for purchasing propane. For calculating the first set of scenarios, we used actual gas consumption of ABRF for the period 2006-2010. The next scenario, Decision Rule with actual consumption, assumes that a farmer buys LPG only in the case when the gas reserves drop under 25% (2,500 gallons). The second set of alternatives is based on average monthly propane consumption. The scenario, Decision Rule with average consumption, simulates a purchasing pattern starting on July, 2006, when gas price per gallon was supposed to be lowest during summer, but with reference to our analysis we found that farmers' expenditures for propane usage are even lower during the SummerFall season. The last scenario, Propane Pre-purchased, was simulated using average monthly usage. We propose the farmer pre-purchase LPG for one year with an open credit line (operating loan) to have enough funds for purchase. We suppose the interest rate for borrowing would be 7.5% and farmer would buy propane every July from 2006-2010.

Motivation for this study was the considerable energy price fluctuation over last five years. Farmers' energy expenditures are increasing; we are trying to discover the most cost efficient way for broiler producer to purchase propane gas. On the basis of our results, it is difficult to convey an explicit answer. The results show the Purchasing Rule with Actual Consumption has the best results in two years of five. And has a cumulative advantage over other propane purchasing scenarios analyzed herein. Outcome from simulating pre-purchasing scenario indicates two years (2006 and 2008) would be profitable for grower. If the fluctuations in the energy market continue, we still believe the pre-purchasing scenario can be economically efficient for farmers and save a substantial amount of funds and decrease expenditures. We would recommend a detailed analysis of the pre-purchase scenario. We think farmers can be successful in pre-purchasing LPG for a good price when they have adequate knowledge about market prices and detailed familiarity about current energy markets.

5.3 Limitations

Information used in the study are limited, occurrence of missing data can make difference in results and incidence of biases. Even after we excluded or adapted the dataset, we suspect that results could be more relevant for the Slovak analysis.

Another limitation was using information only for the last 5 years in analyzing purchasing scenarios. We used only last 5 years due to renovation in 2006 when houses were renovated on same location to a common structure. We are trying to make the purchasing alternatives analysis relevant for predominant type of housing. How behavior would be in other (older) type of house does not seem to be important when the trend is the farmer adjusts the housing to the production needs.

One final limitation is we really did not use a sophisticated technique to project propane costs. More sophistication in price projection is advisable to obtain a more accurate picture of the efficacy of the purchase scenarios assessed. In addition, the analysis suggests there is potential for cooperative or consortia purchasing to access increased knowledge and purchasing power through group action, the end result being lower prices and therefore, lower propane expenditures for poultry growers.

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APPENDIX A

Table: Pearson Correlation Coefficients of Variables used in Model 1

Pearson Correlation Coefficients, N = 3189 Prob > |r| under H0: Rho=0						
	gas_gal_ daily	Gas_Cost_ Gal	Dollar_ KWH	Head_ Placed	Net_wt	mortality_ daily_avg
gas_gal_daily	1	0.01221	-0.05245	0.14692	-0.04358	0.08787
		0.4907	0.003	<.0001	0.0139	<.0001
Gas_Cost_Gal	0.01221	1	0.51974	0.08758	0.53203	-0.04447
	0.4907		<.0001	<.0001	<.0001	0.012
Dollar_KWH	-0.05245	0.51974	1	0.17313	0.23686	-0.06178
	0.003	<.0001		<.0001	<.0001	0.0005
Head_Placed	0.14692	0.08758	0.17313	1	-0.31088	0.0571
	<.0001	<.0001	<.0001		<.0001	0.0013
Net_wt	-0.04358	0.53203	0.23686	-0.31088	1	-0.13975
	0.0139	<.0001	<.0001	<.0001		<.0001
mortality_daily_avg	0.08787	-0.04447	-0.06178	0.0571	-0.13975	1
	<.0001	0.012	0.0005	0.0013	<.0001	
avglow	-0.53042	0.05495	0.15463	-0.0738	-0.03686	-0.0565
	<.0001	0.0019	<.0001	<.0001	0.0374	0.0014
Drop_ceiling	-0.04622	0.80653	0.5466	-0.11197	0.68693	-0.11722
	0.009	<.0001	<.0001	<.0001	<.0001	<.0001
Firm	0.05493	0.50029	0.43838	0.08923	0.25771	0.0025
	0.0019	<.0001	<.0001	<.0001	<.0001	0.8876
House_1	0.0134	-0.00235	-0.00095	-0.00116	-0.005	-0.00376
	0.4493	0.8945	0.9572	0.9477	0.7778	0.8318
House_2	-0.03835	0.00465	0.00061	0.00237	0.01864	-0.00207
	0.0303	0.793	0.9725	0.8934	0.2927	0.9071
House_3	-0.00513	-0.00088	0.0002	0.0012	-0.00646	-0.00036
	0.7723	0.9602	0.9912	0.9461	0.7153	0.9838
House_4	0.02993	-0.0014	0.00014	-0.0024	-0.00711	0.00618
	0.091	0.937	0.9935	0.8922	0.6881	0.7272
Week_1	0.34763	0.0071	0.00893	0.03632	-0.02463	0.32722
	<.0001	0.6887	0.6143	0.0403	0.1643	<.0001
Week_2	0.26856	0.0071	0.00893	0.03632	-0.02463	-0.14549
	<.0001	0.6887	0.6143	0.0403	0.1643	<.0001
Week_3	0.11773	0.0071	0.00893	0.03632	-0.02463	-0.18794
	<.0001	0.6887	0.6143	0.0403	0.1643	<.0001
Week_4	-0.1083	0.0071	0.00893	0.03632	-0.02463	-0.18027
	<.0001	0.6887	0.6143	0.0403	0.1643	<.0001
Week_5	-0.19734	0.0071	0.00893	0.03632	-0.02463	-0.10431
	<.0001	0.6887	0.6143	0.0403	0.1643	<.0001
Week_6	-0.2127	0.0071	0.00893	0.03632	-0.02463	0.02088
	<.0001	0.6887	0.6143	0.0403	0.1643	0.2386
Week_7	-0.16034	0.01276	0.01494	-0.09071	0.10678	0.11523
	<.0001	0.4713	0.399	<.0001	<.0001	<.0001
Week_8	-0.11751	-0.0806	-0.10259	-0.20076	0.07363	0.24426
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Week_9	-0.03041	-0.01121	-0.00439	-0.07603	0.06108	0.09643
	0.086	0.5269	0.8043	<.0001	0.0006	<.0001

Pearson Correlation Coefficients, N = 3189
Prob > |r| under H0: Rho=0

	avglow	Drop_ ceiling	Firm	House_1	House_2	House_3	House_4	Week_1	Week_2
gas_gal_daily	-0.53042	-0.04622	0.05493	0.0134	-0.03835	-0.00513	0.02993	0.34763	0.26856
	<.0001	0.009	0.0019	0.4493	0.0303	0.7723	0.091	<.0001	<.0001
Gas_Cost_Gal	0.05495	0.80653	0.50029	-0.00235	0.00465	-0.00088	-0.0014	0.0071	0.0071
	0.0019	<.0001	<.0001	0.8945	0.793	0.9602	0.937	0.6887	0.6887
Dollar_KWH	0.15463	0.5466	0.43838	-0.00095	0.00061	0.0002	0.00014	0.00893	0.00893
	<.0001	<.0001	<.0001	0.9572	0.9725	0.9912	0.9935	0.6143	0.6143
Head_Placed	-0.0738	-0.11197	0.08923	-0.00116	0.00237	0.0012	-0.0024	0.03632	0.03632
	<.0001	<.0001	<.0001	0.9477	0.8934	0.9461	0.8922	0.0403	0.0403
Net_wt	-0.03686	0.68693	0.25771	-0.005	0.01864	-0.00646	-0.00711	-0.02463	-0.02463
	0.0374	<.0001	<.0001	0.7778	0.2927	0.7153	0.6881	0.1643	0.1643
mortality_daily_avg	-0.0565	-0.11722	0.0025	-0.00376	-0.00207	-0.00036	0.00618	0.32722	-0.14549
	0.0014	<.0001	0.8876	0.8318	0.9071	0.9838	0.7272	<.0001	<.0001
avglow	1	0.04621	0.05588	0.00198	-0.00371	0.00055	0.00116	0.00993	0.00682
		0.0091	0.0016	0.9111	0.8343	0.9752	0.9476	0.5752	0.7001
Drop_ceiling	0.04621	1	0.37795	-0.00198	0.00299	-0.0003	-0.00071	-0.00336	-0.00336
	0.0091		<.0001	0.9109	0.8658	0.9867	0.9682	0.8494	0.8494
Firm	0.05588	0.37795	1	-0.00151	0.0072	-0.00307	-0.00259	0.00756	0.00756
	0.0016	<.0001		0.9322	0.6846	0.8622	0.8837	0.6696	0.6696
House_1	0.00198	-0.00198	-0.00151	1	-0.33208	-0.33431	-0.33459	0.00001	0.00001
	0.9111	0.9109	0.9322		<.0001	<.0001	<.0001	0.9998	0.9998
House_2	-0.00371	0.00299	0.0072	-0.33208	1	-0.33208	-0.33235	0.00028	0.00028
	0.8343	0.8658	0.6846	<.0001		<.0001	<.0001	0.9874	0.9874
House_3	0.00055	-0.0003	-0.00307	-0.33431	-0.33208	1	-0.33459	0.00001	0.00001
	0.9752	0.9867	0.8622	<.0001	<.0001		<.0001	0.9998	0.9998
House_4	0.00116	-0.00071	-0.00259	-0.33459	-0.33235	-0.33459	1	-0.00029	-0.00029
	0.9476	0.9682	0.8837	<.0001	<.0001	<.0001		0.987	0.987
Week_1	0.00993	-0.00336	0.00756	0.00001	0.00028	0.00001	-0.00029	1	-0.16472
	0.5752	0.8494	0.6696	0.9998	0.9874	0.9998	0.987		<.0001
Week_2	0.00682	-0.00336	0.00756	0.00001	0.00028	0.00001	-0.00029	-0.16472	1
	0.7001	0.8494	0.6696	0.9998	0.9874	0.9998	0.987	<.0001	
Week_3	-0.01819	-0.00336	0.00756	0.00001	0.00028	0.00001	-0.00029	-0.16472	-0.16472
	0.3046	0.8494	0.6696	0.9998	0.9874	0.9998	0.987	<.0001	<.0001
Week_4	-0.00077	-0.00336	0.00756	0.00001	0.00028	0.00001	-0.00029	-0.16472	-0.16472
	0.9651	0.8494	0.6696	0.9998	0.9874	0.9998	0.987	<.0001	<.0001
Week_5	0.01581	-0.00336	0.00756	0.00001	0.00028	0.00001	-0.00029	-0.16472	-0.16472
	0.3722	0.8494	0.6696	0.9998	0.9874	0.9998	0.987	<.0001	<.0001
Week_6	-0.00111	-0.00336	0.00756	0.00001	0.00028	0.00001	-0.00029	-0.16472	-0.16472
	0.9502	0.8494	0.6696	0.9998	0.9874	0.9998	0.987	<.0001	<.0001
Week_7	-0.01754	0.05439	-0.00711	0.00143	0.00086	-0.00103	-0.00126	-0.13198	-0.13198
	0.3221	0.0021	0.688	0.9355	0.9613	0.9538	0.9432	<.0001	<.0001
Week_8	-0.00901	-0.04391	-0.0608	-0.00193	-0.00384	0.00133	0.00442	-0.09511	-0.09511
	0.6112	0.0131	0.0006	0.9134	0.8284	0.9401	0.803	<.0001	<.0001
Week_9	0.04585	0.01294	-0.00338	-0.00008	0.00028	-0.00008	-0.00012	-0.02494	-0.02494
	0.0096	0.4651	0.8486	0.9965	0.9874	0.9965	0.9945	0.1591	0.1591

Pearson Correlation Coefficients, N = 3189 Prob > |r| under H0: Rho=0							
	Week_3	Week_4	Week_5	Week_6	Week_7	Week_8	Week_9
gas_gal_daily	0.11773	-0.1083	-0.19734	-0.2127	-0.16034	-0.11751	-0.03041
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.086
Gas_Cost_Gal	0.0071	0.0071	0.0071	0.0071	0.01276	-0.0806	-0.01121
	0.6887	0.6887	0.6887	0.6887	0.4713	<.0001	0.5269
Dollar_KWH	0.00893	0.00893	0.00893	0.00893	0.01494	-0.10259	-0.00439
	0.6143	0.6143	0.6143	0.6143	0.399	<.0001	0.8043
Head_Placed	0.03632	0.03632	0.03632	0.03632	-0.09071	-0.20076	-0.07603
	0.0403	0.0403	0.0403	0.0403	<.0001	<.0001	<.0001
Net_wt	-0.02463	-0.02463	-0.02463	-0.02463	0.10678	0.07363	0.06108
	0.1643	0.1643	0.1643	0.1643	<.0001	<.0001	0.0006
mortality_daily_avg	-0.18794	-0.18027	-0.10431	0.02088	0.11523	0.24426	0.09643
	<.0001	<.0001	<.0001	0.2386	<.0001	<.0001	<.0001
avglow	-0.01819	-0.00077	0.01581	-0.00111	-0.01754	-0.00901	0.04585
	0.3046	0.9651	0.3722	0.9502	0.3221	0.6112	0.0096
Drop_ceiling	-0.00336	-0.00336	-0.00336	-0.00336	0.05439	-0.04391	0.01294
	0.8494	0.8494	0.8494	0.8494	0.0021	0.0131	0.4651
Firm	0.00756	0.00756	0.00756	0.00756	-0.00711	-0.0608	-0.00338
	0.6696	0.6696	0.6696	0.6696	0.688	0.0006	0.8486
House_1	0.00001	0.00001	0.00001	0.00001	0.00143	-0.00193	-0.00008
	0.9998	0.9998	0.9998	0.9998	0.9355	0.9134	0.9965
House_2	0.00028	0.00028	0.00028	0.00028	0.00086	-0.00384	0.00028
	0.9874	0.9874	0.9874	0.9874	0.9613	0.8284	0.9874
House_3	0.00001	0.00001	0.00001	0.00001	-0.00103	0.00133	-0.00008
	0.9998	0.9998	0.9998	0.9998	0.9538	0.9401	0.9965
House_4	-0.00029	-0.00029	-0.00029	-0.00029	-0.00126	0.00442	-0.00012
	0.987	0.987	0.987	0.987	0.9432	0.803	0.9945
Week_1	-0.16472	-0.16472	-0.16472	-0.16472	-0.13198	-0.09511	-0.02494
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.1591
Week_2	-0.16472	-0.16472	-0.16472	-0.16472	-0.13198	-0.09511	-0.02494
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.1591
Week_3	1	-0.16472	-0.16472	-0.16472	-0.13198	-0.09511	-0.02494
		<.0001	<.0001	<.0001	<.0001	<.0001	0.1591
Week_4	-0.16472	1	-0.16472	-0.16472	-0.13198	-0.09511	-0.02494
	<.0001		<.0001	<.0001	<.0001	<.0001	0.1591
Week_5	-0.16472	-0.16472	1	-0.16472	-0.13198	-0.09511	-0.02494
	<.0001	<.0001		<.0001	<.0001	<.0001	0.1591
Week_6	-0.16472	-0.16472	-0.16472	1	-0.13198	-0.09511	-0.02494
	<.0001	<.0001	<.0001		<.0001	<.0001	0.1591
Week_7	-0.13198	-0.13198	-0.13198	-0.13198	1	-0.07621	-0.01999
	<.0001	<.0001	<.0001	<.0001		<.0001	0.2592
Week_8	-0.09511	-0.09511	-0.09511	-0.09511	-0.07621	1	-0.0144
	<.0001	<.0001	<.0001	<.0001	<.0001		0.4162
Week_9	-0.02494	-0.02494	-0.02494	-0.02494	-0.01999	-0.0144	1
	0.1591	0.1591	0.1591	0.1591	0.2592	0.4162	

Table: Pearson Correlation Coefficients of Variables used in Model 2

Pearson Correlation Coefficients, N = 3189 Prob > |r| under H0: Rho=0						
	gas_cost_daily	Gas_Cost_Gal	Dollar_KWH	Head_Placed	Net_wt	mortality_daily_avg
gas_cost_daily	1	0.28095	0.10417	0.1401	0.10146	0.02855
		<.0001	<.0001	<.0001	<.0001	0.107
Gas_Cost_Gal	0.28095	1	0.51974	0.08758	0.53203	-0.04447
	<.0001		<.0001	<.0001	<.0001	0.012
Dollar_KWH	0.10417	0.51974	1	0.17313	0.23686	-0.06178
	<.0001	<.0001		<.0001	<.0001	0.0005
Head_Placed	0.1401	0.08758	0.17313	1	-0.31088	0.0571
	<.0001	<.0001	<.0001		<.0001	0.0013
Net_wt	0.10146	0.53203	0.23686	-0.31088	1	-0.13975
	<.0001	<.0001	<.0001	<.0001		<.0001
mortality_daily_avg	0.02855	-0.04447	-0.06178	0.0571	-0.13975	1
	0.107	0.012	0.0005	0.0013	<.0001	
avglow	-0.44925	0.05495	0.15463	-0.0738	-0.03686	-0.0565
	<.0001	0.0019	<.0001	<.0001	0.0374	0.0014
avghigh	-0.44497	0.04247	0.15226	-0.05887	-0.06331	-0.0705
	<.0001	0.0165	<.0001	0.0009	0.0003	<.0001
Drop_ceiling	0.16676	0.80653	0.5466	-0.11197	0.68693	-0.11722
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Firm	0.18103	0.50029	0.43838	0.08923	0.25771	0.0025
	<.0001	<.0001	<.0001	<.0001	<.0001	0.8876
Feed_lb_daily	-0.39067	0.1239	0.08943	0.0234	0.17447	-0.05615
	<.0001	<.0001	<.0001	0.1864	<.0001	0.0015
water_gal_daily	-0.38419	0.15347	0.13137	0.05597	0.17571	-0.06012
	<.0001	<.0001	<.0001	0.0016	<.0001	0.0007
House_1	0.01355	-0.00235	-0.00095	-0.00116	-0.005	-0.00376
	0.4443	0.8945	0.9572	0.9477	0.7778	0.8318
House_2	-0.04383	0.00465	0.00061	0.00237	0.01864	-0.00207
	0.0133	0.793	0.9725	0.8934	0.2927	0.9071
House_3	0.00991	-0.00088	0.0002	0.0012	-0.00646	-0.00036
	0.5759	0.9602	0.9912	0.9461	0.7153	0.9838
House_4	0.02021	-0.0014	0.00014	-0.0024	-0.00711	0.00618
	0.2539	0.937	0.9935	0.8922	0.6881	0.7272
WtrWtr	0.16139	-0.07558	-0.14674	0.09083	-0.05355	0.0677
	<.0001	<.0001	<.0001	<.0001	0.0025	0.0001
WtrSprg	0.09833	0.03725	0.00647	0.03975	-0.03471	0.0405
	<.0001	0.0354	0.7148	0.0248	0.05	0.0222
SprgSprg	-0.05968	0.00129	0.06294	0.13069	-0.20428	0.01212
	0.0007	0.942	0.0004	<.0001	<.0001	0.4937
SprgSmmr	-0.20012	-0.00266	0.05749	-0.12879	-0.02531	0.00049
	<.0001	0.8807	0.0012	<.0001	0.153	0.9781
SmmrFall	-0.13059	-0.01986	0.12302	-0.03492	0.14409	-0.06557
	<.0001	0.2622	<.0001	0.0486	<.0001	0.0002
FallFall	0.07105	0.05506	-0.08132	0.04319	0.0282	-0.01384
	<.0001	0.0019	<.0001	0.0147	0.1113	0.4346
FallWtr	0.28218	-0.00143	-0.08671	-0.07895	0.13293	0.0217
	<.0001	0.9356	<.0001	<.0001	<.0001	0.2206

Pearson Correlation Coefficients, N = 3189
Prob > |r| under H0: Rho=0

	avglow	avghigh	Drop_ ceiling	Firm	Feed_lb_daily	water_gal_daily	House_1	House_2
gas_cost_daily	-0.44925	-0.44497	0.16676	0.18103	-0.39067	-0.38419	0.01355	-0.04383
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.4443	0.0133
Gas_Cost_Gal	0.05495	0.04247	0.80653	0.50029	0.1239	0.15347	-0.00235	0.00465
	0.0019	0.0165	<.0001	<.0001	<.0001	<.0001	0.8945	0.793
Dollar_KWH	0.15463	0.15226	0.5466	0.43838	0.08943	0.13137	-0.00095	0.00061
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.9572	0.9725
Head_Placed	-0.0738	-0.05887	-0.11197	0.08923	0.0234	0.05597	-0.00116	0.00237
	<.0001	0.0009	<.0001	<.0001	0.1864	0.0016	0.9477	0.8934
Net_wt	-0.03686	-0.06331	0.68693	0.25771	0.17447	0.17571	-0.005	0.01864
	0.0374	0.0003	<.0001	<.0001	<.0001	<.0001	0.7778	0.2927
mortality_daily_avg	-0.0565	-0.0705	-0.11722	0.0025	-0.05615	-0.06012	-0.00376	-0.00207
	0.0014	<.0001	<.0001	0.8876	0.0015	0.0007	0.8318	0.9071
avglow	1	0.9516	0.04621	0.05588	-0.05825	0.00255	0.00198	-0.00371
		<.0001	0.0091	0.0016	0.001	0.8854	0.9111	0.8343
avghigh	0.9516	1	0.02687	0.06384	-0.0675	0.00033	0.00199	-0.0037
	<.0001		0.1293	0.0003	0.0001	0.9854	0.9105	0.8346
Drop_ceiling	0.04621	0.02687	1	0.37795	0.14103	0.16202	-0.00198	0.00299
	0.0091	0.1293		<.0001	<.0001	<.0001	0.9109	0.8658
Firm	0.05588	0.06384	0.37795	1	0.09966	0.13452	-0.00151	0.0072
	0.0016	0.0003	<.0001		<.0001	<.0001	0.9322	0.6846
Feed_lb_daily	-0.05825	-0.0675	0.14103	0.09966	1	0.9779	0.0051	0.0006
	0.001	0.0001	<.0001	<.0001		<.0001	0.7734	0.9729
water_gal_daily	0.00255	0.00033	0.16202	0.13452	0.9779	1	-0.03478	0.01096
	0.8854	0.9854	<.0001	<.0001	<.0001		0.0495	0.5362
House_1	0.00198	0.00199	-0.00198	-0.00151	0.0051	-0.03478	1	-0.33208
	0.9111	0.9105	0.9109	0.9322	0.7734	0.0495		<.0001
House_2	-0.00371	-0.0037	0.00299	0.0072	0.0006	0.01096	-0.33208	1
	0.8343	0.8346	0.8658	0.6846	0.9729	0.5362	<.0001	
House_3	0.00055	0.00061	-0.0003	-0.00307	-0.01267	0.00873	-0.33431	-0.33208
	0.9752	0.9727	0.9867	0.8622	0.4746	0.6223	<.0001	<.0001
House_4	0.00116	0.00109	-0.00071	-0.00259	0.00696	0.01513	-0.33459	-0.33235
	0.9476	0.951	0.9682	0.8837	0.6943	0.393	<.0001	<.0001
WtrWtr	-0.37739	-0.35413	-0.07352	-0.02346	0.01608	-0.00908	-0.00395	-0.00195
	<.0001	<.0001	<.0001	0.1853	0.364	0.6081	0.8237	0.9125
WtrSprg	-0.15195	-0.11249	0.04057	0.02261	0.00553	-0.00895	0.00113	0.00553
	<.0001	<.0001	0.022	0.2018	0.7548	0.6133	0.9492	0.7547
SprgSprg	0.17082	0.15906	-0.03348	-0.02402	-0.03482	-0.03435	0.00008	0.00225
	<.0001	<.0001	0.0587	0.1751	0.0493	0.0524	0.9965	0.8989
SprgSmmr	0.48442	0.43441	-0.01532	0.01411	-0.02723	0.00132	0.00347	-0.01012
	<.0001	<.0001	0.3872	0.4257	0.1241	0.9407	0.8449	0.5677
SmmrFall	0.09919	0.12843	0.00558	-0.01003	0.01371	0.03203	-0.00986	-0.0079
	<.0001	<.0001	0.7527	0.5712	0.439	0.0705	0.5777	0.6555
FallFall	-0.2147	-0.21418	-0.01302	0.0726	0.01396	-0.00835	0.00064	0.0028
	<.0001	<.0001	0.4625	<.0001	0.4307	0.6375	0.9712	0.8745
FallWtr	-0.48614	-0.52572	0.03404	-0.06236	0.02403	-0.00555	-0.00103	-0.00095
	<.0001	<.0001	0.0546	0.0004	0.1749	0.7539	0.9538	0.9571

Pearson Correlation Coefficients, N = 3189

Prob > |r| under H0: Rho=0

	House_3	House_4	WtrWtr	WtrSprg	SprgSprg	SprgSmmr	SmmrFall	FallFall	FallWtr
gas_cost_daily	0.00991	0.02021	0.16139	0.09833	-0.05968	-0.20012	-0.13059	0.07105	0.28218
	0.5759	0.2539	<.0001	<.0001	0.0007	<.0001	<.0001	<.0001	<.0001
Gas_Cost_Gal	-0.00088	-0.0014	-0.07558	0.03725	0.00129	-0.00266	-0.01986	0.05506	-0.00143
	0.9602	0.937	<.0001	0.0354	0.942	0.8807	0.2622	0.0019	0.9356
Dollar_KWH	0.0002	0.00014	-0.14674	0.00647	0.06294	0.05749	0.12302	-0.08132	-0.08671
	0.9912	0.9935	<.0001	0.7148	0.0004	0.0012	<.0001	<.0001	<.0001
Head_Placed	0.0012	-0.0024	0.09083	0.03975	0.13069	-0.12879	-0.03492	0.04319	-0.07895
	0.9461	0.8922	<.0001	0.0248	<.0001	<.0001	0.0486	0.0147	<.0001
Net_wt	-0.00646	-0.00711	-0.05355	-0.03471	-0.20428	-0.02531	0.14409	0.0282	0.13293
	0.7153	0.6881	0.0025	0.05	<.0001	0.153	<.0001	0.1113	<.0001
mortality_daily_avg	-0.00036	0.00618	0.0677	0.0405	0.01212	0.00049	-0.06557	-0.01384	0.0217
	0.9838	0.7272	0.0001	0.0222	0.4937	0.9781	0.0002	0.4346	0.2206
avglow	0.00055	0.00116	-0.37739	-0.15195	0.17082	0.48442	0.09919	-0.2147	-0.48614
	0.9752	0.9476	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
avghigh	0.00061	0.00109	-0.35413	-0.11249	0.15906	0.43441	0.12843	-0.21418	-0.52572
	0.9727	0.951	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Drop_ceiling	-0.0003	-0.00071	-0.07352	0.04057	-0.03348	-0.01532	0.00558	-0.01302	0.03404
	0.9867	0.9682	<.0001	0.022	0.0587	0.3872	0.7527	0.4625	0.0546
Firm	-0.00307	-0.00259	-0.02346	0.02261	-0.02402	0.01411	-0.01003	0.0726	-0.06236
	0.8622	0.8837	0.1853	0.2018	0.1751	0.4257	0.5712	<.0001	0.0004
Feed_lb_daily	-0.01267	0.00696	0.01608	0.00553	-0.03482	-0.02723	0.01371	0.01396	0.02403
	0.4746	0.6943	0.364	0.7548	0.0493	0.1241	0.439	0.4307	0.1749
water_gal_daily	0.00873	0.01513	-0.00908	-0.00895	-0.03435	0.00132	0.03203	-0.00835	-0.00555
	0.6223	0.393	0.6081	0.6133	0.0524	0.9407	0.0705	0.6375	0.7539
House_1	-0.33431	-0.33459	-0.00395	0.00113	0.00008	0.00347	-0.00986	0.00064	-0.00103
	<.0001	<.0001	0.8237	0.9492	0.9965	0.8449	0.5777	0.9712	0.9538
House_2	-0.33208	-0.33235	-0.00195	0.00553	0.00225	-0.01012	-0.0079	0.0028	-0.00095
	<.0001	<.0001	0.9125	0.7547	0.8989	0.5677	0.6555	0.8745	0.9571
House_3	1	-0.33459	0.01009	-0.00965	-0.00213	0.00347	0.00899	-0.00158	0.00113
		<.0001	0.5691	0.586	0.9044	0.8449	0.6117	0.929	0.9492
House_4	-0.33459	1	-0.0042	0.003	-0.00019	0.00316	0.00874	-0.00185	0.00085
	<.0001		0.8128	0.8654	0.9913	0.8586	0.6217	0.917	0.9618
WtrWtr	0.01009	-0.0042	1	-0.13369	-0.12956	-0.14803	-0.11894	-0.12862	-0.13369
	0.5691	0.8128		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
WtrSprg	-0.00965	0.003	-0.13369	1	-0.14419	-0.16474	-0.13237	-0.14314	-0.14878
	0.586	0.8654	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001
SprgSprg	-0.00213	-0.00019	-0.12956	-0.14419	1	-0.15966	-0.12829	-0.13872	-0.14419
	0.9044	0.9913	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
SprgSmmr	0.00347	0.00316	-0.14803	-0.16474	-0.15966	1	-0.14658	-0.1585	-0.16474
	0.8449	0.8586	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
SmmrFall	0.00899	0.00874	-0.11894	-0.13237	-0.12829	-0.14658	1	-0.12735	-0.13237
	0.6117	0.6217	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
FallFall	-0.00158	-0.00185	-0.12862	-0.14314	-0.13872	-0.1585	-0.12735	1	-0.14314
	0.929	0.917	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
FallWtr	0.00113	0.00085	-0.13369	-0.14878	-0.14419	-0.16474	-0.13237	-0.14314	1
	0.9492	0.9618	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	

Table: Pearson Correlation Coefficients of Variables used in Model 3

Pearson Correlation Coefficients, N = 54 Prob > |r| under H0: Rho=0						
	Gass_ usage_m3_	Cost_KWH	Feed_kg	Water_L	Age_days	Av_weight _kg_
Gass_usage_m3_	1	0.2036	-0.46812	0.06404	0.12545	0.08779
		0.1398	0.0004	0.6455	0.366	0.5279
Cost_KWH	0.2036	1	0.07092	-0.08329	0.06517	-0.09513
	0.1398		0.6104	0.5493	0.6396	0.4938
Feed_kg	-0.46812	0.07092	1	-0.03557	0.08947	0.54427
	0.0004	0.6104		0.7984	0.52	<.0001
Water_L	0.06404	-0.08329	-0.03557	1	0.29305	0.08108
	0.6455	0.5493	0.7984		0.0315	0.56
Age_days	0.12545	0.06517	0.08947	0.29305	1	0.16053
	0.366	0.6396	0.52	0.0315		0.2462
Av_weight_kg_	0.08779	-0.09513	0.54427	0.08108	0.16053	1
	0.5279	0.4938	<.0001	0.56	0.2462	
Head_placed	0.33182	-0.19963	-0.63412	0.21776	0.07235	-0.30962
	0.0142	0.1478	<.0001	0.1137	0.6031	0.0227
Mortality_Pct	-0.20496	-0.22445	0.05133	0.12036	0.13982	-0.11654
	0.1371	0.1028	0.7124	0.386	0.3133	0.4013
House	0	0	0	0.06495	0.09021	0.00407
	1	1	1	0.6408	0.5165	0.9767
Season	-0.36292	-0.0894	0.65545	-0.05838	0.07945	0.43592
	0.007	0.5203	<.0001	0.675	0.5679	0.001
House_1	0	0	0	-0.25873	-0.09375	0.00783
	1	1	1	0.0589	0.5001	0.9552
House_2	0	0	0	0.40496	0.03125	-0.02271
	1	1	1	0.0024	0.8225	0.8705
House_3	0	0	0	-0.14623	0.0625	0.01488
	1	1	1	0.2914	0.6535	0.915
WtrWtr	0.77265	0.19494	-0.54015	-0.04202	-0.10938	-0.05951
	<.0001	0.1578	<.0001	0.7629	0.4311	0.669
WtrSprg	0.11672	0.03749	-0.14714	0.10837	0.03953	-0.1466
	0.4006	0.7878	0.2883	0.4354	0.7766	0.2902
SprgSprg	-0.18522	-0.03631	-0.3389	0.0134	0	-0.34866
	0.18	0.7943	0.0122	0.9234	1	0.0098
SprgSmmr	-0.20685	-0.1836	0.04908	-0.0149	-0.04287	-0.25838
	0.1334	0.1839	0.7245	0.9149	0.7582	0.0592
SmmrSmmr	-0.48055	-0.11363	0.2298	-0.132	0.03953	-0.07825
	0.0002	0.4133	0.0946	0.3414	0.7766	0.5738
SmmrFall	-0.26969	-0.01874	0.38977	0.08445	-0.07906	0.50417
	0.0486	0.893	0.0036	0.5438	0.5699	0.0001
FallFall	0.14947	-0.18013	0.24908	-0.02643	0.03125	0.35277
	0.2807	0.1924	0.0693	0.8495	0.8225	0.0089
FallWtr	0.27377	0.37673	0.13304	-0.01195	0.15006	-0.03116
	0.0452	0.005	0.3375	0.9317	0.2788	0.823

Pearson Correlation Coefficients, N = 54 Prob > |r| under H0: Rho=0								
	Head_ placed	Mortality_ Pct	House	Season	House_1	House_2	House_3	WtrWtr
Gass_usage_m3_	0.33182	-0.20496	0	-0.36292	0	0	0	0.77265
	0.0142	0.1371	1	0.007	1	1	1	<.0001
Cost_KWH	-0.19963	-0.22445	0	-0.0894	0	0	0	0.19494
	0.1478	0.1028	1	0.5203	1	1	1	0.1578
Feed_kg	-0.63412	0.05133	0	0.65545	0	0	0	-0.54015
	<.0001	0.7124	1	<.0001	1	1	1	<.0001
Water_L	0.21776	0.12036	0.06495	-0.05838	-0.25873	0.40496	-0.14623	-0.04202
	0.1137	0.386	0.6408	0.675	0.0589	0.0024	0.2914	0.7629
Age_days	0.07235	0.13982	0.09021	0.07945	-0.09375	0.03125	0.0625	-0.10938
	0.6031	0.3133	0.5165	0.5679	0.5001	0.8225	0.6535	0.4311
Av_weight_kg_	-0.30962	-0.11654	0.00407	0.43592	0.00783	-0.02271	0.01488	-0.05951
	0.0227	0.4013	0.9767	0.001	0.9552	0.8705	0.915	0.669
Head_placed	1	0.03083	0.00422	-0.4008	-0.01463	0.02195	-0.00732	0.2111
		0.8248	0.9758	0.0027	0.9164	0.8748	0.9581	0.1254
Mortality_Pct	0.03083	1	0.13694	0.35803	-0.15633	0.07547	0.08086	-0.24045
	0.8248		0.3234	0.0079	0.259	0.5875	0.5611	0.0799
House	0.00422	0.13694	1	0	-0.86603	0	0.86603	0
	0.9758	0.3234		1	<.0001	1	<.0001	1
Season	-0.4008	0.35803	0	1	0	0	0	-0.48453
	0.0027	0.0079	1		1	1	1	0.0002
House_1	-0.01463	-0.15633	-0.86603	0	1	-0.5	-0.5	0
	0.9164	0.259	<.0001	1		0.0001	0.0001	1
House_2	0.02195	0.07547	0	0	-0.5	1	-0.5	0
	0.8748	0.5875	1	1	0.0001		0.0001	1
House_3	-0.00732	0.08086	0.86603	0	-0.5	-0.5	1	0
	0.9581	0.5611	<.0001	1	0.0001	0.0001		1
WtrWtr	0.2111	-0.24045	0	-0.48453	0	0	0	1
	0.1254	0.0799	1	0.0002	1	1	1	
WtrSprg	0.35958	-0.06466	0	-0.57335	0	0	0	-0.15811
	0.0076	0.6423	1	<.0001	1	1	1	0.2535
SprgSprg	-0.05692	-0.07611	0	-0.17794	0	0	0	-0.15811
	0.6827	0.5844	1	0.198	1	1	1	0.2535
SprgSmmr	0.1147	-0.13447	0	-0.07506	0	0	0	-0.08575
	0.4089	0.3323	1	0.5896	1	1	1	0.5376
SmmrSmmr	-0.19668	0.37067	0	0.25702	0	0	0	-0.15811
	0.154	0.0058	1	0.0606	1	1	1	0.2535
SmmrFall	-0.31608	-0.25198	0	0.29656	0	0	0	-0.15811
	0.0199	0.066	1	0.0294	1	1	1	0.2535
FallFall	0.00256	0.4645	0	0.54705	0	0	0	-0.125
	0.9853	0.0004	1	<.0001	1	1	1	0.3678
FallWtr	-0.06601	-0.13699	0	0.31094	0	0	0	-0.08575
	0.6353	0.3233	1	0.0221	1	1	1	0.5376

Pearson Correlation Coefficients, N = 54 Prob > |r| under H0: Rho=0							
	WtrSprg	SprgSprg	SprgSmmr	SmmrSmmr	SmmrFall	FallFall	FallWtr
Gass_usage_m3_	0.11672	-0.18522	-0.20685	-0.48055	-0.26969	0.14947	0.27377
	0.4006	0.18	0.1334	0.0002	0.0486	0.2807	0.0452
Cost_KWH	0.03749	-0.03631	-0.1836	-0.11363	-0.01874	-0.18013	0.37673
	0.7878	0.7943	0.1839	0.4133	0.893	0.1924	0.005
Feed_kg	-0.14714	-0.3389	0.04908	0.2298	0.38977	0.24908	0.13304
	0.2883	0.0122	0.7245	0.0946	0.0036	0.0693	0.3375
Water_L	0.10837	0.0134	-0.0149	-0.132	0.08445	-0.02643	-0.01195
	0.4354	0.9234	0.9149	0.3414	0.5438	0.8495	0.9317
Age_days	0.03953	0	-0.04287	0.03953	-0.07906	0.03125	0.15006
	0.7766	1	0.7582	0.7766	0.5699	0.8225	0.2788
Av_weight_kg_	-0.1466	-0.34866	-0.25838	-0.07825	0.50417	0.35277	-0.03116
	0.2902	0.0098	0.0592	0.5738	0.0001	0.0089	0.823
Head_placed	0.35958	-0.05692	0.1147	-0.19668	-0.31608	0.00256	-0.06601
	0.0076	0.6827	0.4089	0.154	0.0199	0.9853	0.6353
Mortality_Pct	-0.06466	-0.07611	-0.13447	0.37067	-0.25198	0.4645	-0.13699
	0.6423	0.5844	0.3323	0.0058	0.066	0.0004	0.3233
House	0	0	0	0	0	0	0
	1	1	1	1	1	1	1
Season	-0.57335	-0.17794	-0.07506	0.25702	0.29656	0.54705	0.31094
	<.0001	0.198	0.5896	0.0606	0.0294	<.0001	0.0221
House_1	0	0	0	0	0	0	0
	1	1	1	1	1	1	1
House_2	0	0	0	0	0	0	0
	1	1	1	1	1	1	1
House_3	0	0	0	0	0	0	0
	1	1	1	1	1	1	1
WtrWtr	-0.15811	-0.15811	-0.08575	-0.15811	-0.15811	-0.125	-0.08575
	0.2535	0.2535	0.5376	0.2535	0.2535	0.3678	0.5376
WtrSprg	1	-0.2	-0.10847	-0.2	-0.2	-0.15811	-0.10847
		0.1471	0.435	0.1471	0.1471	0.2535	0.435
SprgSprg	-0.2	1	-0.10847	-0.2	-0.2	-0.15811	-0.10847
	0.1471		0.435	0.1471	0.1471	0.2535	0.435
SprgSmmr	-0.10847	-0.10847	1	-0.10847	-0.10847	-0.08575	-0.05882
	0.435	0.435		0.435	0.435	0.5376	0.6726
SmmrSmmr	-0.2	-0.2	-0.10847	1	-0.2	-0.15811	-0.10847
	0.1471	0.1471	0.435		0.1471	0.2535	0.435
SmmrFall	-0.2	-0.2	-0.10847	-0.2	1	-0.15811	-0.10847
	0.1471	0.1471	0.435	0.1471		0.2535	0.435
FallFall	-0.15811	-0.15811	-0.08575	-0.15811	-0.15811	1	-0.08575
	0.2535	0.2535	0.5376	0.2535	0.2535		0.5376
FallWtr	-0.10847	-0.10847	-0.05882	-0.10847	-0.10847	-0.08575	1
	0.435	0.435	0.6726	0.435	0.435	0.5376	

APPENDIX B

Table: MODEL 4, Parameter Estimates, Average Daily LPG Usage Model, Uncorrected and Corrected for Heteroskedasticity

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent Standard Error	Heteroscedasticity Consistent t Value	Heteroscedasticity Consistent Pr > |t|
Intercept	1	51.57303	5.54013	9.31	<.0001	5.97948	8.63	<.0001
Gas_Cost_Gal	1	4.07357	1.16625	3.49	0.0005	1.02119	3.99	<.0001
Dollar_KWH	1	-82.73115	57.2998	-1.44	0.1489	52.49908	-1.58	0.1152
Head_Placed	1	-0.00001588	0.0001693	-0.09	0.9253	0.00021484	-0.07	0.9411
Net_wt	1	-0.00005281	0.0000263	-2.01	0.0448	0.00002958	-1.79	0.0743
mortality_daily_avg	1	0.00546	0.01342	0.41	0.6842	0.01251	0.44	0.6628
avglow	1	-0.86594	0.01814	-47.72	<.0001	0.02316	-37.39	<.0001
Drop_ceiling	1	-5.03597	1.36014	-3.7	0.0002	1.37352	-3.67	0.0002
Firm	1	2.99941	0.71999	4.17	<.0001	0.72068	4.16	<.0001
Feed_lb_daily	1	-0.00653	0.0006628	-9.85	<.0001	0.0007704	-8.48	<.0001
water_gal_daily	1	0.03636	0.00337	10.8	<.0001	0.00331	10.97	<.0001
House_1	1	0.76506	0.77668	0.99	0.3247	0.77201	0.99	0.3218
House_2	1	-3.08353	0.76703	-4.02	<.0001	0.77741	-3.97	<.0001
House_3	1	-1.8314	0.76572	-2.39	0.0168	0.78413	-2.34	0.0196
Week_1	1	32.65887	1.80115	18.13	<.0001	2.83013	11.54	<.0001
Week_2	1	24.0102	1.4338	16.75	<.0001	2.23259	10.75	<.0001
Week_3	1	12.89677	1.14591	11.25	<.0001	1.39116	9.27	<.0001
Week_5	1	-5.3302	1.12202	-4.75	<.0001	1.19129	-4.47	<.0001
Week_6	1	-8.76463	1.23074	-7.12	<.0001	1.49461	-5.86	<.0001
Week_7	1	-8.03591	1.41594	-5.68	<.0001	1.61763	-4.97	<.0001
Week_8	1	-8.28687	1.64104	-5.05	<.0001	1.80165	-4.6	<.0001
Week_9	1	4.47367	4.6307	0.97	0.3341	2.02863	2.21	0.0275

SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	21	1,165,432	55,497	237.37	<.0001
Error	3,167	740,438	233.80		
Corrected Total	3,188	1,905,871			

R-Square	0.6115
Adj R-Sq	0.6089
RMSE	15.29046
Dependent Mean	16.77291
Coeff Var	91.16161

Test	White's Test of Heteroskedasticity
Statistic	896.9
DF	182
Pr > ChiSq	<.0001
Variables	Cross of all vars

Table: MODEL 5, Parameter Estimates, Average Daily LPG Cost Model, Uncorrected and Corrected for Heteroskedasticity.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent Standard Error	Heteroscedasticity Consistent t Value	Heteroscedasticity Consistent Pr > |t|
Intercept	1	6.36781	8.00538	0.8	0.4264	8.47217	0.75	0.4523
Gas_Cost_Gal	1	21.2735	1.54918	13.73	<.0001	2.23059	9.54	<.0001
Dollar_KWH	1	155.94663	78.30344	1.99	0.0465	71.62519	2.18	0.0295
Head_Placed	1	0.00050466	0.00020209	2.5	0.0126	0.00024214	2.08	0.0372
Net_wt	1	-0.00004542	0.00003518	-1.29	0.1968	0.00003838	-1.18	0.2367
mortality_daily_avg	1	-0.01039	0.01497	-0.69	0.4874	0.01337	-0.78	0.437
avglow	1	-0.58431	0.04699	-12.43	<.0001	0.04866	-12.01	<.0001
Drop_ceiling	1	-8.29632	1.82381	-4.55	<.0001	2.26834	-3.66	0.0003
Firm	1	3.27396	0.93915	3.49	0.0005	0.74755	4.38	<.0001
House_1	1	-0.28741	1.00917	-0.28	0.7758	1.03599	-0.28	0.7815
House_2	1	-2.91587	1.01207	-2.88	0.004	0.94908	-3.07	0.0021
House_3	1	-0.46701	1.00909	-0.46	0.6435	1.04078	-0.45	0.6537
WtrWtr	1	4.99293	2.23909	2.23	0.0258	2.23095	2.24	0.0253
WtrSprg	1	4.17159	1.80698	2.31	0.021	1.50826	2.77	0.0057
SprgSprg	1	1.66118	1.52182	1.09	0.2751	0.94946	1.75	0.0803
SprgSmmr	1	1.65275	1.35402	1.22	0.2223	0.59287	2.79	0.0053
SmmrFall	1	-3.56616	1.61795	-2.2	0.0276	1.03296	-3.45	0.0006
FallFall	1	-0.03055	1.93667	-0.02	0.9874	1.79742	-0.02	0.9864
FallWtr	1	9.71767	2.28448	4.25	<.0001	2.44765	3.97	<.0001

SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	18	633,381	35,188	86.46	<.0001
Error	3,170	1,290,151	406.99		
Corrected Total	3,188	1,923,532			

R-Square	0.3293
Adj R-Sq	0.3255
RMSE	20.17394
Dependent Mean	14.93168
Coeff Var	135.10826

Test	White`s Test of Heteroskedasticity
Statistic	1,248
DF	151
Pr > ChiSq	<.0001
Variables	Cross of all vars

Table: MODEL 6, Parameter Estimates, Average Daily LPG Usage Model, Uncorrected and Corrected for Heteroskedasticity

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent Standard Error	Heteroscedasticity Consistent t Value	Heteroscedasticity Consistent Pr > |t|
Intercept	1	32.763	3.9666	8.26	<.0001	3.8573	8.49	<.0001
avglow	1	-0.804	0.0174	-46.30	<.0001	0.0212	-37.88	<.0001
Dollar_KWH	1	-34.571	57.4162	-0.60	0.5471	53.3964	-0.65	0.5174
water_gal_daily	1	0.00707	0.0017	4.09	<.0001	0.0021	3.33	0.0009
Head_Placed	1	0.00042	0.0002	2.64	0.0083	0.0002	2.36	0.0182
Drop_ceiling	1	-3.377	0.8466	-3.99	<.0001	0.8132	-4.15	<.0001
Firm	1	4.151	0.6934	5.99	<.0001	0.7148	5.81	<.0001
House_1	1	-0.411	0.7815	-0.53	0.5991	0.7788	-0.53	0.5979
House_2	1	-3.047	0.7803	-3.91	<.0001	0.7869	-3.87	0.0001
House_3	1	-1.478	0.7783	-1.90	0.0576	0.7978	-1.85	0.064
Week_1	1	33.641	1.7627	19.08	<.0001	2.0512	16.4	<.0001
Week_2	1	26.823	1.4046	19.10	<.0001	1.6661	16.1	<.0001
Week_3	1	14.969	1.1368	13.17	<.0001	1.1599	12.91	<.0001
Week_5	1	-6.613	1.1240	-5.88	<.0001	0.9358	-7.07	<.0001
Week_6	1	-8.997	1.2282	-7.33	<.0001	1.1295	-7.97	<.0001
Week_7	1	-8.622	1.3972	-6.17	<.0001	1.2714	-6.78	<.0001
Week_8	1	-7.134	1.5702	-4.54	<.0001	1.4416	-4.95	<.0001
Week_9	1	3.158	4.6364	0.68	0.4959	1.7865	1.77	0.0772

SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	1,138,162	66,951	276.54	<.0001
Error	3,171	767,709	242.10		
Corrected Total	3,188	1,905,871			

R-Square	0.597
Adj R-Sq	0.595
RMSE	15.560
Dependent Mean	16.773
Coeff Var	92.767

Test	White`s Test of Heteroskedasticity
Statistic	547.9
DF	105
Pr > ChiSq	<.0001
Variables	Cross of all vars

Table: MODEL 7, Parameter Estimates, Average Daily LPG Cost Model, Uncorrected and Corrected for Heteroskedasticity

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent		
						Standard Error	t Value	Pr > |t|
Intercept	1	9.732	5.3712	1.81	0.0701	4.2614	2.28	0.0224
avglow	1	-0.605	0.0413	-14.64	<.0001	0.0419	-14.43	<.0001
Dollar_KWH	1	173.583	67.8684	2.56	0.0106	60.3175	2.88	0.004
water_gal_daily	1	-0.02277	0.0007	-34.08	<.0001	0.0010	-22.88	<.0001
Head_Placed	1	0.00166	0.0002	10.00	<.0001	0.0002	8.96	<.0001
Drop_ceiling	1	10.498	0.9437	11.12	<.0001	0.9281	11.31	<.0001
Firm	1	8.999	0.7847	11.47	<.0001	0.6263	14.37	<.0001
House_1	1	-1.241	0.8889	-1.40	0.1628	0.9107	-1.36	0.1731
House_2	1	-3.032	0.8908	-3.40	0.0007	0.8185	-3.7	0.0002
House_3	1	-0.592	0.8885	-0.67	0.5051	0.9225	-0.64	0.5209
WtrWtr	1	3.196	1.9678	1.62	0.1044	1.8409	1.74	0.0827
WtrSprg	1	2.998	1.5852	1.89	0.0586	1.2301	2.44	0.0148
SprgSprg	1	0.783	1.3258	0.59	0.555	0.8632	0.91	0.3646
SprgSmmr	1	2.467	1.1885	2.08	0.038	0.6633	3.72	0.0002
SmmrFall	1	-3.592	1.4047	-2.56	0.0106	0.8116	-4.43	<.0001
FallFall	1	-0.092	1.6953	-0.05	0.9565	1.5340	-0.06	0.9519
FallWtr	1	8.592	2.0031	4.29	<.0001	2.1065	4.08	<.0001

SUMMARY RESULTS FOR CORRECTED MODEL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	16	922,805	57,675	182.81	<.0001
Error	3,172	1,000,726	315.49		
Corrected Total	3,188	1,923,532			

R-Square	0.4797
Adj R-Sq	0.4771
RMSE	17.76197
Dependent Mean	14.93168
Coeff Var	118.9549

Test	White`s Test of Heteroskedasticity
Statistic	855.5
DF	114
Pr > ChiSq	<.0001
Variables	Cross of all vars

Table MODEL 8: Parameter Estimates, Net Weight LPG Cost Model, Uncorrected and Corrected for Heteroskedasticity

Variable		Estimate	Standard Error	t Value	Pr > |t|
Intercept		114948.423	3429.4539	33.52	<.0001
gas_gal_daily		55.856	15.13176	3.69	0.0002
Dollar_KWH		737722.363	41396.644	17.82	<.0001
Head_Placed		-3.0351	0.12631	-24.03	<.0001
Feed_lb_daily		-0.3001	0.56573	-0.53	0.5959
water_gal_daily		8.0227	2.6692	3.01	0.0027
avglow		-67.5223	20.9919	-3.22	0.0013
SUMMARY RESULTS FOR CORRECTED MODEL					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1.8241E+11	3.04E+10	153.6	<.0001
Error	3182	6.2983E+11	197935367		
Corrected Total	3188	8.1224E+11			
R-Square		0.224578			
RMSE		14068.95			
Dependent Mean		100850.2			
Coeff Var		13.95034			