PREDICTIONS OF MONTHLY ENERGY CONSUMPTIONS AND ANNUAL PATTERNS OF ENERGY USAGE FOR CONVENIENCE STORES BY USING MULTIPLE AND NONLINEAR REGRESSION MODELS

A Thesis

by

KRISANEE MUENDEJ

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2004

Major Subject: Architecture

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August 2004

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ABSTRACT

Predictions of Monthly Energy Consumptions and Annual Patterns of Energy Usage for Convenience Stores by Using Multiple and Nonlinear Regression Models. (August 2004)

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Thirty convenience stores in College Station, Texas, have been selected as the samples for an energy consumption prediction. The predicted models assist facility energy managers for making decisions of energy demand/supply plans. The models are applied to historical data for two years: 2001 and 2002. The approaches are (1) to analyze nonlinear regression models for long term forecasting of annual patterns compared with outdoor temperature, and (2) to analyze multiple regression models for the building type regardless of outdoor temperature.

In the first approach, twenty four buildings are categorized as base load group and no base group. Average temperature, cooling efficiencies, and cooling knot temperature are estimated by nonlinear regression models: segment and parabola models. The adjusted r-square results in good performance up to ninety percent accuracy. In the second approach, the other selected six buildings are categorized as no trend group. This group does not respond to outdoor temperature. As the result, multiple

a regression model is formed by combination of variables from the nonlinear models and physical building variables of cooling efficiency, cooling temperature, light bulbs, area, outdoor temperature, and orientation of fronts. This model explains up to sixty percent of all convenience stores' data.

In conclusion, the accuracy of prediction models is measured by the adjusted r-square results. Among these three models, the multiple regression model shows the highest adjusted r-square (0.597) over the parabola (0.5419) and segment models (0.4806). When the three models come to the application, the multiple regression model is best fit for no trend data type. However, when it is used to predict the energy consumption with the buildings that relate to outdoor temperature, segment and parabola model provide a better prediction result.

DEDICATION

To my beloved family through all support.

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CHAPTER I

INTRODUCTION

1.1 Background and problems

Energy use in commercial buildings accounts for 17 % of the total energy use in the United States (EIA, 2003). Electricity was the most commonly used energy source in commercial buildings (98 % of commercial floor space) (DOE, 2004). The convenience store is one kind of commercial building. There are about 132,000 convenience stores in the U.S. (Trade Dimension International, 2003). Due to their small sizes, people usually ignore energy conservation; however, this building type often operates 24 hours a day, 7 days a week, consuming more energy in comparison to buildings of similar size.

Because electricity cannot be stored and producing electricity is not a fixed cost, it is important to manage this resource within the framework of facility energy management. As a variable, the cost of energy is determined by the amount used and the energy peak load cost per unit. Through analysis, energy managers can control how efficiently energy is used and the cost per unit (Anderson, 1995; Carpentier, Menniti, Pinnarelli, Scordino, & Sorrentino, 2001). Therefore, energy planning, integrated with demand and supply-side management, has to be developed and updated to provide a current basis for making prudent short-term decisions and to establish long-term decisions (Farag, Mousa, Cheng, & Beshir, 1999). The main purpose for energy planning is to combine demand and supply-side management to forecast the precise

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This thesis follows the style and format of the *International Journal of Forecasting.*

amount of energy use. Consequently, the need for accurate short-to-medium range load forecasts is obvious.

1.2 Importance of this study

The energy market in the United States has been deregulated. Since 1990's, the deregulated energy market has been faced with an unpredictable amount of electricity required each month (IEA, 2001). This affects both demand and supply-side management. Primarily, demand-side management is based on the customers' ability to change the amount and/or timing of energy consumption. The utility goal is to maximize electric use for all end-users and postpone the construction of new generating plants (DOE, 2003). In addition, there is reflection on the new technologies for transmission of power and generation that assists to adjust capacity flexibly in response to demand. Utilities are now able to adjust capacity and demand through short-term purchases and sales of power (Ramanathan, Engle, Granger, Vahid-Araghi, & Brace, 1997). Second, supply-side management refers to the profit and loss of electric production as well as saving natural resources. The major goals of forecasting groups are to incorporate their utilities' increasing demand-side management (DSM) activities. This seeks to alter the ways in which utility customers use energy by providing prediction that best supports DSM (Altaf & Juliet, 1994). The more precise prediction of electric consumption is, the more energy saving there will be.

As previously recognized, precise forecasting for today increases the chance that excess power can be sold and shortfalls can be made up by purchases in the future. A careful calculation of both demand and supply-side electric use can lead to contracts that enhance the profitability of the utility. Thus, medium range demand- and supply-side load forecasting is an effective investment for the utility and an advantage for its customers.

1.3 The specific research purpose

The purpose of this study was to evaluate monthly energy consumption and to predict annual patterns for convenience stores in College Station, Texas, USA by using a combination of Multiple Linear Regression Models (MLR) and Nonlinear Regression Model (NLR). The non-linear prediction models are shown in terms of average daily energy consumption over a billing period (nominally a month) relative to average outside temperature per billing cycle (also nominally a month). The linear regression models can then be used to predict annual energy consumption patterns for a normal year.

1.4 Research objectives

To accomplish the purpose, the study consists of the following steps:

1. analyze annual energy consumption patterns for all convenience stores by using nonlinear regression;
2. analyze variables which affect energy consumption of convenience stores in College Station using linear regression;
3. predict average daily energy consumption (kWh/day) for each store each month from long term monthly temperature averages and the regression model found in step 2 .

1.5 Anticipated benefits of study

The results from this study should indicate the relationship among environmental variables, energy consumption, and electric annual patterns in the subject convenience stores. They can be used:

1. to be a guideline for forecasting how much energy will be used in each building, and
2. to help develop imaginative, comprehensive, and cost effective solutions for energy management

1.6. Working hypothesis

1. Energy consumption (average kWh per billing cycle) for convenience stores can be predicted based on a few easily observed variables.

1.7 Limitations

1. Some convenience stores cannot be surveyed and College Station Utility also had incomplete data for the convenience store numbers: 101048, 120466, and 192608.
2. The data form College Station Utility are available from December 2001 to March 2003.
3. Collecting internal loads variables and orientations of front were done by on-site survey.

CHAPTER II

LITERATURE REVIEW

A literature review found that has been much work done to study and predict electric usage in buildings by estimating energy consumption and energy saving through the use of computerized simulation programs. These studies can be classified into two models: (1) engineering and (2) statistical, which serve different purposes.

2.1 Energy prediction models

2.1.1 Energy consumption model comparisons: engineering models

DOE-2 and BLAST are well-known engineering simulation models and both have been used in these studies. DOE-2 is a precise program for simulating building energy consumption before buildings are built. This method can be used by the utility companies and energy consultants as an option to the use of micro dynamics comprehensive simulation programs and simplified tools like analyzing the monthly utility bills. (Abushakra, 1999) The complexity of these simulation programs and the time consumed to prepare input files, etc. often makes them difficult to use. Additionally, differences between DOE-2 results and actual observations are often found.

Another model is BLAST. It is a powerful program that can be calibrated to match past energy consumption patterns and estimate future energy savings due to proposed conservation measures in existing buildings. For both simulations the output will not be effective if the inputs do not exactly corresponded to the operation of consuming systems after buildings are built. (Abushakra, 1999)

In the electric engineering field, recently Artificial Neural Network (ANN) has been used to forecasting the daily peak load, daily curve and so on. One significant characteristic of neural network is to perform nonlinear modeling between input and output data. Since the modeling is not explicit and there are many parameters in the network, then the neural network model is proper as a load model. The neural network model can only develop a forecasting model by training it with actual operating data. Then, the ANN is regarded as a powerful method for handling nonlinear complex phenomenon, however; the structure of trained ANN is difficult to understand. (Matsui, Lizaka, & Fukuyama, 2001; Haida & Muto, 1999)

2.1.2 Energy consumption model comparisons: statistical models

Many statistical methods have been conventionally used for forecasting. Usually, a linear regression model has been used for a central load-dispatching center. An operator is able to understand the reason and relevance of forecasting results using the linear regression model. However, it is difficult to obtain accurate forecasts because the model is constructed of linear functions. Moreover, it has been difficult to construct a proper nonlinear regression model to investigate complex correlations between electric load and input variables such as weather conditions, seasonal factors, and difference between weekdays and weekends.

Another methodology is nonlinear regression (change-point or segment models) used to measure energy use. Both simple linear regression and three-parameter change-point linear regression models of Princeton Scorekeeping Method (PRISM) are suitable in analyzing monthly residential energy consumption and heating energy use. (Fels and Reynolds, 1991)

2.2 Model selection

2.2.1 Multiple linear regression model

Woods (1982); Larson (1994); Sharma, Nair, & Balasubramanian (2002) used multiple regressions for forecasting energy consumption both in residential and commercial buildings. Multiple regression has also been widely used in energy monitoring projects. Palmiter and Hanford (1986) used a slightly more sophisticated regression between energy use and ambient temperature to predict daily average electrical heating, cooling, and refrigeration loads. Liu (2001) used multiple linear regressions for electrical demand forecasting on the customer side. Since electric demand may be related to activity and production, the load is composed of three main components: production sensitive, weather sensitive, and base load. The model can be expressed as the following:

$$Y(t) = a+b_1x_1(t)+\ldots+b_nx_n(t)+c_1x_{n+1}(t)+\ldots+c_mx_m(t)+d(t) \qquad (2.1)$$

where

$Y(t)$ is the electrical load;

$x_1(t),\ldots,x_n(t)$ are independent variables correlated with $y(t)$;

a is the base load component (regression constant coefficient);

$b_0, b_1,\ldots,b_n$ are regression coefficients of the weather sensitive components;

c_0, c_1,…,c_m are regression coefficients of the production sensitive, and

d(t) is a random variable with zero mean and constant variance.

2.2.2 Nonlinear regression models

Also, recently there are several studies that show the regression model is effective in analyzing energy usage in commercial buildings and forecasting various commodities like electric, coal, and petroleum products as shown in Table 2.1 and Fig. 2.1 (Claridge, 1998; Sharma, Nair, & Balasubramanian, 2002). A five-parameter change-point linear regression model technique was developed by adding more functionality (Fels, Kissock, & Marean, 1994). Therefore, the statistical regression models and artificial neural networks have been effective when the models are generated by hourly data. This is done to predict the hourly building energy usage (Kreider & Harberl, 1994; Harberl & Thamilseran, 1996).

Table 2.1 Change Point Regression Models and Equations.

Model	**Equation**	**Fig.**
One parameter	$E_{period} = B_0$	1a
Two parameter	$E_{period} = B_0 + B_1T$	1b
Three parameter heating	$E_{period} = B_0 + B1(B_2 – T)+$	1c
Three parameter cooling	$E_{period} = B_0 + B_1(T – B_2)^+$	1d
Four parameter heating	$E_{period} = B_0+B_1(B_3\text{-}T)^+ – B_2(T – B_3)^+$	1e
Four parameter cooling	$E_{period} = B_0+B_1(B_2\text{-}T)+B_2\max((T\text{-}B_3),0)+e$	1f

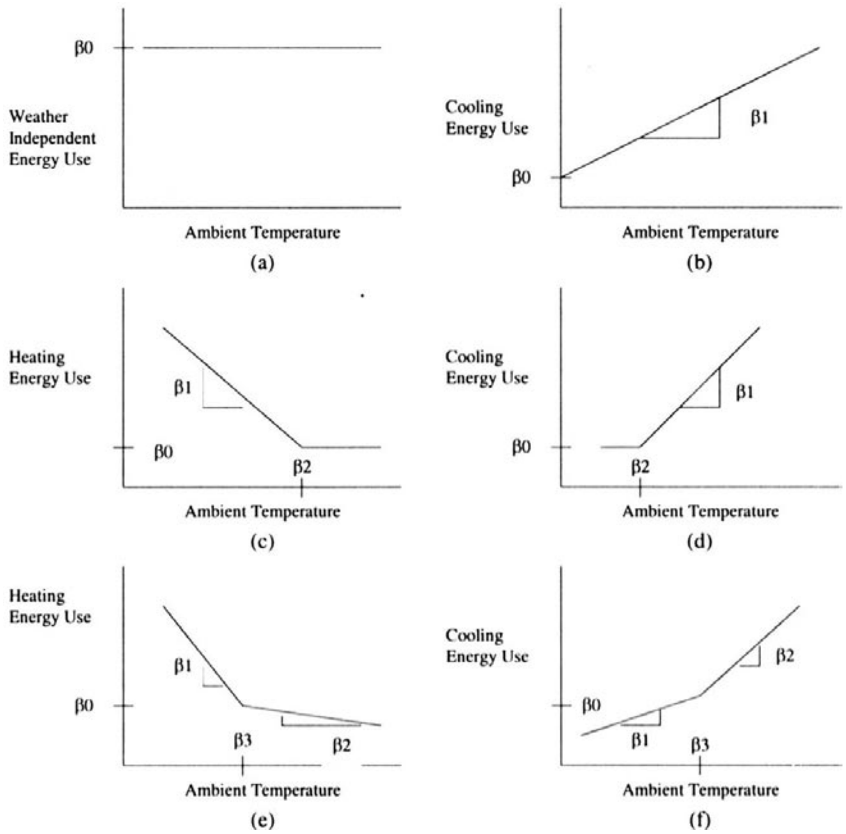


Fig.2.1 Change Point Regression Models. (a) one-parameter model, (b) two-parameter model, (c) three parameter for heating energy use, (d) three-parameter model for cooling energy use, (e) four-parameter model for heating energy use, and (f) four-parameter model for cooling energy use. (Beasley, 1999)

2.3 Physical variable effects

2.3.1 Weather variables

2.3.1.1 Outdoor temperature, humidity

Short term load forecasting deals with load management. Weather variables that affect energy consumption are outdoor temperature, humidity, wind speed and cloud cover. (Sargunaraj, Gupta, Sen, & Devi, 1996; Reddy, Kissock, & Ruch, 1998; Pardo, Meneu, & Valor, 2001; Sailor, 2001).

2.3.2 Main equipment variables

2.3.2.1Electrical equipment: lighting, air-conditioning, and refrigerating systems

Convenience stores are frequently open 24 hours. This means that lighting, air-conditioning, and refrigerating systems operate continuously during the working hours. As a result, mechanical systems work every day, but the energy consumption still is likely to be different because of the affect of weather variables.

2.3.2.2 Heating systems: gas, electric, or combination system

Some convenience stores use only one system, while others use a combination of these systems. These are reflected on bills. In the winter season, it is a significantly different amount of electric cost between the buildings that use electric or gas systems.

The cost for buildings using only electrical systems is generally higher than buildings using gas.

2.3.3 Heating and cooling load

2.3.3.1 Building heat transmission coefficient

Convenience stores were built using different materials and designs, which show in dissimilar results of energy gain and loss. Heat flow calculations are considered through the building envelope: wall, floor, basement, and roof. Following is the formula to be used:

Conduction through building envelope

$$Q^{\circ}_{cond} = \Sigma\ U_k A_k (T_i - T_0) \qquad (2.2)$$

where

A = area of building envelope (sq.ft)

U = conductance (Btu/h.ft^2.$^{\circ}$F)

$T_i - T_0$ = the difference between the in/outdoor temperature ($^{\circ}$F)

ASHRAE/IES Standard 90.1 Energy Efficient Design of New Buildings Except New Low-Rise Residential Buildings presents tables of whole-wall, whole-floor, and whole-roof U-values that account for thermal bridging. In addition to equation (2.1), air exchange into buildings must be considered. A precise model of heat flow due to air-exchange that flows through an opening is proportional to the area and to some power of the pressure difference.

2.3.3.2 Heat exchange (infiltration and/or ventilation), at rate V°

$$Q^{\circ}_{v} = V^{\circ} (1.08) (T_i - T_0) \qquad (2.3)$$

where

Q°_{v} = sensible heat exchange due to ventilation (Btu/h)

V° = volume flow rate (cfm) of outdoor air introduced, ft^3/h (m^3/s)

$(T_i - T_0)$ = temperature difference between outdoor and indoor (°F)

1.08 = a constant derived from the density of air at 0.075 lb/ft3 under "average" conditions, multiplied by the specific heat of air (heat required to raise one lb of air 1F), which is 0.024 Btu/lb°F, and by 60 min/h. The units of this frequently encountered constant are Btu-min/$ft^{3\circ}$F.

2.3.3.3 Heat gain

Heat gain from building envelops and walls

$$q_{roof,\ walls} = UxAxDETD \quad (2.4)$$

where

U-values are for summer, and

A = area of the roof or wall, and

DETD (design equivalent temperature differences)

Heat gain from glass opening

$$q_{glass} = A \times DCLF \quad (2.5)$$

where

A = area of the glass

DCLF (design cooling load factor) values and include the U-values as well as temperature differences.

Heat gain from lights

The power supplied to electric lights (those that normally are on while cooling equipment is functioning) can be added directly to the sensible heat gain. Be sure to include ballast heat gains along with fluorescent lights, usually done by taking from 1.12 to 1.2 times the total bulb wattage of such lights (use the lower figure with energy-efficient ballasts).

Heat gain from equipment

In residences a standard assumption is that 350 to 470 W (1,200 to 1,600 Btu/h) of sensible heat gain is produced by appliances. (Other residential heat loads are assumed to be vented.)

2.4 Building orientations

Building direction affects energy consumption in buildings. The degree of exposure to daylight, direct sun, and wind is obviously important to HVAC zoning. Consider a square office building, on a cold, sunny, and windy day. Perimeter spaces with direct sun through the windows may gain more heat than is lost, and thus need cooling. Comparison of heat gain from four different faces, the highest heat transmission through space is on the west direction. The next is the south, east and north direction. To reduced heating, this might be done by the opening of windows, but too much cold air may make the workers near the windows uncomfortable. Perimeter spaces without direct sun may have a net heat loss due to heat loss through glass, infiltration, and lack of electric lights. These spaces will need heat from a mechanical support system.

2.5 Facility energy management

The purpose of energy management is “The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions.” (Capehart & Capehart, 1995) This broad definition covers many operations from product and equipment design through product shipment. Waste minimization and disposal also presents many energy management opportunities. The primary objective of energy management is to maximize profits or minimize costs.

Prediction of energy consumption for convenience stores is one way to reduce both energy waste and cost. A good forecasting model can demonstrate to facility managers how they can successfully implement such a model through better understanding of their facilities' needs, combined with financial details of various programs offered by local suppliers of electricity. (Pate, 2003)

2.6 Summary of literature review

From the facility energy management aspect, the major goals of forecasting groups are to incorporate their utilities' increasing demand-side management (DSM) activities into their forecasts, and providing forecasts that best support DSM. (Altaf & Juliet, 1994)

Regression models could be used for electric consumption prediction for small commercial building projects. According to the previous research, this strategy is useful for analyzing various variables and assisting engineering decisions in the short term. The variables chosen are of two types: weather sensitive—outdoor temperature, humidity, wind speed, and wet bulb-- and building sensitive—working hours and building systems.

CHAPTER III

DATASET

3.1 Population and sample

The research was focused on convenience stores in College Station, Texas. There were 33 convenience stores, but three of them had incomplete data. (See Table 3.1) As a result, the analysis was done by using 30 convenience stores datasets. These varied in area, outdoor mean temperature per billing cycle, building orientation, internal loads, working hours, and taxable value.

3.2 Data collection

3.2.1 Dependent variable

The raw data was monthly energy consumption (kWh) for all convenience stores in College Station from December 2001 to March 2003 and was provided by the College Station Utility. Because of the imbalance in days contained within the billing period, the dependent variable was calculated by averaging of monthly energy consumption over individually the number of days in each convenience store's billing cycle, kWh/day/billing period. This was done to normalize comparisons.

3.2.2 Independent variables

3.2.2.1 Outdoor temperature (degree Fahrenheit, °F)

Daily temperature means for College Station were collected from National Climatic Data Center (NCDC), and published by National Environmental Satellite, Data,

Table 3.1 The Details of Convenience Stores in College Station.

No.	Name	Address		Tel. no.
101056	H & M	12677 FM 2154		
107390	Super Trac Food Mart	2000 FM 158	College Station, TX 77845	(979) 731-1756
108000	Max*Express	4150 Hwy 6 S	College Station, TX 77845	(979) 690-8939
115142	Max*Express	301 University Dr.		
117218	Javico or Jim's Food Mart	425 Texas Ave.	College Station, TX 77840	(979) 846-5007
119114	Max*Express	400 George Bush		
119818	DIAMOND shamrock	603 Harvey Rd.		
120400	Speedy Stop	1721 Texas Ave.		
120424	Max*Express	1405 Texas Ave.		
125530	DIAMOND shamrock	3129 Texas Ave.		
126226	Checkers Foodmart	604 Holleman Dr	College Station, TX 77840	(979) 694-2539
126630	WILLTEX	1011 Wellborn Rd	College Station, TX 77840	(979) 764-2747
133124	E-Z Mart Stores Inc No 458	1401 Harvey Rd	College Station, TX 77840	(979) 693-5449
133130	Harvey's Tiger Mart	1601 Harvey Rd	College Station, TX 77840	(979) 696-0872
135916	Broach Stations	101 Southwest		
137580	M C Food Mart	815 Texas Ave S	College Station, TX 77840	(979) 694-2574
144454	Broach Stations	609 University Dr.		
146654	Reveille's No 1 Convenience Store	300 George Bush Dr	College Station, TX 77840	(979) 696-7898
147338	Barkers country store	101 A Dowling RD		
151242	Shop and go 2	319 Dominik		
161494	Afnan Shell Oil	321 Redmond Dr	College Station, TX 77840	(979) 693-0101
167260	Shop and go	1500 Holleman		
167330	E Z Mart	1714 Southwest Pkwy		
170988	Speedy Stop	2202 Harvey Mitchell	College Station, TX 77845	(979) 696-2180
171034	Max*Express	3300 SH 6		
171040	Tiger mart	1800 Harvey Mitchell		
173446	Exxon Tigerland Express	3998 Rock Prairie Rd At	College Station, TX 77845	(979) 680-8083
173540	Franky's	2801 Harvey Mitchell		
186030	Springers Chevron & Cafe Express	2601 Harvey Rd	College Station, TX 77845	(979) 695-0020
187564	Gateway Fuels LLC	804 Earl Rudder Fw S	College Station, TX 77840	(979) 268-0641

and Information Service. The high, mean, and low daily temperatures for College Station, which were recorded at the Easterwood Airport, were used from this published data. The mean daily temperatures were averaged over the billing periods for each individual convenience store.

3.2.2.2 Indoor temperature and humidity (degree Fahrenheit and percentage)

For the measurement of indoor temperatures and indoor humidity, the Hobo device was used to record the dataset for all convenience stores starting from September 27 to October 3, 2003. The measurement was done during the peak load hours from 10:00 am to 4:00 pm. The convenience stores only allowed this data recorded between these hours.

3.2.2.3 Internal load: light bulbs and refrigerator units

The relationships between internal loads, lighting, refrigerators, and occupancy levels were examined. All internal load data were collected by onsite surveys. The sizes of light and refrigerator units did not greatly vary so collecting the data by counting the amounts of refrigerator units and lighting bulbs could be used. According to a few people working in the stores, occupancy level was not counted as a predicting variable. The effect of internal loads was evaluated as two independent variables that were the combination of the prediction models.

Lighting bulbs

There are many lighting types to be used in buildings, for College Station convenience stores. Most of them use fluorescent- T-8 48 inches in length. Energy consumption was around 32 watts. Table 3.2 showed energy consumption and lighting luminance details.

Table 3.2 Energy Consumption and Lighting Luminance Details.

Length inches	Watts	Lumens
24	17	1325-1350
36	25	2080-2150
48	32	2850-2950
60	40	3600-3725
96	59	5800-5950

Refrigerator units

There are several types of refrigerators: ice-cream frozen unit, cooling beverage unit, and ice frozen, which consume energy. Beverage coolers and ice-cream freezers in the raw dataset should probably be separated as they may use significantly different amounts of energy. However since there was only one freezer in each convenience store, it was acceptable to combine the two types of equipment.

3.2.2.4 Orientations of fronts

A digital compass was used to report the orientations of store fronts: North, East, South, and West. Table 3.3 shows the four main dummy variables to be used.

Table 3.3 Four Main Dummy Variables That Represented Orientations of Fronts.

Orientations	Building directions
North (N)	North to North-East
South (S)	South to South-West
East (E)	East to South-East
West (E)	West to North-West

3.2.2.5 Area and taxable value

Building areas and taxable values were obtained from Brazos County Appraisal District and published property assessment and tax information.

The following tables summarize variables used in the two prediction models, multiple regression and nonlinear regression models. Table 3.4 shows the variables for monthly energy consumption predictions using the multiple regression model. Table 3.5 shows the data used for prediction of annual patterns in nonlinear regression model for convenience store numbers 101056 and 107390.

Table 3.4 Variables Used for Multiple Regression Model for January.

Stores	From	To	kWh/day	OT	N	E	S	W	IT	IRH	Hr	Refrig	Light	Area	Tax
101056	12/3/00	1/3/01	327.32	44.31	0	0	0	0	78.36	28.33	24	14	154	3672	199580
101056	12/2/02	1/2/03	327.94	52.92	0	0	0	0	78.36	28.33	24	14	154	3672	199580
101056	11/30/01	1/2/02	280.67	52.92	0	0	0	0	78.36	28.33	24	14	154	3672	199580
107390	12/30/00	1/30/01	819.35	46.92	0	0	0	0	71.77	35.87	24	14	97	6375	67220
107390	12/30/02	1/30/03	914.84	48.47	0	0	0	0	71.77	35.87	24	14	97	6375	67220
107390	12/28/01	1/31/02	807.06	50.62	0	0	0	0	71.77	35.87	24	14	97	6375	67220
108000	12/17/00	1/16/01	665.81	45.53	0	0	0	0	74.53	30.83	18	12	130	3458.25	145760
108000	12/17/01	1/16/02	706.67	47.18	0	0	0	0	74.53	30.83	18	12	130	3458.25	145760
108000	12/16/02	1/16/03	604.00	51.56	0	0	0	0	74.53	30.83	18	12	130	3458.25	145760
115142	12/3/00	1/3/01	686.45	44.31	0	0	1	0	76.62	30.09	24	17	43	2622	121030
115142	12/2/02	1/2/03	398.40	52.92	0	0	1	0	76.62	30.09	24	17	43	2622	83910
115142	11/13/01	1/2/02	603.87	52.92	0	0	1	0	76.62	30.09	24	17	43	2622	88950
117218	12/30/02	1/30/03	492.90	48.47	0	0	1	0	76.05	28.41	24	15	74	2191	154940
117218	12/28/01	1/31/02	542.50	50.62	0	0	1	0	76.05	28.41	24	15	74	2191	154940
117218	12/30/00	1/31/01	508.24	47.52	0	0	1	0	76.05	28.41	24	15	74	2191	154940
119114	12/4/01	1/4/02	306.52	51.26	0	0	0	0	77.31	28.70	24	11	55	1080	40530
119114	12/3/02	1/6/03	261.21	52.32	0	0	0	0	77.31	28.70	24	11	55	1080	42095
119114	12/5/00	1/5/01	351.61	44.33	0	0	0	0	77.31	28.70	24	11	55	1080	41110
120400	12/27/01	1/29/02	997.50	48.23	0	0	1	0	80.47	25.15	24	20	150	3800	228490
120400	12/26/00	1/26/01	1016.97	49.79	0	0	1	0	80.47	25.15	24	20	150	3800	228490
120400	12/26/02	1/27/03	1099.35	44.82	0	0	1	0	80.47	25.15	24	20	150	3800	228490
120424	12/26/00	1/26/01	386.45	44.82	0	0	0	1	79.41	33.88	18	13	74	1215	54180
120424	12/26/02	1/27/03	369.38	48.23	0	0	0	1	79.41	33.88	18	13	74	1215	45260
120424	12/27/01	1/29/02	361.88	49.79	0	0	0	1	79.41	33.88	18	13	74	1215	52530
125530	12/23/01	1/24/02	712.50	48.42	0	0	1	0	73.84	34.07	18	12	85	1944	116460
125530	12/19/02	1/23/03	622.86	49.84	0	0	1	0	73.84	34.07	18	12	85	1944	122100
125530	12/21/00	1/24/01	708.24	44.82	0	0	1	0	73.84	34.07	18	12	85	1944	116460
126226	12/6/02	1/8/03	322.42	52.00	0	0	0	1	80.82	36.10	18	15	88	3264	63460
126226	12/6/01	1/9/02	529.41	52.73	0	0	0	1	80.82	36.10	18	15	88	3264	63460
126226	12/28/00	1/8/01	447.27	45.55	0	0	0	1	80.82	36.10	18	15	88	3264	63460

Table 3.4 Continued.

Stores	From	To	kWh/day	OT	N	E	S	W	IT	IRH	Hr	Refrig	Light	Area	Tax
126630	12/4/01	1/4/02	1029.68	51.26	0	0	1	0	73.15	40.79	24	20	83	3300	54260
126630	12/3/02	1/6/03	897.65	52.32	0	0	1	0	73.15	40.79	24	20	83	3300	54260
126630	12/5/00	1/5/01	1070.97	44.33	0	0	1	0	73.15	40.79	24	20	83	3300	54260
133124	12/26/00	1/26/01	520.00	44.82	0	1	0	0	71.77	36.30	17	18	73	6579	89940
133124	12/28/01	1/29/02	458.75	49.79	0	1	0	0	71.77	36.30	17	18	73	6579	87260
133124	12/26/02	1/27/03	482.50	48.23	0	1	0	0	71.77	36.30	17	18	73	6579	87260
133130	12/28/01	1/29/02	652.90	48.04	0	0	1	0	80.82	27.77	24	10	32	1104	43690
133130	12/26/00	1/26/01	755.43	49.79	0	0	1	0	80.82	27.77	24	10	32	1104	12900
133130	12/23/02	1/27/03	650.00	44.82	0	0	1	0	80.82	27.77	24	10	32	1104	43690
135916	12/3/01	1/4/02	546.25	51.26	0	0	1	0	71.77	30.57	18	16	58	2519	78600
135916	12/3/02	1/6/03	544.71	52.32	0	0	1	0	71.77	30.57	18	16	58	2519	79520
135916	12/2/00	1/5/01	577.65	44.33	0	0	1	0	71.77	30.57	18	16	58	2519	87450
137580	1/3/03	1/29/03	418.31	47.56	0	0	0	0	74.19	27.08	18	18	112	1944	87060
137580	12/28/01	1/25/02	449.21	49.79	0	0	0	0	74.19	27.08	18	18	112	1944	87060
137580	12/29/00	1/29/01	363.90	46.60	0	0	0	0	74.19	27.08	18	18	112	1944	87060
137580	11/22/02	1/3/03	402.69	52.35	0	0	0	0	74.19	27.08	18	18	112	1944	87060
144454	12/2/01	1/2/02	521.29	52.42	0	0	1	0	80.65	36.68	18	12	38	2486.8	19890
144454	11/30/01	1/2/2002	489.70	52.42	0	0	1	0	80.65	36.68	18	12	38	2486.8	19890
144454	12/2/02	1/2/03	616.77	52.92	0	0	1	0	80.65	36.68	18	12	38	2486.8	19895
144454	12/1/00	1/3/01	460.61	44.31	0	0	1	0	80.65	36.68	18	12	38	2486.8	19890
146654	12/3/01	1/4/02	483.75	51.26	0	0	0	0	79.41	33.40	16	13	98	1890	91220
146654	12/3/02	1/6/03	427.06	52.32	0	0	0	0	79.41	33.40	16	13	98	1890	79450
146654	12/5/00	1/5/01	378.06	44.33	0	0	0	0	79.41	33.40	16	13	98	1890	131530
147338	12/5/01	1/4/02	465.80	50.57	0	0	0	0	72.46	31.63	15	13	42	2176	34840
147338	12/3/02	1/6/03	546.79	52.32	0	0	0	0	72.46	31.63	15	13	42	2176	47100
147338	12/5/00	1/5/01	348.94	44.33	0	0	0	0	72.46	31.63	15	13	42	2176	34840
151242	12/3/01	1/4/02	436.69	51.26	0	0	0	0	77.11	30.07	18	14	78	2632	137271
151242	12/3/02	1/6/03	437.85	52.32	0	1	0	0	77.11	30.07	18	14	105	2632	137271
151242	12/26/00	1/26/01	181.94	44.82	0	1	0	0	77.11	30.07	18	14	105	2632	137271
161494	12/4/01	1/3/02	206.80	51.26	0	0	0	0	83.57	42.87	16	8	40	540	7100
161494	12/3/02	1/6/03	200.21	52.32	0	0	0	0	83.57	42.87	16	8	40	540	7200

Table 3.4 Continued.

Stores	From	To	kWh/day	OT	N	E	S	W	IT	IRH	Hr	Refrig	Light	Area	Tax
161494	12/5/00	1/5/01	192.35	44.33	0	0	0	0	83.57	42.87	16	8	40	540	7000
167260	12/8/01	1/9/02	55.00	49.12	0	0	0	1	79.41	30.60	24	16	59	5957	32970
167260	12/6/02	1/8/03	346.67	52.00	0	0	0	1	79.41	30.60	24	16	59	5957	32970
167260	12/8/00	1/8/01	278.71	45.55	0	0	0	1	79.41	30.60	24	16	59	5957	56470
167260	1/8/01	1/23/01	296.00	44.27	0	0	0	1	79.41	30.60	24	16	59	5957	32970
167330	12/6/02	1/8/03	530.91	52.00	0	0	0	1	79.41	29.47	18	19	60	2440	87500
167330	12/27/01	1/9/02	1520.00	53.05	0	0	0	1	79.41	29.47	18	19	60	2440	100340
167330	12/3/00	1/3/01	495.48	45.55	0	0	0	1	79.41	29.47	18	19	60	2440	111260
167330	1/3/01	1/8/01	568.00	48.00	0	0	0	1	79.41	29.47	18	19	60	2440	111260
170988	12/10/01	1/10/02	634.84	47.83	0	0	0	1	73.84	34.00	24	15	128	3000	148840
170988	12/11/02	1/13/03	766.06	52.24	0	0	0	1	73.84	34.00	24	15	128	3000	148840
170988	12/10/00	1/10/01	797.42	45.43	0	0	0	1	73.84	34.00	24	15	128	3000	155720
171034	12/9/01	1/10/02	596.25	47.83	0	0	0	1	72.46	33.78	18	12	51	2019	60610
171034	12/11/02	1/13/03	635.15	52.24	0	0	0	1	72.46	33.78	18	12	51	2019	50460
171034	12/10/00	1/10/01	665.81	45.43	0	0	0	1	72.46	33.78	18	12	51	2019	63815
171040	12/9/01	1/10/02	905.00	47.83	0	0	0	1	77.31	37.70	18	15	135	8180	98750
171040	12/11/02	1/13/03	930.91	52.24	0	0	0	1	77.31	37.70	18	15	135	8180	98750
171040	12/10/00	1/10/01	1166.45	45.43	0	0	0	1	77.31	37.70	18	15	135	8180	98750
173446	12/14/01	1/16/02	1008.48	48.15	0	0	0	1	82.24	29.90	18	15	111	6399.25	31100
173446	12/16/02	1/16/03	985.81	51.56	0	0	0	1	82.24	29.90	18	15	111	6399.25	69050
173446	12/18/00	1/18/01	1334.19	45.66	0	0	0	1	82.24	29.90	18	15	111	6399.25	69050
173540	12/15/01	1/16/02	1191.25	48.15	0	0	0	0	75.22	32.64	18	13	124	1584	148840
173540	12/16/02	1/16/03	1212.90	51.56	0	0	0	0	75.22	32.64	18	13	124	1584	148840
173540	12/16/00	1/16/01	1372.90	45.52	0	0	0	0	75.22	32.64	18	13	124	1584	148840
186030	12/30/02	1/30/03	792.26	48.47	0	1	0	0	73.15	39.90	19	12	48	3268	131850
186030	12/30/01	1/31/02	770.00	50.62	0	1	0	0	73.15	39.90	19	12	48	3268	131850
186030	12/30/00	1/30/01	809.03	46.92	0	1	0	0	73.15	39.90	19	12	48	3268	131850
187564	12/30/02	1/30/03	1037.42	48.47	0	0	0	0	83.67	27	18	13	89	3388	250560
187564	12/30/01	1/31/02	1077.50	50.62	0	0	0	0	83.67	27	18	13	89	3388	250560
187564	12/30/00	1/30/01	1163.87	46.92	0	0	0	0	83.67	27	18	13	89	3388	250560
187564	12/28/01	1/31/02	1014.12	51.26	0	0	0	0	83.67	27	18	13	89	3388	250560

Table 3.5 Variable Used for Nonlinear Regression Model for the Convenience Strores: 101056 and 107390.

Store	To	From	kWh/day	OT
101056	1/2/2002	11/30/01	280.67	52.92
	1/2/2003	12/2/02	327.94	52.92
	1/3/2001	12/3/00	327.32	44.31
	10/1/2001	8/31/01	377.97	78.31
	10/31/2001	10/1/01	351.17	68.15
	10/31/2002	9/30/02	375.19	69.92
	11/30/2001	10/31/01	327.73	64.32
	12/2/2002	10/31/02	341.47	56.64
	2/1/2001	1/3/01	282.66	48.66
	2/1/2002	1/2/02	280.50	48.93
	2/3/2003	1/2/03	348.56	48.73
	3/1/2001	2/1/01	264.11	56.79
	3/1/2002	2/1/02	317.50	48.93
	3/3/2003	2/3/03	343.54	50.36
	4/1/2003	3/3/03	383.59	59.76
	4/2/2001	3/1/01	245.06	55.09
	4/2/2002	3/1/02	351.72	59.41
	5/1/2002	4/2/02	426.76	73.12
	5/2/2001	4/2/01	301.40	71.52
	5/1/2003	4/1/03	428.50	69.40
	6/1/2001	5/2/01	334.03	77.45
	6/3/2002	5/1/02	443.18	76.61
	7/2/2001	6/1/01	370.16	81.81
	7/2/2002	6/3/02	423.48	82.09
	8/1/2001	7/2/01	410.37	86.22
	8/2/2002	7/2/02	468.77	82.84
	8/31/2001	8/1/01	410.07	86.45
	9/3/2002	8/2/02	438.91	83.89
	9/30/2002	9/3/02	405.52	79.59

Store	To	From	kWh/day	OT
107390	1/30/2001	12/30/00	819.35	46.92
	1/30/2003	12/30/02	914.84	48.47
	1/31/2002	12/28/01	807.06	50.62
	10/29/2001	9/27/01	848.75	68.64
	10/29/2002	9/27/02	975.00	70.74
	11/26/2002	10/29/02	890.00	58.93
	11/28/2001	10/29/01	840.00	65.82
	12/28/2001	11/28/01	829.33	53.47
	12/30/2002	11/26/02	909.41	51.84
	2/27/2001	1/30/01	754.29	56.25
	2/27/2002	1/31/02	829.63	50.84
	2/27/2003	1/30/03	932.86	51.39
	3/27/2002	2/27/02	830.00	56.50
	3/29/2001	2/27/01	758.67	55.35
	3/31/2003	2/27/03	842.50	59.19
	4/27/2001	3/29/01	743.45	69.79
	4/29/2002	3/27/02	861.82	71.27
	4/29/2003	3/31/03	1019.31	59.19
	5/30/2001	4/27/01	739.39	75.82
	5/31/2002	4/29/02	896.25	76.73
	6/28/2001	5/30/01	954.48	81.83
	6/28/2002	5/31/02	964.29	81.75
	7/30/2001	6/28/01	992.50	85.70
	7/31/2002	6/28/02	968.48	82.38
	8/29/2001	7/30/01	1001.33	87.12
	8/29/2002	7/31/02	1091.03	84.17
	9/19/2001	8/29/01	954.29	80.90
	9/27/2001	9/19/01	760.00	76.44
	9/27/2002	8/29/02	1031.72	80.34

CHAPTER IV

METHODOLOGY

The purpose of this study was to predict monthly energy consumption and annual use patterns for convenience stores in College Station, Texas. The selected models were 1) nonlinear regression models which established annual, weather-related patterns of energy usage and 2) multiple regression model used to predict the effect of several independent variables on energy use.

4.1 The research protocol

First, the researcher collected dependent and independent data from both site survey and internet. The next step was to use regression statistics to analyze the data and build prediction models. Finally, these models were used to predict average daily energy consumption (kWh/day) for each store each month from long-term monthly temperature averages.

4.1.1 Sample size selection

The sample size was all convenience stores in College Station, Texas, USA. There were totally 33 convenience stores, but three of them had incomplete data so this study could do only 30 convenience stores.

4.2 Variables collections

4.2.1 Dependent variable

Average energy consumption per month from 2002 to 2003 for all convenience stores was obtained from the College Station Utility.

4.2.2 Independent variables

Independent variables were selected based on the literature review. The results showed that weather variables, taxable value, main equipment variables, internal load, working hours, and orientation of fronts, affected energy consumption for residential buildings.

Data were collected by three different methods. The first method by site survey was included: lighting bulbs, refrigerator units, working hours, and orientations of store front. Data collection from the Internet was weather data, area, and taxable value. Second, the weather data was from National Oceanic and Atmospheric Administration website and taxable value and area were collected from the Brazos County Appraisal District website. Lastly, data derived from the analysis of nonlinear regression models were efficiencies, and knots temperature.

4.3 Statistical procedures

All statistical analysis, descriptive, and correlative statistics were analyzed by using SPSS version 11.0 for the personal computer. Collecting and manipulating data were done by spreadsheet, Microsoft EXCEL 2002, version 10.

4.3.1 Variables analysis

Variable analysis was done by using correlation in Fig. 4.1 and Table 4.1. The purpose of this process was to measure the relation between average daily energy consumption and the proposed independent variables, and to measure the relation among independent variables. Pearson correlation was used during this evaluation. It assumed that at least two variables are measured at interval scales. It determined the level to which the values of the two variables are proportional to each other. It should be noted that the value of correlation was on the relation. If the independents were linearly related, the resulting correlation was proportional. It could be described by the slope of the regression line that indicated the strength of the correlation, and where the correlation was strongly positive or strongly negative. The result showed that the regression line was close to the 45 degree slope. If there was a very low correlation; the line would be nearly horizontal (as illustrated by a scatter plot).

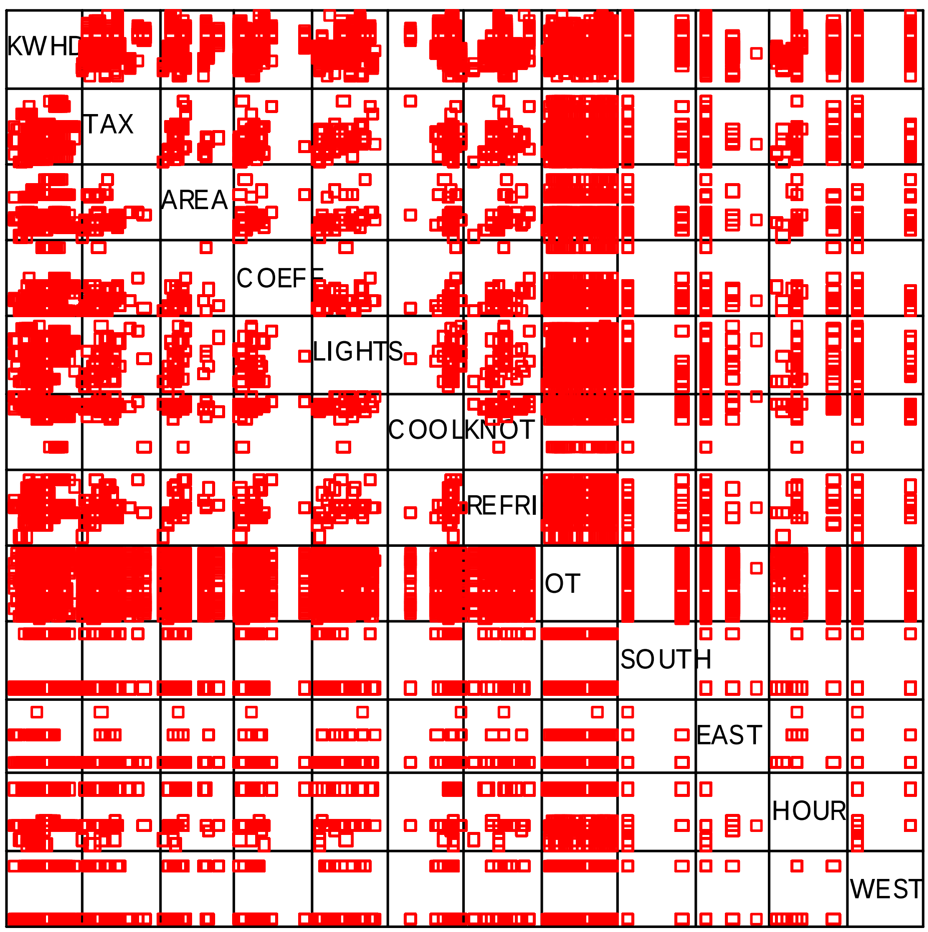


Fig. 4.1 Matrix Relationships among Variables.

Table 4.1 Correlation among Variables for Datasets.

Correlations

		KWHD	TAX	AREA	COEFF	LIGHTS	COOLKNOT	REFRIG	OT	SOUTH	EAST	HOUR	WEST
KWHD	Pearson Correlation	1	.359*	.337*	.326*	.321*	-.291*	.249*	.156*	.113*	-.077*	.055	.033
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.000	.001	.025	.113	.340
	N	835	835	835	835	835	835	835	835	835	835	835	835
TAX	Pearson Correlation	.359*	1	.102*	.091*	.615*	-.367*	.249*	.009	-.002	.046	.175*	-.185*
	Sig. (2-tailed)	.000	.	.003	.008	.000	.000	.000	.790	.945	.181	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
AREA	Pearson Correlation	.337*	.102*	1	.313*	.382*	-.084*	.400*	-.002	-.226*	.180*	.103*	.305*
	Sig. (2-tailed)	.000	.003	.	.000	.000	.015	.000	.964	.000	.000	.003	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
COEFF	Pearson Correlation	.326*	.091*	.313*	1	.145*	.375*	.207*	.009	-.057	.083*	.201*	-.172*
	Sig. (2-tailed)	.000	.008	.000	.	.000	.000	.000	.800	.100	.017	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
LIGHTS	Pearson Correlation	.321*	.615*	.382*	.145*	1	-.036	.316*	.013	-.260*	-.054	.122*	.079*
	Sig. (2-tailed)	.000	.000	.000	.000	.	.293	.000	.716	.000	.119	.000	.023
	N	835	835	835	835	835	835	835	835	835	835	835	835
COOLKNOT	Pearson Correlation	-.291*	-.367*	-.084*	.375*	-.036	1	.095*	.004	.024	.207*	.177*	-.024
	Sig. (2-tailed)	.000	.000	.015	.000	.293	.	.006	.910	.485	.000	.000	.489
	N	835	835	835	835	835	835	835	835	835	835	835	835
REFRIG	Pearson Correlation	.249*	.249*	.400*	.207*	.316*	.095*	1	.002	.186*	.036	.262*	.145*
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.006	.	.954	.000	.304	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
OT	Pearson Correlation	.156*	.009	-.002	.009	.013	.004	.002	1	.006	.051	.003	-.012
	Sig. (2-tailed)	.000	.790	.964	.800	.716	.910	.954	.	.872	.137	.921	.732
	N	835	835	835	835	835	835	835	835	835	835	835	835
SOUTH	Pearson Correlation	.113*	-.002	-.226*	-.057	-.260*	.024	.186*	.006	1	-.188*	.359*	-.381*
	Sig. (2-tailed)	.001	.945	.000	.100	.000	.485	.000	.872	.	.000	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
EAST	Pearson Correlation	-.077*	.046	.180*	.083*	-.054	.207*	.036	.051	-.188*	1	-.197*	-.188*
	Sig. (2-tailed)	.025	.181	.000	.017	.119	.000	.304	.137	.000	.	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
HOUR	Pearson Correlation	.055	.175*	.103*	.201*	.122*	.177*	.262*	.003	.359*	-.197*	1	-.074*
	Sig. (2-tailed)	.113	.000	.003	.000	.000	.000	.000	.921	.000	.000	.	.033
	N	835	835	835	835	835	835	835	835	835	835	835	835
WEST	Pearson Correlation	.033	-.185*	.305*	-.172*	.079*	-.024	.145*	-.012	-.381*	-.188*	-.074*	1
	Sig. (2-tailed)	.340	.000	.000	.000	.023	.489	.000	.732	.000	.000	.033	.
	N	835	835	835	835	835	835	835	835	835	835	835	835

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.3.2 Nonlinear regression models

Nonlinear regression models were used in determining the base load, cooling and heating efficiencies, and the knot temperature for each building. This process was used to construct annual patterns of energy usage for all convenience stores: where T_{avg} was the daily average of billing period outside temperature, T_{cool} was the outdoor average temperature at which cooling began, cooling knot; and T_{heat} was the outdoor average temperature at which heating began, heating knot. The base load is B_0, non-weather-related consumption. B_1 can be thought of as the heating efficiency and B_2 the cooling efficiency. The interval T_{heat} - T_{cool} along the x axis can be thought of as a dead band where energy is neither used for heating nor cooling. For some buildings, there is no dead band, no B_0, no outdoor average daily temperature over a billing cycle for which there is never any heating or cooling energy used.

All nonlinear regression models were based on the following hypothesis:

$$H_0 \quad : \quad B = 0$$

$$H_a \quad : \quad B \neq 0$$

The next model was for the convenience stores that used both heating and cooling over the study period. In this model, shown in Fig. 4.2 (a), there is B_0 because there is a dead band over which energy consumption remained constant and outdoor temperature does not effect. The assumed slope was zero.

Next, it was another type for heating and cooling systems in Fig. 4.2 (b). There is no dead band. It had a common change point where both heating and cooling temperature begin. For this model there is no outdoor average temperature for which there is no heating or cooling.

The statistical model for stores using both heating and cooling:

$$kWh/day = B_0 + B_1 Min((T_{avg}-T_{heat}),0) + B_2 Max((T_{avg}-T_{cool}),0) + error \qquad (4.1)$$

The third model was for the convenience stores that used only heating. When the temperature dropped, energy consumption rose. (See in Fig. 4.2 (c)) That made energy consumption vary according to outside temperature. There is also a base load, B_0.

The statistical model for using heating only:

$$kWh/day = B_0 + B_1 Min((T_{avg}-T_{heat}),0) + error \qquad (4.2)$$

The fourth model was for the convenience stores that used only air-conditioning. When outdoor temperature rose the energy consumption also rose. (See in Fig. 4.2 (d,e)) This behavior pattern correlated with particular change in outside temperature. Some buildings could show no B_0, which was the base load. This probably means that the outdoor average temperature never got low enough for cooling not to be necessary.

The model for using cooling only:

$$kWh/day = B_0 + B_2 Max((T_{avg}-T_{cool}),0) + error \qquad (4.3)$$

4.3.2.1 Procedures

1. A plot of the energy consumption against the billing period mean outdoor temperature revealed the annual patterns of energy consumption, and allowed me to visually estimate heating and cooling knots.

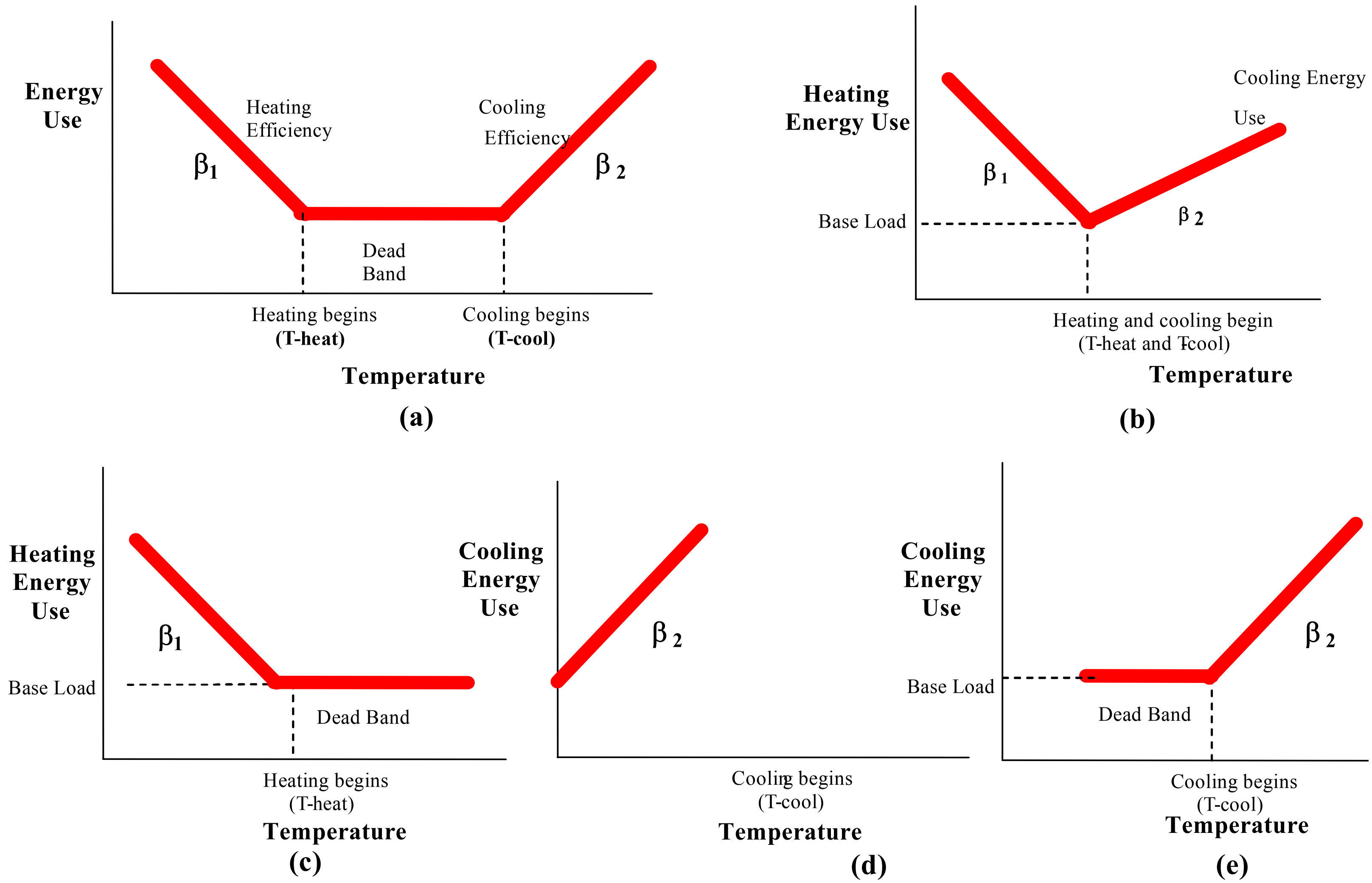
2. A nonlinear regression model was begun from the visual estimate of cooling and heating knot, and base load.

3. A nonlinear regression model was used to find the knots, the intercepts, the slopes of the regression lines, and the base load. The results of this analysis predicted energy consumption and annual patterns for all convenience stores.

4. Plots of the nonlinear regression model provided a comparative picture of yearly use patterns through heating/cooling seasons. A typical nonlinear regression pattern shows electrical kWh usage plotted against outside temperature. Measures of efficiency were the rate of slope of the inclined lined and the length of the flat line between the knot temperatures. Not all of the convenience stores were electrically heated and cooled so the configuration of the plots varied.

5. Comparisons of predicted value with the segment and parabola estimation.

Fig. 4.2 Segment Regression Models: (a), (b) Heating and cooling systems, (c) Heating only system, and (d), (e) Cooling system only.



4.3.3 Multiple regression procedure

4.3.3.1 Checking assumptions

Ho: Zero expectation: E (ε_i) = 0 for all i.

The first assumption, zero expectation, deals with model selection and additional independent variables that are needed to be included in the model.

Ho: Constant variance: V (ε_i) = δ_i for all i.

The variability of the dependent variable should be the same for all values of every independent variable. Studying scatterplots, if the plot of the standardized residual (Zre) and unstandardized predicted residual (Pre_d) fail to show normal distribution, the higher order model method will be applied.

Ho: Normality test: ε_i is normally distributed.

The test was used to assume the errors around the idealized regression model at any specified values of the independent variables follow a normal model. The property of normality can be examined by the plot of residuals. The skewness or outliers can be detected by the plot of residuals. If the plot of the standardized residual (Zre) versus independent variables shows non normal distribution, a transformation will be applied to make the data normal.

Ho: Independence: the ε_i is independent.

The independence assumption concerns the errors, so checking the corresponding conditions on the residuals is required. When the time sequence of the observations is taken, it is possible to construct a plot of the residuals versus time to observe where the residuals are serially correlated. A formal test is based on the Durbin-Watson Statistic. *ê* denotes the residual at time *t* and *n* the total number of time points.

$$d = \frac{\Sigma_{t=1}^{n-1} (\hat{e}_{t+1} - \hat{e}_{t})^2}{\Sigma_t \hat{e}_t^2} \qquad (4.4)$$

When there is no serial correlation, the expected value of the Durbin-Watson test statistics *d* is approximately 2.0; positive serial correlation when *d* is less than 2.0 and negative serial correlation when *d* is more than 2.0. (Ott, R. L. & Longnecker, 2001)

After testing the data with four main hypotheses, the next step was to perform the prediction models as described by the following processes.

4.3.2.2 The use of multiple regression analysis

Finding the response regressions was the best combination of the variables which would serve as predictors, by running the multiple regression model with stepwise, forward selection, and backward elimination. Variables combination in the multiple regression model was composed of two main variables. First was dependent variable, daily average energy consumption per billing cycle (kWh/day). Because of the inconsistent length of billing periods the electrical usage during a billing period had to be transformed to the average kWh per day during a billing period. Second, the independent variables included outdoor temperature, internal loads: refrigerator units and lighting bulbs, area, working hours, taxable value, orientations of front, efficiencies, and knots temperature. The model as showed in the equation (4.5). After selecting the best model from the techniques, a final run of the multiple regression procedure provided a printout of the plot of the prediction models.

$$kWh/day = B_0 + B_1X_1 + B_2X_2 + \ldots. + B_kX_k + e \quad (4.5)$$

where

B_0 = Intercept

B_1 = Slope of the line for X_1, the predicted change in y when there is one unit changed in X_1.

B_k = Slope of the line for X_k, the predicted change in y when there is one unit changed in X_k.

4.3.3.2 Procedure: details analysis

Variance inflation factors (VIF)

VIF and eigen analysis of matrix were used to detect multiple collinearity of independent variables when doing the regression techniques. The VIF value for the normal data is approximately 1 to 2.

Box-Cox transformation

If some data did not meet the normality hypothesis requirement, residual analysis was required. Diagnostic analysis of the residuals from the regression models revealed errors that were heterogeneous and often non-Gaussian. The objective was usually to make the residuals of the regression closer to a normal distribution. A Box-Cox power transformation on the dependent variable is a useful method to alleviate heteroscedasticity when the distribution of the dependent variable is not known. From the Fig. 4.3, it showed that this data was not normal distribution, and then transformation had to be used. For situations in which the dependent variable Y is known to be positive, the following transformation can be used:

$$Y_i^{(\lambda)} = Y_i^{\lambda} - 1 \quad \text{when } \lambda \neq 0$$

$$= \log (Y_i) \text{ when } \lambda = 0$$

Some data did not work using Box-Cox transformation so the next step was to use arc*sin transformation method.

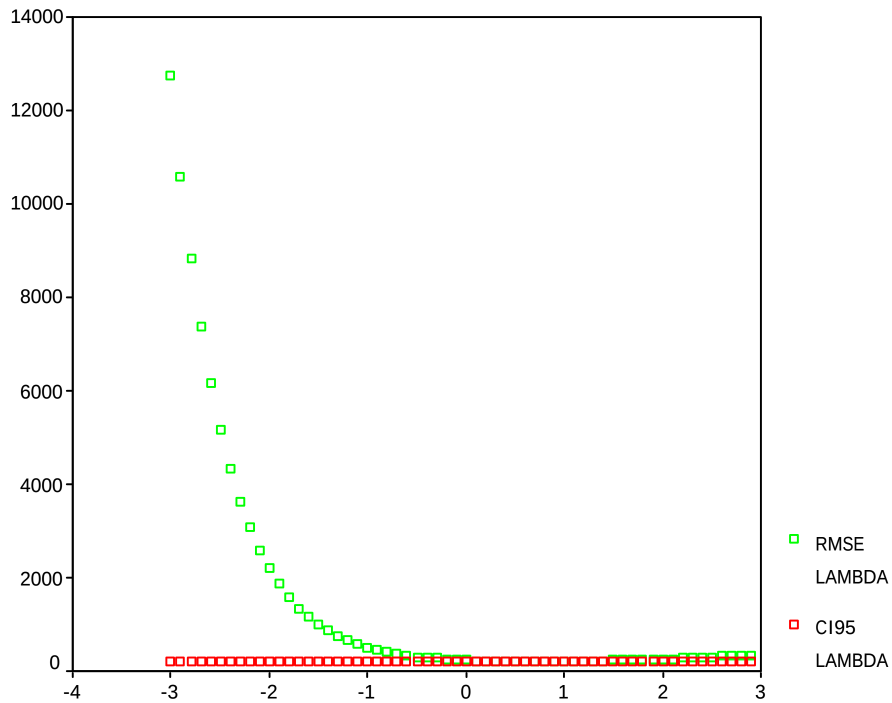


Fig. 4.3 Box – Cox Plot Analysis.

CHAPTER V

RESEARCH RESULTS

The research results are divided into four parts. First, descriptive analysis of raw data analyzes raw data for primary investigating data. Second, correlation analysis utilizes the relationship among variables. Third, analysis of the patterns of annual energy usage is presented by nonlinear regression models: parabola and segment models. Finally, analysis of variables and yearly prediction models are analyzed by using multiple regression model.

5.1 Descriptive analysis

The descriptive result in Table 5.1 reports the physical characteristics of 30 convenience stores, which collected a total of 835 observation data. The result shows that the mean value for daily energy consumption (kWh/day) is 670.72, standard deviation is 280.91, and skewness is 0.413, which means positive skewness or skewness on the right.

Table 5.1 Descriptive Statistics.

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
KWHD	835	1511.97	8.03	1520.00	670.7211	280.9147	.413	.085
SOUTH	835	2	0	2	.10	.303	2.811	.085
EAST	835	1	0	1	.28	.450	.974	.085
WEST	835	1	0	1	.28	.451	.967	.085
REFRIG	835	12	8	20	14.32	2.837	.240	.085
LIGHTS	835	129.00	32.00	161.00	84.0383	35.48544	.363	.085
AREA	835	7640	540	8180	3155.03	1836.787	1.134	.085
TAX	835	243560	7000	250560	96704.93	59754.69	.822	.085
HOUR	835	9	15	24	19.87	3.114	.438	.085
OT	835	44.86	42.71	87.57	66.0126	13.60526	.056	.085
COEFF	835	17.61	1.26	18.87	4.7997	3.48989	2.210	.085
COOLKNOT	835	205.78	-113.02	92.76	45.0295	34.33055	-3.248	.085
Valid N (listwise)	835							

5.2 Correlation analysis

The correlation analysis in Table 5.2 is divided into two parts. The first part analyzed the relationship between dependent and individual independent variables, and the next part analyzed the relation among pairs of independent variables.

Daily energy consumption (kWh/day) correlated significantly with taxable value, area, cooling efficiency, number of lights, average outdoor temperature at which heating begins, number of refrigeration units, outside average temperature over a billing period, south orientation and east orientation. These correlations were all significant at $p < .05$ and indicate potential influence on store energy use, kWh per day.

All but two of these correlations were positive. This indicates that the value of the dependent variable, kWh/day, increases as the independent variable values increase. Cooling knot, the outdoor average temperature at which cooling begins, and East Orientation were both negative. This indicates that energy consumption decreases as the outdoor temperature at which cooling begins increases. It also indicates that energy consumption is slightly less for stores whose front faces east.

Correlations over 0.5 between independent variables warn of potential problems with multicolinearity. Only one variable pair exhibits this characteristic. It is Tax vs Number of lights. This correlation was significant at $p < .000$ and consequently, it may not be possible to include both as independent variables in a regression model.

Table 5.2 Correlation among Variables.

Correlations

		KWHD	TAX	AREA	COEFF	LIGHTS	COOLKNOT	REFRIG	OT	SOUTH	EAST	HOUR	WEST
KWHD	Pearson Correlation	1	.359*	.337*	.326*	.321*	-.291*	.249*	.156*	.113*	-.077*	.055	.033
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.000	.001	.025	.113	.340
	N	835	835	835	835	835	835	835	835	835	835	835	835
TAX	Pearson Correlation	.359*	1	.102*	.091*	.615*	-.367*	.249*	.009	-.002	.046	.175*	-.185*
	Sig. (2-tailed)	.000	.	.003	.008	.000	.000	.000	.790	.945	.181	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
AREA	Pearson Correlation	.337*	.102*	1	.313*	.382*	-.084*	.400*	-.002	-.226*	.180*	.103*	.305*
	Sig. (2-tailed)	.000	.003	.	.000	.000	.015	.000	.964	.000	.000	.003	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
COEFF	Pearson Correlation	.326*	.091*	.313*	1	.145*	.375*	.207*	.009	-.057	.083*	.201*	-.172*
	Sig. (2-tailed)	.000	.008	.000	.	.000	.000	.000	.800	.100	.017	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
LIGHTS	Pearson Correlation	.321*	.615*	.382*	.145*	1	-.036	.316*	.013	-.260*	-.054	.122*	.079*
	Sig. (2-tailed)	.000	.000	.000	.000	.	.293	.000	.716	.000	.119	.000	.023
	N	835	835	835	835	835	835	835	835	835	835	835	835
COOLKNOT	Pearson Correlation	-.291*	-.367*	-.084*	.375*	-.036	1	.095*	.004	.024	.207*	.177*	-.024
	Sig. (2-tailed)	.000	.000	.015	.000	.293	.	.006	.910	.485	.000	.000	.489
	N	835	835	835	835	835	835	835	835	835	835	835	835
REFRIG	Pearson Correlation	.249*	.249*	.400*	.207*	.316*	.095*	1	.002	.186*	.036	.262*	.145*
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.006	.	.954	.000	.304	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
OT	Pearson Correlation	.156*	.009	-.002	.009	.013	.004	.002	1	.006	.051	.003	-.012
	Sig. (2-tailed)	.000	.790	.964	.800	.716	.910	.954	.	.872	.137	.921	.732
	N	835	835	835	835	835	835	835	835	835	835	835	835
SOUTH	Pearson Correlation	.113*	-.002	-.226*	-.057	-.260*	.024	.186*	.006	1	-.188*	.359*	-.381*
	Sig. (2-tailed)	.001	.945	.000	.100	.000	.485	.000	.872	.	.000	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
EAST	Pearson Correlation	-.077*	.046	.180*	.083*	-.054	.207*	.036	.051	-.188*	1	-.197*	-.188*
	Sig. (2-tailed)	.025	.181	.000	.017	.119	.000	.304	.137	.000	.	.000	.000
	N	835	835	835	835	835	835	835	835	835	835	835	835
HOUR	Pearson Correlation	.055	.175*	.103*	.201*	.122*	.177*	.262*	.003	.359*	-.197*	1	-.074*
	Sig. (2-tailed)	.113	.000	.003	.000	.000	.000	.000	.921	.000	.000	.	.033
	N	835	835	835	835	835	835	835	835	835	835	835	835
WEST	Pearson Correlation	.033	-.185*	.305*	-.172*	.079*	-.024	.145*	-.012	-.381*	-.188*	-.074*	1
	Sig. (2-tailed)	.340	.000	.000	.000	.023	.489	.000	.732	.000	.000	.033	.
	N	835	835	835	835	835	835	835	835	835	835	835	835

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5.3 Annual prediction models

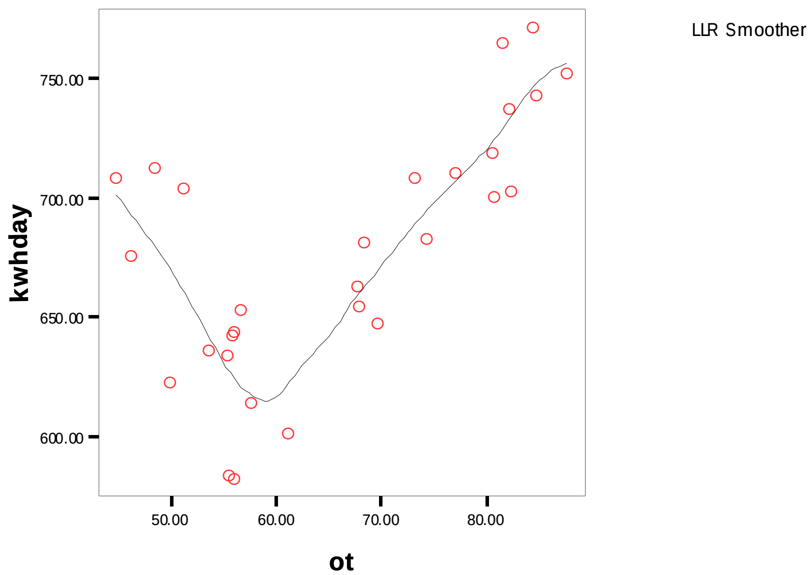
5.3.1 Nonlinear regression models: parabola regression models

Testing relationship between outdoor temperature and daily energy consumption is analyzed by using scatter plot with smoother method. Some convenience stores show curve relationship between energy consumption and outdoor temperature as shown in Fig. 5.1 (a-c). From the test, the power of outdoor temperature is introduced to add as a new variable in the parabola regression models; as the results, the r-squares for some convenience stores are increased.

$$\text{kWh/day} = B_0 + B_1OT + B_2OT^2 \qquad (5.1)$$

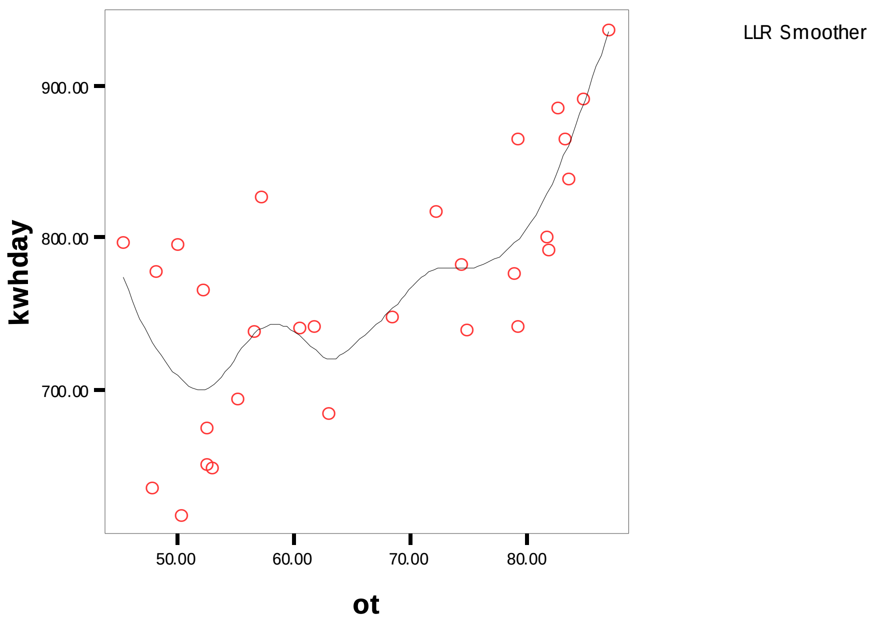
5.3.2.1 Results

The results of the parabola regression models on data from convenience stores numbers (125530, 170988, and 187564) is shown in the Tables 5.3A - 5.3C. The adjusted r-square results are 0.672, 0.524, and 0.526, with confidence interval 0.05, respectively. Finally, the plots of actual and predicted values are shown in Fig. 5.2A – 5.2C.



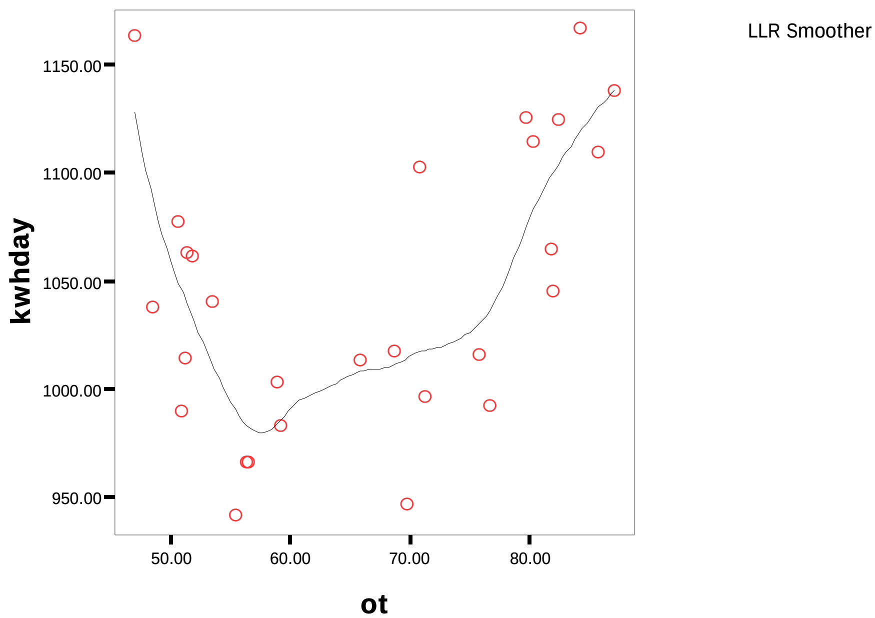
(a)

Fig. 5.1 Trend Line Analysis by Using Scatter Plot with Smoother Methodology for the Convenience Store Numbers (a) 125530, (b) 170988, and (c) 187564.



(b)

Fig. 5.1 Continued.



(c)

Fig. 5.1 Continued.

Table 5.3A Analysis of Variance from Parabola Regression Model for the Convenience Store Number 125530. Model Summary, ANOVA, Coefficients, and Residual Statistics.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.834[a]	.695	.672	29.88630

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	53001.22	2	26500.609	29.670	.000[a]
	Residual	23222.97	26	893.191		
	Total	76224.19	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1385.657	179.125		7.736	.000
	OT	-24.806	5.556	-6.413	-4.464	.000
	OT2	.205	.042	7.074	4.925	.000

a. Dependent Variable: KWHDAY

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	635.8219	786.5161	677.7221	43.50748	29
Residual	-57.2017	50.8294	.0000	28.79916	29
Std. Predicted Value	-.963	2.501	.000	1.000	29
Std. Residual	-1.914	1.701	.000	.964	29

a. Dependent Variable: KWHDAY

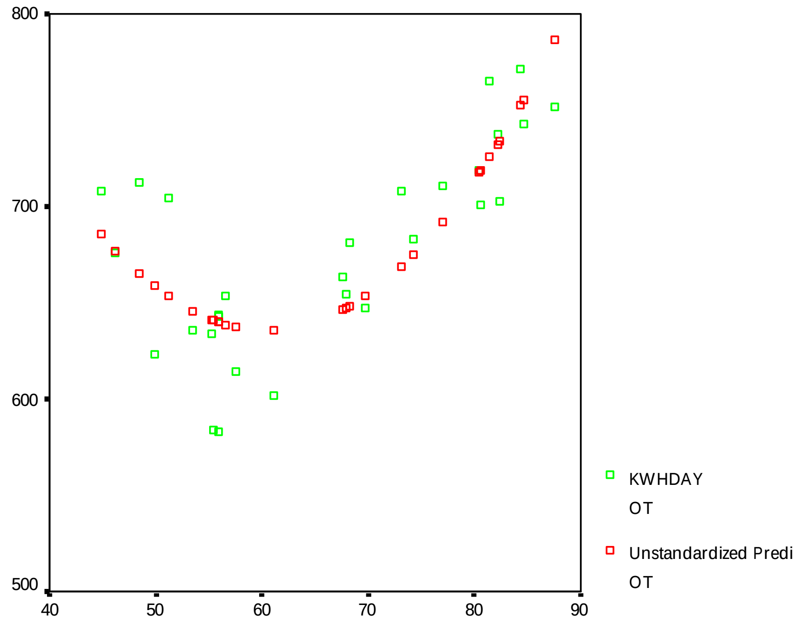


Fig. 5.2A Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 125530.

Table 5.3B Analysis of Variance from Parabola Regression Model for the Convenience Store Number 170988. Model Summary, ANOVA, Coefficients, and Residual Statistics.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.747[a]	.558	.524	56.14493

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	103607.2	2	51803.615	16.434	.000[a]
	Residual	81958.58	26	3152.253		
	Total	185565.8	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1342.747	368.331		3.645	.001
	OT	-22.357	11.490	-3.854	-1.946	.063
	OT2	.198	.086	4.548	2.296	.030

a. Dependent Variable: KWHDAY

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	711.6330	896.3011	767.8655	60.82975	29
Residual	-101.7827	114.9197	.0000	54.10261	29
Std. Predicted Value	-.924	2.111	.000	1.000	29
Std. Residual	-1.813	2.047	.000	.964	29

a. Dependent Variable: KWHDAY

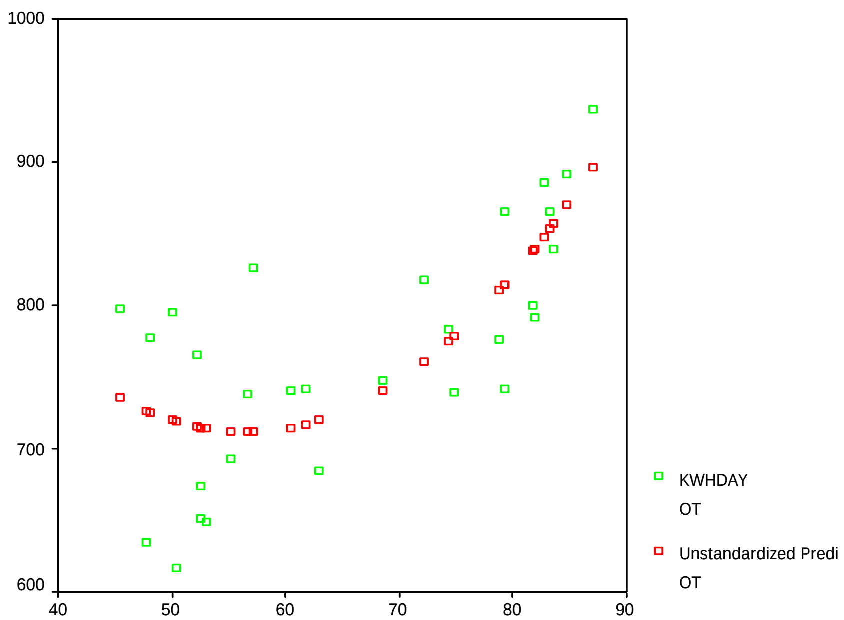


Fig. 5.2B Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 170988.

Table 5.3C Analysis of Variance from Parabola Regression Model for the Convenience Store Number 187564. Model Summary, ANOVA, Coefficients, and Residual Statistics.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.749[a]	.561	.526	45.06028

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	64838.94	2	32419.469	15.967	.000[a]
	Residual	50760.72	25	2030.429		
	Total	115599.7	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2374.894	307.465		7.724	.000
	OT	-43.450	9.504	-8.976	-4.572	.000
	OT2	.339	.071	9.396	4.786	.000

a. Dependent Variable: KWHDAY

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	985.4210	1165.603	1045.707	49.00451	28
Residual	-68.4213	102.8124	.0000	43.35928	28
Std. Predicted Value	-1.230	2.447	.000	1.000	28
Std. Residual	-1.518	2.282	.000	.962	28

a. Dependent Variable: KWHDAY

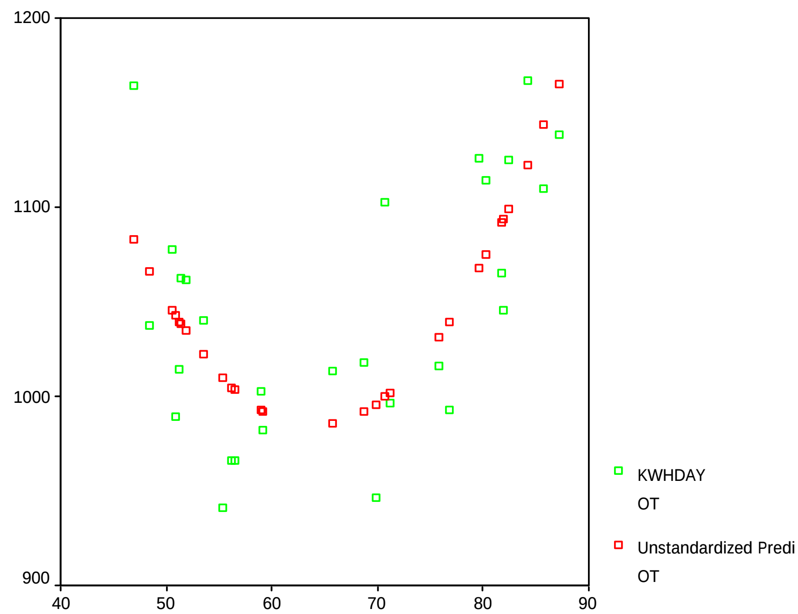
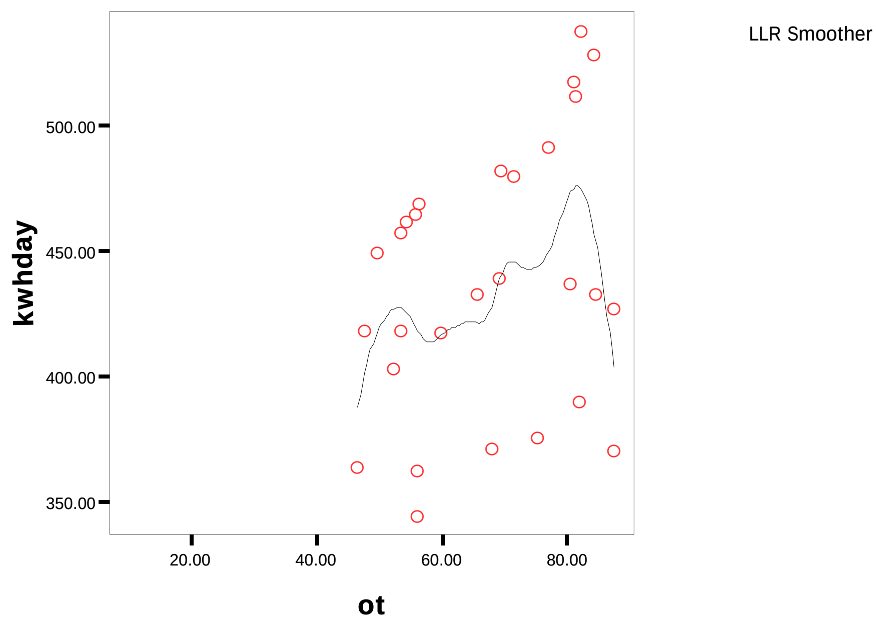


Fig. 5.2C Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 187564.

5.3.2 The data with no trend

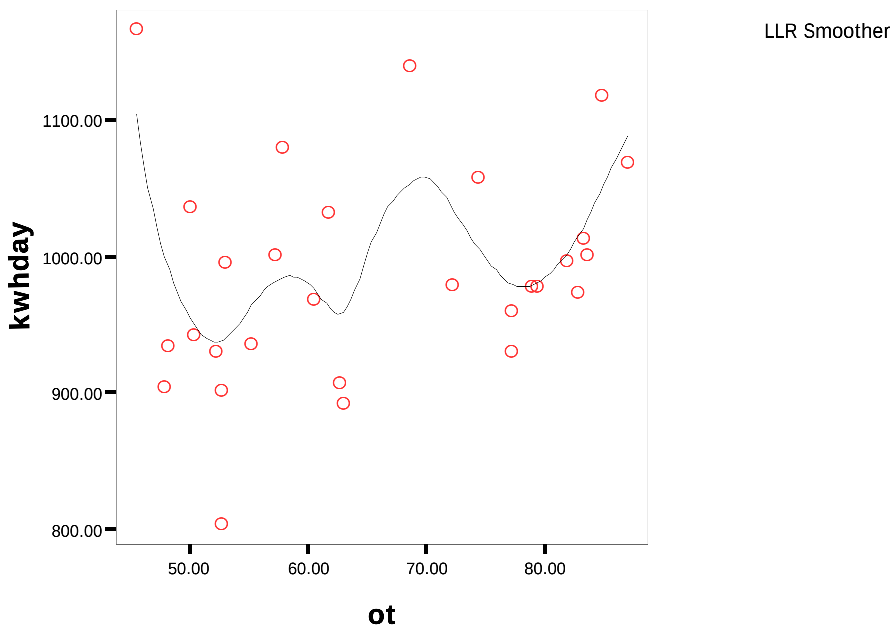
The scatter plots with smoother method of the daily energy consumption (kWh/day) against average daily temperature per billing cycle (degree Fahrenheit) in convenience stores 137580, 151242, and 173466 are randomly distributed shown in Fig. 5.3 (a-c). Most of the trends are up and down with no rhythm which is difficult for setting up the prediction models.

Conducting the parabola and segment regression models are introduced because there are some trends from the data that should explain by using these models. However the results are not good, the prediction models can be explained solitary less than 10 percent of the overall data as shown in the Table 5.4, Table 5.5, and Fig. 5.4.



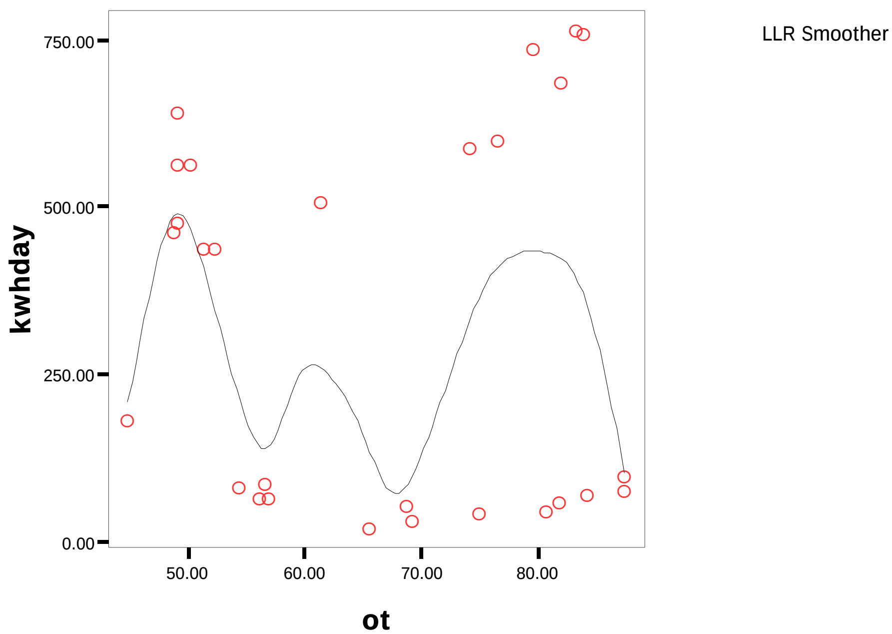
(a)

Fig. 5.3 Trend Line Analysis by Using Scatter Plot with Smoother Methodology for the Convenience Store Numbers: (a) 137580, (b) 151242, and (c) 173466.



(b)

Fig. 5.3 Continued.



(c)

Fig. 5.3 Continued.

Table 5.4 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 137540. Model Summary, ANOVA, Coefficients, and Residual Statistics.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.341[a]	.116	.046	52.23638

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8970.015	2	4485.008	1.644	.213[a]
	Residual	68215.98	25	2728.639		
	Total	77185.99	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	157.066	344.488		.456	.652
	OT	7.278	10.532	1.855	.691	.496
	OT2	-4.45E-02	.078	-1.536	-.572	.572

a. Dependent Variable: KWHDAY

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	399.5895	454.6434	437.5350	18.22698	28
Residual	-82.7740	83.2439	.0000	50.26448	28
Std. Predicted Value	-2.082	.939	.000	1.000	28
Std. Residual	-1.585	1.594	.000	.962	28

a. Dependent Variable: KWHDAY

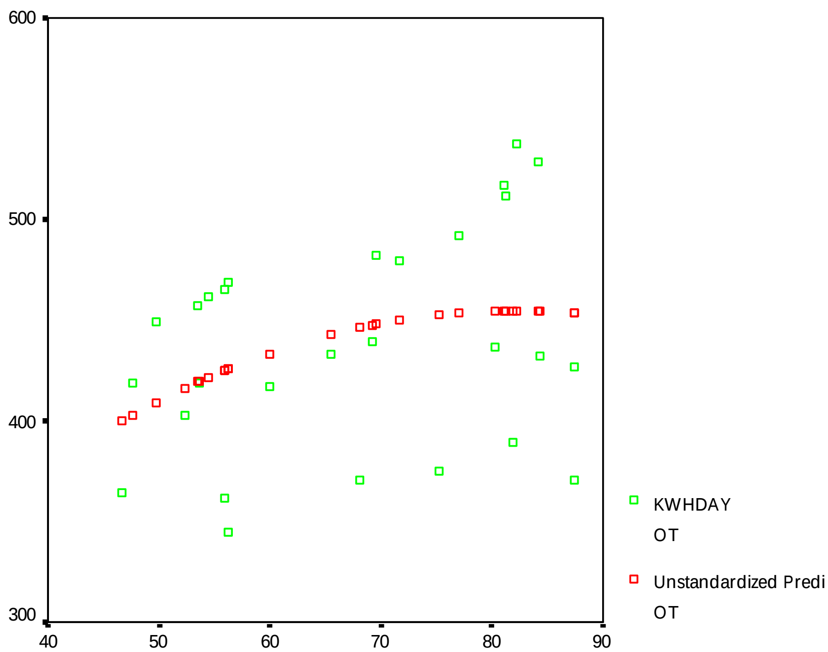


Fig. 5.4 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 137540.

Table 5.5 Analysis of Variance Table from Segment Regression Model for the Convenience Store Number 137540.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

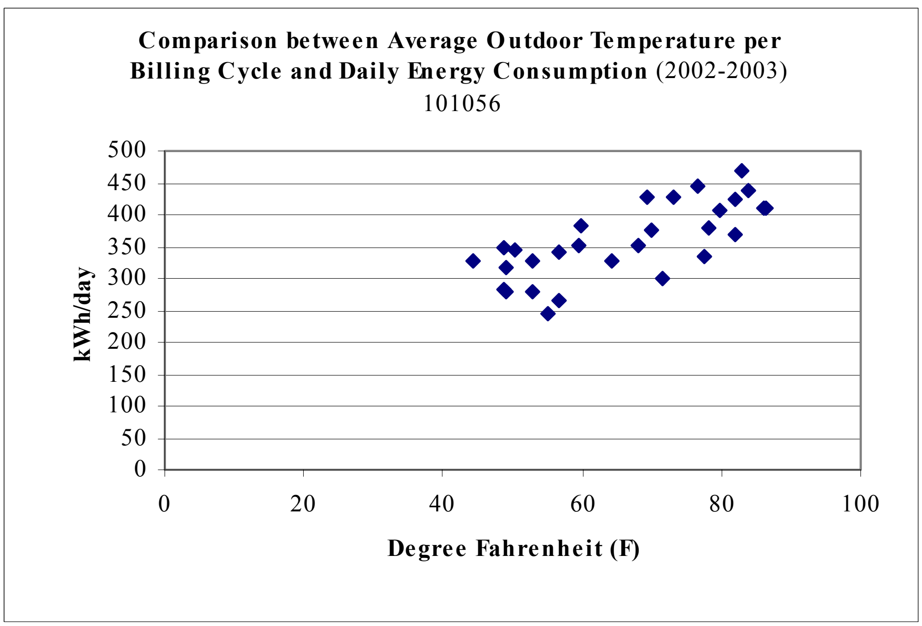
Source	DF	Sum of Squares	Mean Square
Regression	5	5368309.9501	1073661.99002
Residual	23	69108.57870	3004.72081
Uncorrected Total	28	5437418.5288	
(Corrected Total)	27	77185.99450	

R squared = 1 - Residual SS / Corrected SS = .10465

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	351.94775110	53.218486473	241.85692404	462.03857816
B_2	1.269013400	.773984195	-.332094894	2.870121695

5.3.3 Nonlinear regression models: segment regression model

From the previous research; Taylor and Buizza (2003), Sailor (2001), and Ramamathan, et al. (1997) expected that outdoor temperature would be an important predictor of energy consumption. The data analysis process is begun by the plotting average daily energy consumption per billing period (kWh/day) against average daily outdoor temperature per billing period (degree Fahrenheit, F). The plots from Fig. 5.5a-d show that outdoor temperature and daily energy consumption are related or have trends.



(a)

Fig. 5.5 Comparison between Average Outdoor Temperature and Daily Energy Consumption for the Convenience Store Numbers: (a) 101056, (b) 117218, (c) 120400, and (d) 120424.

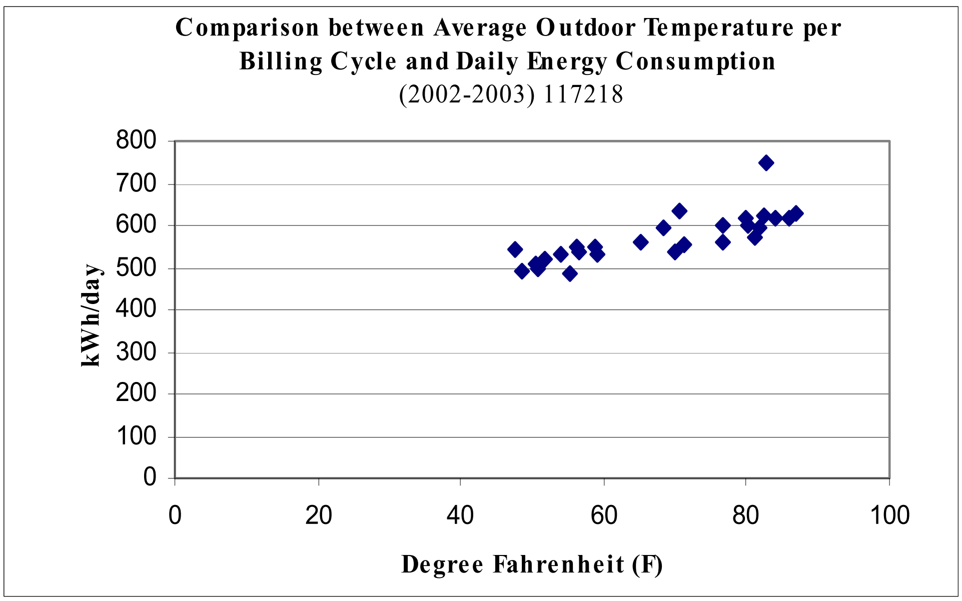


Fig. 5.5 Continued.

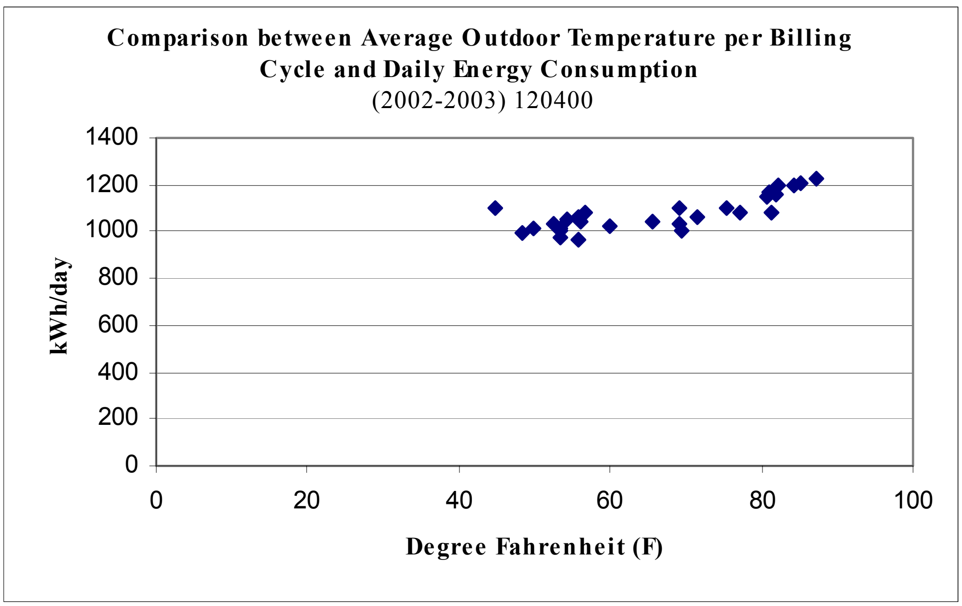


Fig. 5.5 Continued.

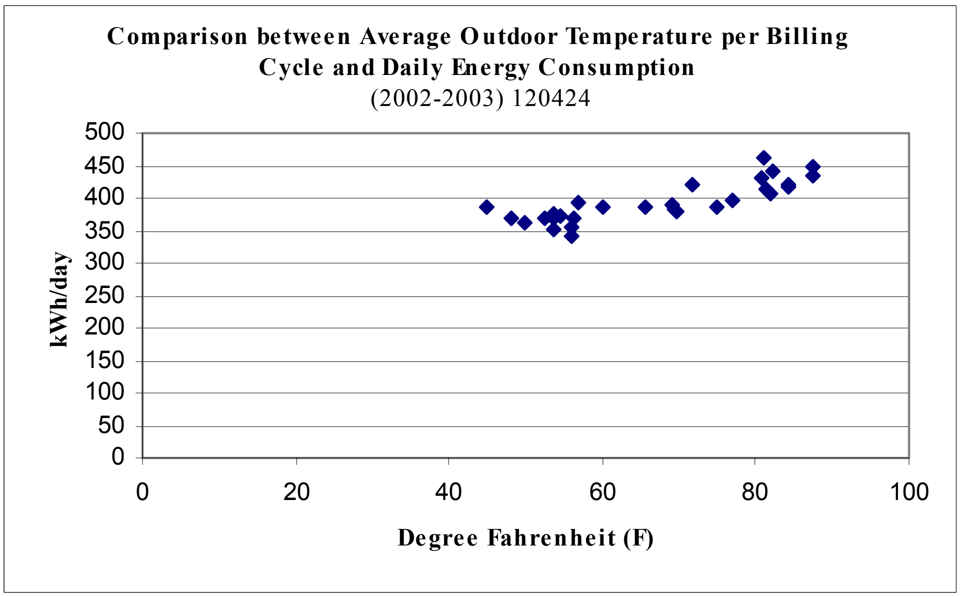


Fig. 5.5 Continued.

5.3.3.1 Cool-only with no base load

The nonlinear regression process comes up with the linear regression model. Parameter estimates for cooling begins (T_{cool}) and cooling efficiencies (B_2) as shown in Fig. 5.6. Tables 5.6A–5.6C show the analysis of variance for linear regression models, which use to estimate the cooling efficiencies. The adjusted r-square results from the convenience store numbers (133124, 171034, and 173540) are 0.87, 0.85, and 0.72, with confidence interval 0.05, respectively. At last, the plot of actual and predicted value revealed in Figs. 5.7A – 5.7C.

$$\text{kWh/day} = B_0 + B_2 \text{Max}((T_{avg} - T_{cool}), 0) + \text{error} \qquad (5.2)$$

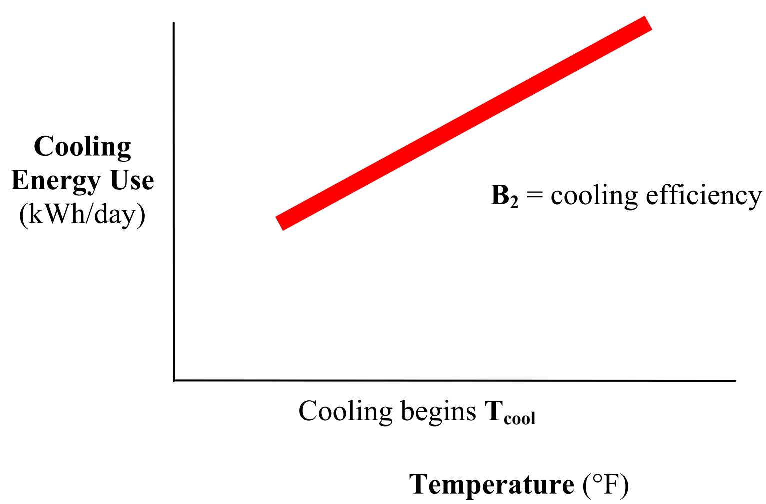


Fig. 5.6 Segment Regression Model: Cooling System with No Base Load.

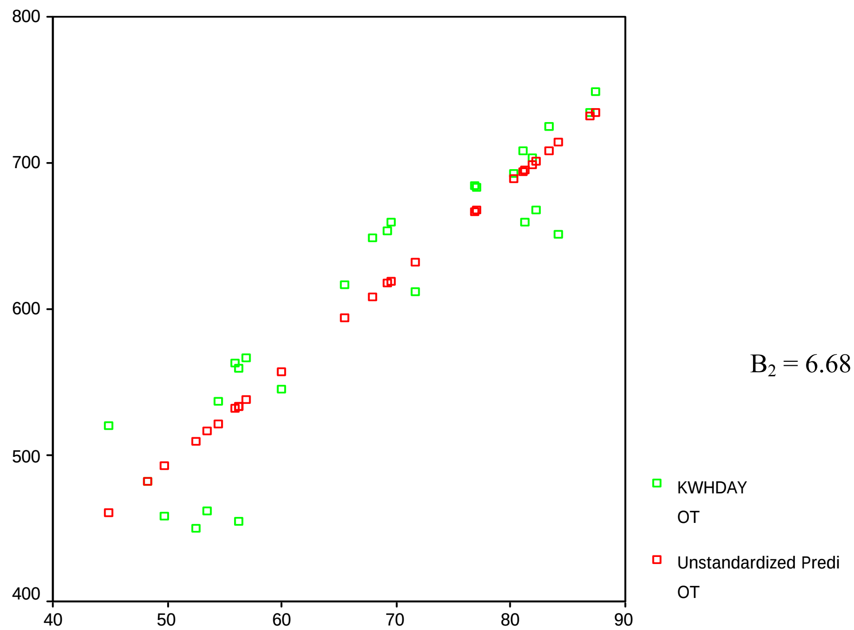
Table 5.6A Analysis of Variance from Segment Regression Model for the Convenience Store Number 133124.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	10223193.8433	2044638.76865
Residual	22	30553.06634	1388.77574
Uncorrected Total	27	10253746.9096	
(Corrected Total)	26	232991.73781	

R squared = 1 - Residual SS / Corrected SS = .86887

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	153.60698265	45.632482191	58.971006813	248.24295849
B_2	6.680283751	.638333134	5.356461856	8.004105646



$B_2 = 6.68$

Fig. 5.7A Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 133124.

Table 5.6B Analysis of Variance from Segment Regression Model for the Convenience Store Number 171034.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	13918297.3885	2783659.47771
Residual	24	16221.49877	675.89578
Uncorrected Total	29	13934518.8873	
(Corrected Total)	28	107477.34702	

R squared = 1 - Residual SS / Corrected SS = .84907

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	363.24690451	44.96104741	270.45186342	456.04194560
B_2	4.879998183	.607718644	3.625728547	6.134267819

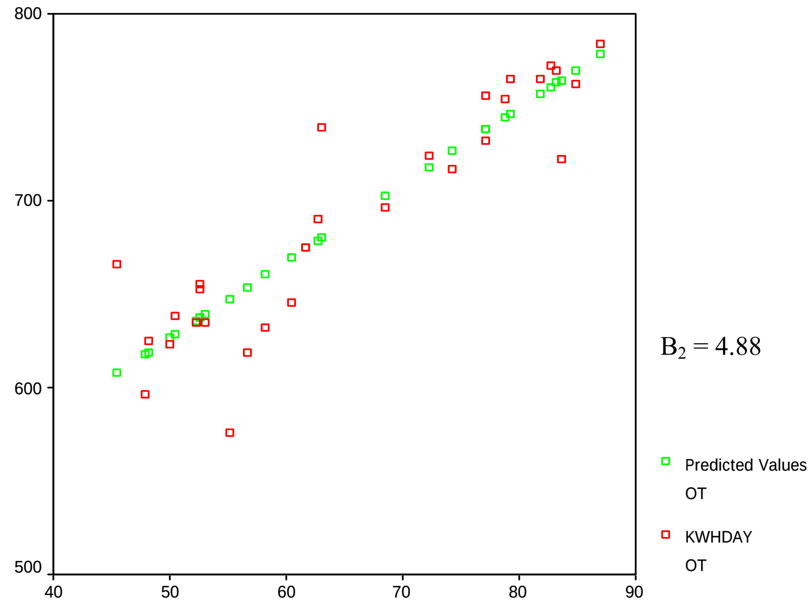


Fig. 5.7B A Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 171034.

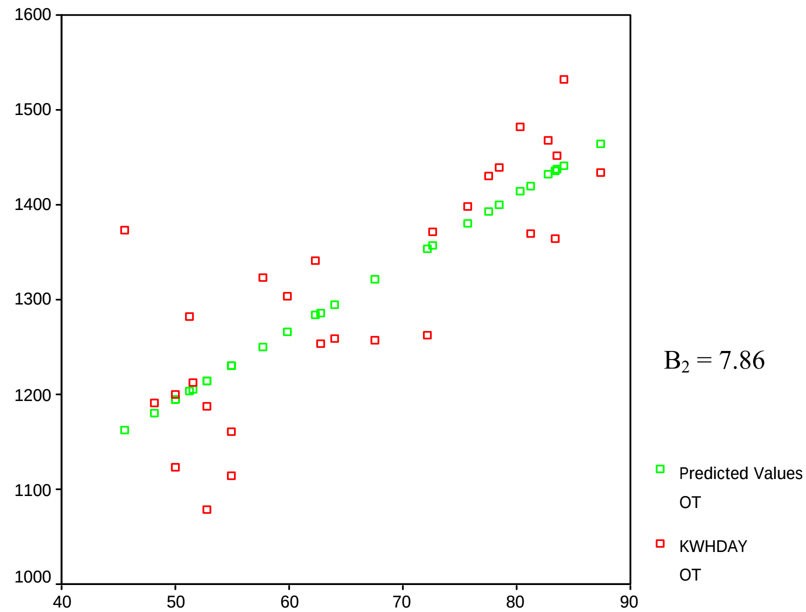
Table 5.6C Analysis of Variance from Segment Regression Model for the Convenience Store Number 173540.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	48296283.6124	9659256.72248
Residual	23	112463.93522	4889.73631
Uncorrected Total	28	48408747.5476	
(Corrected Total)	27	405724.46554	

R squared = 1 - Residual SS / Corrected SS = .72281

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	784.48476233	108.70996975	559.60105608	1009.3684686
B_2	7.857840592	1.491230451	4.772995370	10.942685813



$B_2 = 7.86$

Fig. 5.7C A Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 173540.

5.3.3.2 Cool-only with base load

The nonlinear regression process provides more exact parameter estimated for the base loads (B_0), cooling efficiencies (B_2), and cooling knots as shown in Fig. 5.8. The nonlinear regression process estimates the need for the researcher to make a several regressions, each with a change in the values of the knots to get the adjusted r-square value. Tables 5.7A – 5.7D show the analysis of variance for segment regression models, which use to estimate the cooling knots, cooling efficiencies, and base load, and the adjusted r-square results for the convenience store numbers 101056, 117218, 120400, and 120424. The adjusted r-square results are 0.58, 0.76, 0.77, and 0.78, with confidence interval 0.05, respectively. It has seven convenience stores fit this model. These convenience stores have base loads and cooling usage patterns. No convenience store has both heating and cooling systems provided by electric appliances. Finally, the results show in terms of the plots of predicted and actual value in the Figs. 5.9A – 5.9D.

$$kWh/day = B_0 + B_2Max((T_{avg}-T_{cool}),0) \qquad (5.3)$$

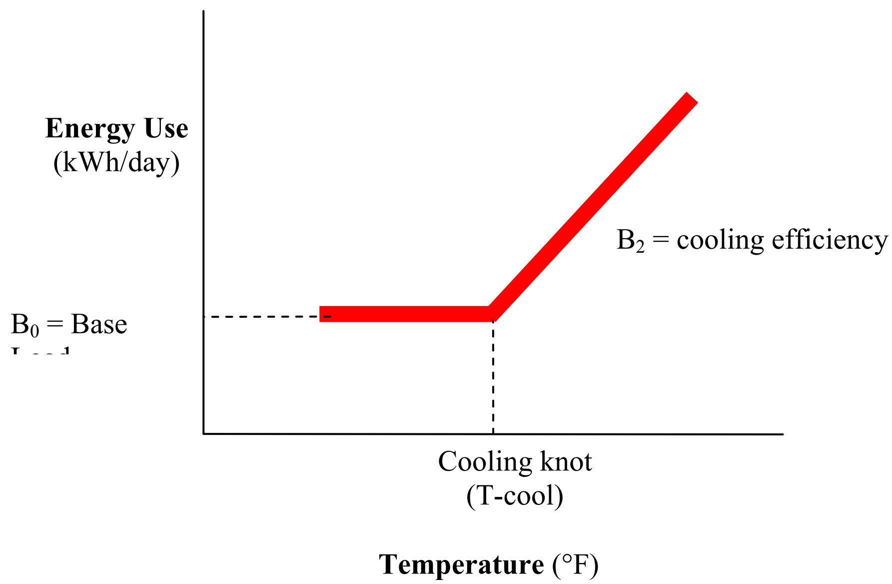


Fig. 5.8 Segment Regression Model: Cooling System Only with Base Load.

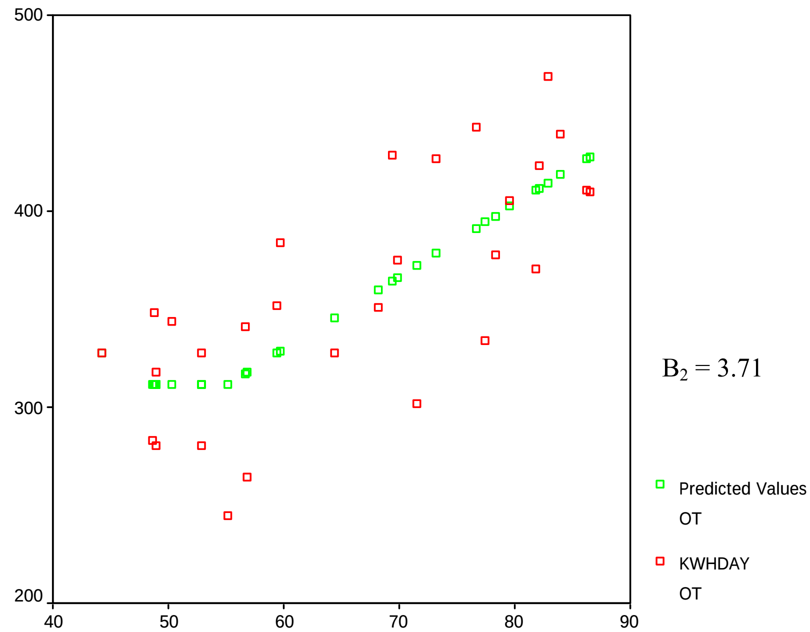
Table 5.7A Analysis of Variance from Segment Regression Model: Cooling Only with Base Load for the Convenience Store Number 101056.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	3776943.92371	755388.78474
Residual	24	41337.72399	1722.40517
Uncorrected Total	29	3818281.64770	
(Corrected Total)	28	97335.86761	

R squared = 1 - Residual SS / Corrected SS = .57531

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	311.27597175	.892638894	309.43365562	313.11828788
B_2	3.717643703	15.686232209	-28.65714839	36.092435796



B_0 =311.28

B_2 = 3.71

Cooling knot = 55.10

Fig. 5.9A Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 101056.

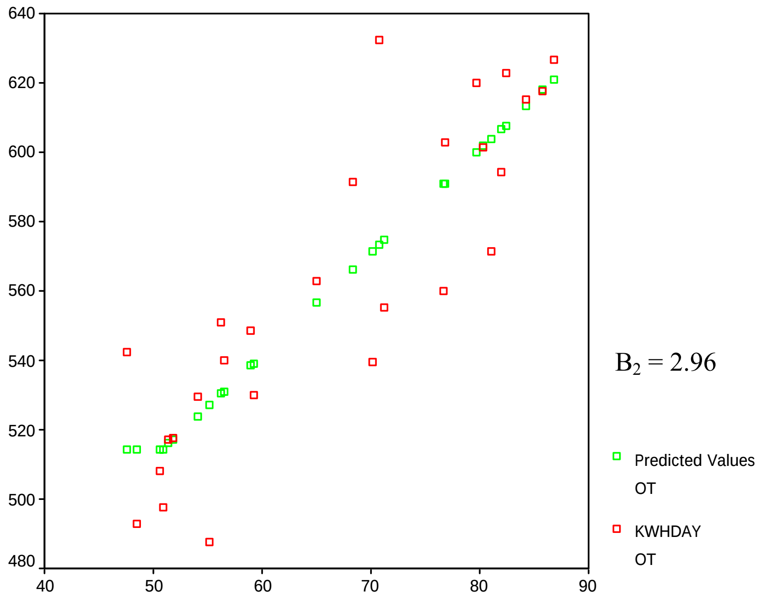
Table 5.7B Analysis of Variance from Segment Regression Model: Cooling Only with Base Load for the Convenience Store Number 117218.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	8570740.40228	1714148.08046
Residual	22	12429.25132	564.96597
Uncorrected Total	27	8583169.65360	
(Corrected Total)	26	52436.51936	

R squared = 1 - Residual SS / Corrected SS = .76297

		Asymptotic	Asymptotic 95 % Confidence Interval	
Parameter	Estimate	Std. Error	Lower	Upper
B_0	514.37182992	12.300160959	488.86285737	539.88080246
B_2	2.963307410	.401623338	2.130391586	3.796223234



B_0 =514.37

B_2 = 2.96

Cooling knot = 50.84

Fig. 5.9B Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 117218.

Table 5.7C Analysis of Variance from Segment Regression Model: Cooling Only with Base Load for the Convenience Store Number 120400.

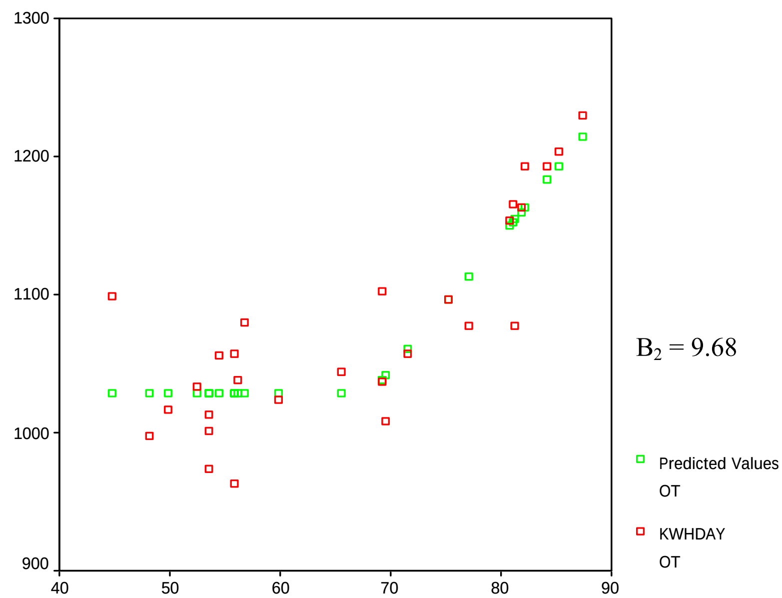
Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	32589191.3010	6517838.26020
Residual	23	33169.98141	1442.17310
Uncorrected Total	28	32622361.2824	
(Corrected Total)	27	147407.89039	

R squared = 1 - Residual SS / Corrected SS = .77498

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	1028.3242857	10.149500708	1007.3284438	1049.3201276
B_2	9.675763338	1.676544809	6.207566160	13.143960516

B_0 =1028.32



B_2 = 9.68

Cooling knot = 68.22

Fig. 5.9C Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 120400.

Table 5.7D Analysis of Variance from Segment Regression Model: Cooling Only with Base Load for the Convenience Store Number 120424.

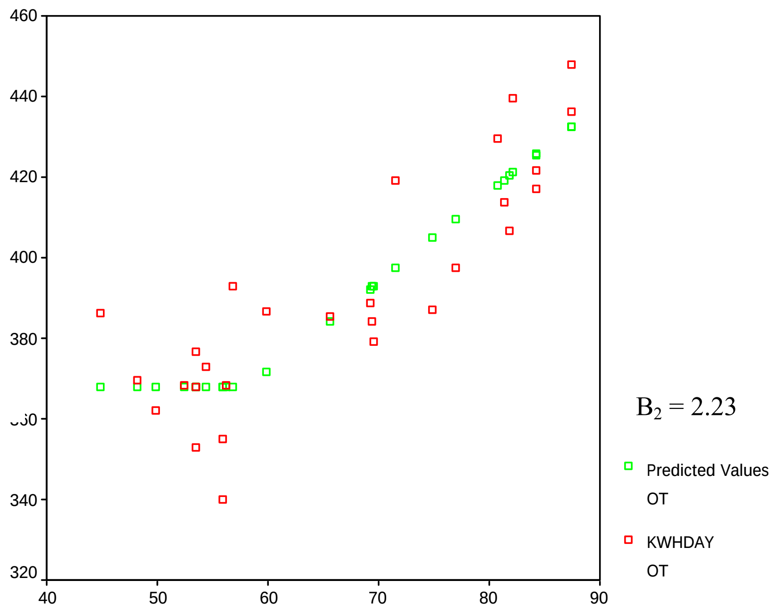
Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	4301304.66985	860260.93397
Residual	23	4778.75535	207.77197
Uncorrected Total	28	4306083.42520	
(Corrected Total)	27	21426.29627	

R squared = 1 - Residual SS / Corrected SS = .77697

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	367.73333333	4.161049265	359.12554710	376.34111956
B_2	2.225202453	.449102551	1.296163043	3.154241863

B$_0$ =367.73



B$_2$ = 2.23

Cooling knot = 58.04

Fig. 5.9D Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 120424.

5.4 Group analysis and comparisons

Beginning with the first group, parabola regression model is for the data with a significant curve. Table 5.8 shows the adjusted r-square statistics. There are seventeen convenience stores that fit this model. The average r-square is 0.66 with in the range from 0.505 to 0.903, the mean adjusted r-square standard error is 0.029, and standard deviation is 0.120, respectively. In Fig. 5.10A, it shows the frequency of the adjusted r-squares for the model. From the results above and the result in Table 5.9, it could be concluded that the adjusted r-squares of parabola regression models are higher than the segment regression models. On the other hand, it implied that these convenience stores fit with parabola regression models than the segment regression models. However, the mean adjusted r-square is higher; it is not greatly significant enough to be concluded that the parabola regression models provided more accurate than the others.

The second group was the data with No trend. There are six convenience stores. It meant that outdoor temperature was not related with daily energy consumption. The reasons are many, for instance; the building is under construction; the building systems are broken; temperature is unusual, and so on. As the obvious example from the convenience store number 151242, the monthly energy consumptions for 2001 to 2003 were rapidly changed. In 2002, the average of monthly energy consumption was 18,210 kWh per a billing cycle, but in 2001, monthly energy consumption was ten times dropped to be 1,923 kWh per a billing cycle. As the fact in 2001, the building was renovated causing energy consumption to decrease. The other convenience stores are unusual data for these building numbers: 119818, 133130, 137580, 171040, and 173446, correspondingly.

The adjusted r-squares results for the unusual group in Table 5.8 are from 0.041 to 0.270. The mean adjusted r-square average is 0.141; mean r-square standard error is 0.032, and standard deviation is 0.079, respectively. In Fig. 5.10B, the plot shows the histogram plot of the adjusted r-square frequency.

Lastly, segment regression model, combining both the cool-only with Base load and with No base model, there are seven convenience stores fit in this model (101056, 107390, 117218, 133124, 135916, 171034, and 173540). The more the temperature increases; the more the average daily energy consumption consumes, conversely in the winter season. These results implied that convenience stores use natural gas or propane for heating systems in the winter season. From the descriptive Table 5.8, it shows the adjusted r-square results ranges from 0.436 to 0.869. The mean adjusted r-square, when doing individual segment regression is 0.668; the mean adjusted r-square standard error is 0.292, and the standard deviation is 0.079, respectively. In Fig. 5.10C, it shows the frequency of the adjusted r-square for this model.

Table 5.8 The Adjusted R-Squares Descriptive Statistics for Three Different Groups.

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std.
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
SEGMENT	7	.436	.869	.66757	.06757	.178785
PARABOLA	17	.505	.903	.69265	.02915	.120184
NOPATTER	6	.041	.270	.14083	.03228	.079073
Valid N (listwise)	6					

Table 5.9 Comparisons of the Adjusted R-Square Results between Segment and Parabola Regression Models.

Store no.	Parabola	Segment
	Adj. R-squared	Adj. R-squared
101056	**0.515**	**0.525**
107390	**0.324**	**0.204**
108000	**0.896**	**0.837**
115142	**0.784**	**0.762**
117218	**0.736**	**0.746**
119114	**0.517**	**0.501**
119818	**0.066**	**0.064**
120400	**0.783**	**0.610**
120424	**0.773**	**0.709**
125530	**0.672**	**0.389**
126226	**0.634**	**0.643**
126630	**0.467**	**0.470**
133124	**0.846**	**0.850**
133130	**0.211**	**0.217**
135916	**0.378**	**0.401**
137580	**0.146**	**0.070**
144454	**0.728**	**0.704**
146654	**0.688**	**0.678**
147338	**0.666**	**0.677**
151242	**0.000**	**0.000**
161494	**0.619**	**0.593**
167260	**0.859**	**0.624**
167330	**0.726**	**0.676**
170988	**0.524**	**0.449**
171034	**0.813**	**0.816**
171040	**0.120**	**0.027**
173446	**0.097**	**0.027**
173540	**0.644**	**0.629**
186030	**0.500**	**0.394**
187564	**0.526**	**0.126**
Average	**0.5419**	**0.4806**

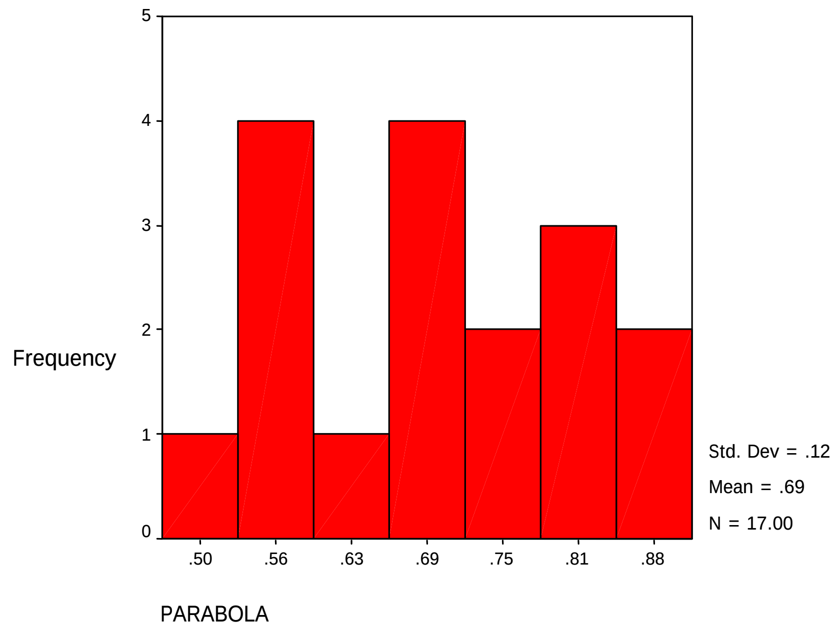


Fig. 5.10A Histogram of the Adjusted R-Square from the Parabola Regression Models.

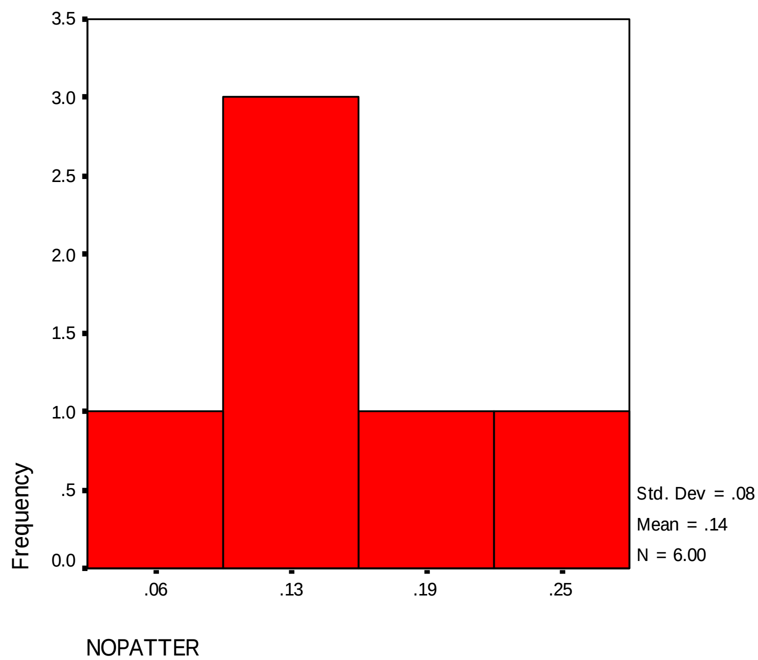


Fig. 5.10B Histogram of the Adjusted R-Square from the Unusual Data.

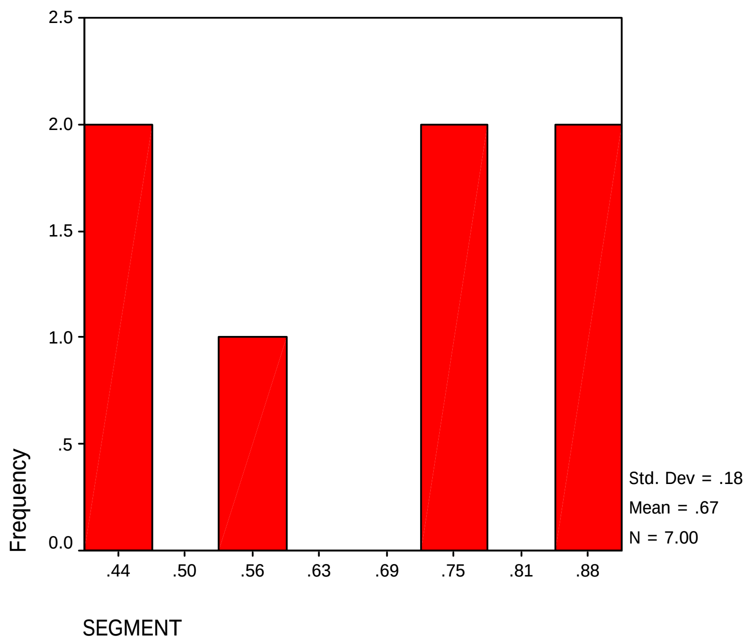


Fig. 5.10C Histogram of the Adjusted R-Square from the Segment Regression Models.

5.5 Multiple regression model

This method focuses on setting (1) the overall energy consumption model and (2) the average year using multiple regression model for energy consumption prediction for individual convenience stores in College Station. The input independent variables were internal load: refrigerator units and lighting bulbs, orientation of fronts: South, East, and West, outdoor temperature, working hours, area, cooling efficiencies, and cooling knot temperature.

5.5.1 Results for the energy consumption prediction model for all convenience stores in College Station

By running the forward selection, backward elimination, and stepwise methods, those provide the same best model with the confidence interval (CI.) at 0.05. In Table 5.10, stepwise method is selected to demonstrate for the best model. The model is combination of eight variables: cooling knot temperature, outdoor temperature, orientations of front: West, East, and South, light bulbs, area, and cooling efficiencies. It produces 0.597 adjusted r-square result, $F(9,781) = 146.91$, $p<.001$. In comparison to the prediction model, which is not included cooling efficiencies and cooling knot temperature, the adjusted r-square is 0.327. The prediction model is significantly improved the power of prediction.

The effects of individual predictors in the monthly prediction models analyzes by the use of unstandardized coefficients (B), indicating the increase in the value of the dependent variable for each unit increases in the predictor variable, with the confidence interval 0.05. The coefficient Table 5.10 shows the relationship of the eight selected variables composed in the model. For example, B_{coeff} = 33.846 measures the effect of the predictor variable cooling efficiencies on the criterion variable daily energy consumption, holding the other predictor scores constant, respectively.

With the standardized coefficients (β), the results show that cooling knot temperature is the most powerful predictor (-0.529), and the following is cooling efficiencies (β_2= 0.473), orientations of front: South (β_3= 0.463), orientations of front: West (β_4= 0.280), light bulbs (β_5= 0.209), area (β_6= 0.177), outdoor temperature (β_7= 0.169), and orientations of front: East (β_8= 0.119), respectively. All selected variables are associated with significance values of 0.000.

$$\begin{aligned}\text{Daily energy consumption (kWh/day)} = {} & 121.045 + 0.02415\text{area} + 257.580\text{south} \\ & -3.790\text{coolknot}+33.846\text{cooleff} \\ & +3.139\text{OT}+155.301\text{west}+1.492\text{lights} \\ & +97.285\text{east} \qquad (5.4)\end{aligned}$$

Table 5.10 Analysis of Variance from Multiple Regression Model. Model Summary, ANOVA Table, and Coefficient Table.

Model Summary[i]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.459	.211	.210	223.84960	
2	.560	.314	.312	208.82145	
3	.641	.411	.409	193.64209	
4	.710	.503	.501	177.88702	
5	.731	.534	.531	172.45755	
6	.751	.565	.561	166.79352	
7	.769	.591	.587	161.81530	
8	.775	.601	.597	159.91192	.531

1. Predictors: (Constant), AREA
2. Predictors: (Constant), AREA, SOUTH
3. Predictors: (Constant), AREA, SOUTH, COOLKNOT
4. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF
5. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT
6. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT, WEST
7. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT, WEST, LIGHTS
8. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT, WEST, LIGHTS, EAST

i. Dependent Variable: KWHD

Table 5.10 Continued.

ANOVA[i]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.1E+07	1	10539931.4	210.342	.000 [a]
	Residual	3.9E+07	788	50108.642		
	Total	5.0E+07	789			
2	Regression	1.6E+07	2	7853652.395	180.103	.000 [b]
	Residual	3.4E+07	787	43606.400		
	Total	5.0E+07	789			
3	Regression	2.1E+07	3	6850898.503	182.704	.000 [c]
	Residual	2.9E+07	786	37497.259		
	Total	5.0E+07	789			
4	Regression	2.5E+07	4	6296290.871	198.974	.000 [d]
	Residual	2.5E+07	785	31643.793		
	Total	5.0E+07	789			
5	Regression	2.7E+07	5	5341624.274	179.601	.000 [e]
	Residual	2.3E+07	784	29741.607		
	Total	5.0E+07	789			
6	Regression	2.8E+07	6	4707069.882	169.197	.000 [f]
	Residual	2.2E+07	783	27820.079		
	Total	5.0E+07	789			
7	Regression	3.0E+07	7	4221357.594	161.218	.000 [g]
	Residual	2.0E+07	782	26184.192		
	Total	5.0E+07	789			
8	Regression	3.0E+07	8	3756743.599	146.910	.000 [h]
	Residual	2.0E+07	781	25571.821		
	Total	5.0E+07	789			

1. Predictors: (Constant), AREA
2. Predictors: (Constant), AREA, SOUTH
3. Predictors: (Constant), AREA, SOUTH, COOLKNOT
4. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF
5. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT
6. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT, WEST
7. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT, WEST, LIGHTS
8. Predictors: (Constant), AREA, SOUTH, COOLKNOT, COEFF, OT, WEST, LIGHTS, EAST

i. Dependent Variable: KWHD

Table 5.10 Continued.

Coefficient Table

Model		Unstandardized Coefficients B	Std. Err	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	(Constant)	447.029	15.967		27.998	.000		
	AREA	6.274E-02	.004	.459	14.503	.000	1.000	1.000
2	(Constant)	358.028	16.991		21.072	.000		
	AREA	7.399E-02	.004	.541	17.761	.000	.938	1.066
	SOUTH	184.491	16.948	.332	10.886	.000	.938	1.066
3	(Constant)	467.501	18.466		25.317	.000		
	AREA	7.092E-02	.004	.519	18.313	.000	.934	1.071
	SOUTH	185.592	15.716	.334	11.809	.000	.938	1.066
	COOLKNO	-2.237	.197	-.312	-11.367	.000	.995	1.005
4	(Constant)	457.098	16.985		26.911	.000		
	AREA	5.149E-02	.004	.377	13.193	.000	.776	1.289
	SOUTH	177.520	14.453	.319	12.283	.000	.936	1.068
	COOLKNO	-3.271	.200	-.456	-16.359	.000	.813	1.230
	COEFF	25.792	2.132	.360	12.099	.000	.713	1.403
5	(Constant)	243.031	34.148		7.117	.000		
	AREA	5.155E-02	.004	.377	13.624	.000	.776	1.289
	SOUTH	178.269	14.012	.321	12.722	.000	.936	1.068
	COOLKNO	-3.274	.194	-.457	-16.892	.000	.813	1.230
	COEFF	25.770	2.067	.360	12.470	.000	.713	1.403
	OT	3.238	.452	.174	7.156	.000	1.000	1.000
6	(Constant)	213.348	33.267		6.413	.000		
	AREA	4.210E-02	.004	.308	10.868	.000	.692	1.445
	SOUTH	216.214	14.483	.389	14.929	.000	.820	1.220
	COOLKNO	-3.493	.190	-.487	-18.405	.000	.793	1.261
	COEFF	30.806	2.111	.430	14.596	.000	.639	1.564
	OT	3.266	.438	.176	7.464	.000	1.000	1.000
	WEST	114.065	15.359	.206	7.426	.000	.723	1.383
7	(Constant)	129.128	34.405		3.753	.000		
	AREA	3.099E-02	.004	.227	7.605	.000	.589	1.698
	SOUTH	234.831	14.296	.422	16.426	.000	.792	1.263
	COOLKNO	-3.518	.184	-.491	-19.105	.000	.793	1.261
	COEFF	31.842	2.053	.445	15.511	.000	.636	1.572
	OT	3.263	.425	.176	7.687	.000	1.000	1.000
	WEST	124.991	14.981	.226	8.343	.000	.716	1.397
	LIGHTS	1.304	.185	.183	7.065	.000	.784	1.276
8	(Constant)	121.045	34.049		3.555	.000		
	AREA	2.415E-02	.004	.177	5.601	.000	.514	1.946
	SOUTH	257.580	15.028	.463	17.141	.000	.700	1.429
	COOLKNO	-3.790	.192	-.529	-19.740	.000	.713	1.403
	COEFF	33.846	2.078	.473	16.286	.000	.606	1.650
	OT	3.139	.420	.169	7.466	.000	.995	1.005
	WEST	155.301	16.302	.280	9.527	.000	.590	1.694
	LIGHTS	1.492	.187	.209	7.970	.000	.744	1.345
	EAST	97.285	21.904	.119	4.441	.000	.714	1.401

a Dependent Variable: KWHD

CHAPTER VI

CONCLUSIONS

6.1 Application of results by model types

From the previous prediction models (segment, parabola, and multiple regression models), the daily temperature data used in these models are based on two years history; therefore, the model may not predict the daily consumed energy as accurate as desired. As a result, the mean temperature data over 50 years at Easterwood Airport, College Station, USA collected from National Oceanic and Atmospheric Administration (NOAA) is used to predict energy consumption over a standard meteorological year. In this analysis, three prediction models are tested with all convenience store groups which are Base load, No base, and No trend. Then, the predicted energy consumption of each convenience store group is compared with the actual data utilizing through the three models.

6.2 Temperature analysis between long term and the studied years

In Fig. 6.1, it shows that the average two-year temperature is lower than the average long term temperature during February to April 2001 and January to March 2002, while they are slightly higher during October to December 2001 and March to May 2002. The rest period is almost the same during (June to September 2001 and August to December 2002). The changing temperature should affect segment and parabola regression model because those models use outdoor temperature as the main predictor.

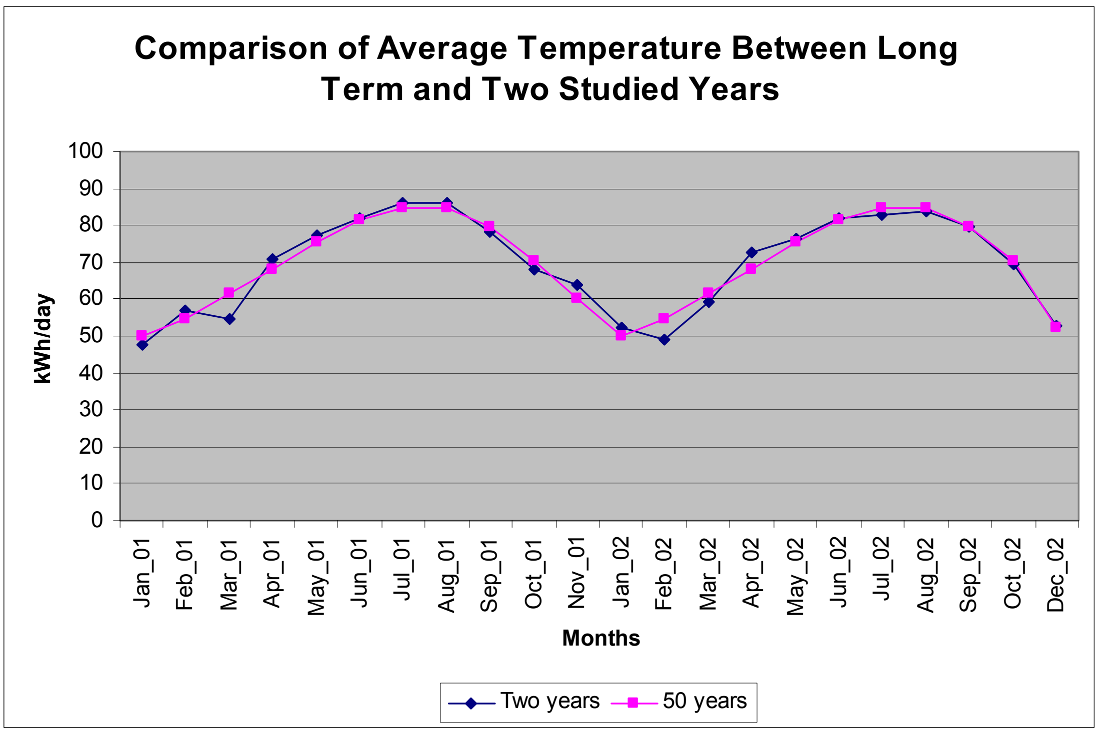


Fig. 6.1 Comparison Results of Average Temperature between Long Term Climate and Two Studied Years.

6.3 Comparisons through the three studied models

The results from the overall convenience stores could be categorized into three groups: under estimate (U), over estimate (O), and good results (R). The following results in Table 6.1 are analyzed from the studied buildings applied by using three models as shown in Appendix B.

6.3.1 Base group

6.3.1.1 Multiple regression model

The result is first analyzed with multiple regression model which almost half of this building type shows good results, but the rest is over and under estimation. For example, the convenience store number 173540 shows double underestimation for whole two years.

6.3.1.2 Segment and parabola regression models

For base load group, the prediction results from five out of six buildings work well with segment and parabola regression models. Only one prediction is over the estimation. It indicates that outdoor temperature is the main effect on energy consumption in these buildings.

6.3.1.3 Best fit model

In conclusion, for base load group segment and parabola regression models work well with this data type. Meanwhile, there is unstable prediction from the multiple regression model.

Table 6.1 Summary of the Best Fit Model for Individual Data Types.

Base	Over estimate (O)	About Right (R)	Under Estimate (U)	Best Model
Multiple regression model	2/7	3/7	2/7	
Segment regression model	0/7	6/7	1/7	Segment regression model
Parabola regression model	2/7	5/7	0/7	Parabola regression model
No Trend	**Over estimate (O)**	**About Right (R)**	**Under Estimate (U)**	**Best Model**
Multiple regression model	1/6	3/6	2/6	Multiple regression model
Segment regression model	1/6	4/6	1/6	Segment regression model
Parabola regression model	3/6	2/6	1/6	
No Base	**Over estimate (O)**	**About Right (R)**	**Under Estimate (U)**	**Best Model**
Multiple regression model	7/17	5/17	5/17	
Segment regression model	0/17	17/17	0/17	Segment regression model
Parabola regression model	1/17	16/17	0/17	Parabola regression model

** Remark: Over estimate (O), About Right (R) , and Under estimate (U)

6.3.2 No trend

6.3.2.1 Multiple regression model

The estimation results show a better prediction in this group. Most of predictions are close to the actual values.

6.3.2.2 Segment and parabola regression models

Since temperature data in No trend group does not have any particular pattern, outdoor temperature does not have as significant an impact on the prediction. Therefore, segment and parabola regression models, which are based on outdoor temperature alone, do not perform well in this group of stores.

6.3.2.3 Best fit model

Although the prediction from multiple regression model indicates some errors, it shows the same pattern and trend as the actual value. Multiple regression model does not only relate to outdoor temperature but also other independent variables. On the other hand, the segment and parabola regression models estimate energy consumption from each individual store. As a result, segment and parabola regression models cannot be used to predict energy use for stores that do not have at least two years of energy consumption data. The multiple regression model could be used as a preliminary prediction model for this no trend data group.

6.3.3 No base group

6.3.3.1 Multiple regression model

Most of the under estimations are shown with the buildings that face to North direction while most of the over estimations are shown in the buildings that face to South and West directions. Since the unstandardized coefficients values play important role in this multiple regression model, the building orientation may lead to incorrect estimated results.

6.3.3.2 Segment and parabola regression models

The estimations from these two models show good results. Almost of the predicted results are close to actual value. Basically, these two models are based on the outdoor temperature alone. Since the average temperature from study years, 2001to 2002, is slightly different from the long term, 50 years, average temperature, this model application shows good prediction results.

6.3.3.3 Best fit model

From the results, it indicates that segment and parabola regression models are better fit to this building type than the multi regression model.

6.4 Conclusion related to research hypothesis

In Base group, segment and parabola regression models can closely predict actual consumption since the data is significantly related to outdoor temperature. However, the multiple regression model does not fit the actual data like the other two models. Therefore, it can be concluded that outdoor temperature is the most influential predictor to Base group. For No base group, all models are suitable to this data type because both outdoor temperature and other independent variables are strongly related to energy consumption for this building type. Finally, the prediction of No trend group by multiple regression model fits best with the actual data. Both parabola regression model and segment regression model are not suitable for No trend group since they depend only on temperature.

6.4.1 The adjusted r-square comparison between studied models

The average adjusted r-square from segment and parabola models are summed up from individual adjusted r-square buildings and, then, use the average values to compare with the adjusted r-square from the multiple regression model. The results show that the average adjusted r-squares for all convenience stores among segment, parabola, and multiple regression models are 0.4806, 0.5419, and 0.597, respectively. Therefore, even the multiple regression model is the most powerful predicted model, when it is used with the buildings that relate to outdoor temperature, segment and parabola model are best fit.

6.5 Future study

The results from this research would be enhanced if the number of sample size is larger. The adjusted r-square would show a better result. The predicted models in this research could be applied and/or developed for the similar building types that operate seven days a week; for example, residential and commercial buildings.

For the model that response outdoor temperature, Parabola model shows a solid predication in comparison to the segment model. However, in this study, it is found that this model is hard to interpret. Therefore, the development or application of the parabola regression model could be investigated in order to find a better predication model for this type of building.

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APPENDIX A

SUMMARY OF MODELS

A.1 The overall energy consumption prediction models

A.1.1 Base load group

Table A.1 Analysis of Variance from Segment Regression Model for the Convenience Store Number 101056.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	3776943.92371	755388.78474
Residual	24	41337.72399	1722.40517
Uncorrected Total	29	3818281.64770	
(Corrected Total)	28	97335.86761	

R squared = 1 - Residual SS / Corrected SS = .57531

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	311.27597175	.892638894	309.43365562	313.11828788
B_2	3.717643703	15.686232209	-28.65714839	36.092435796

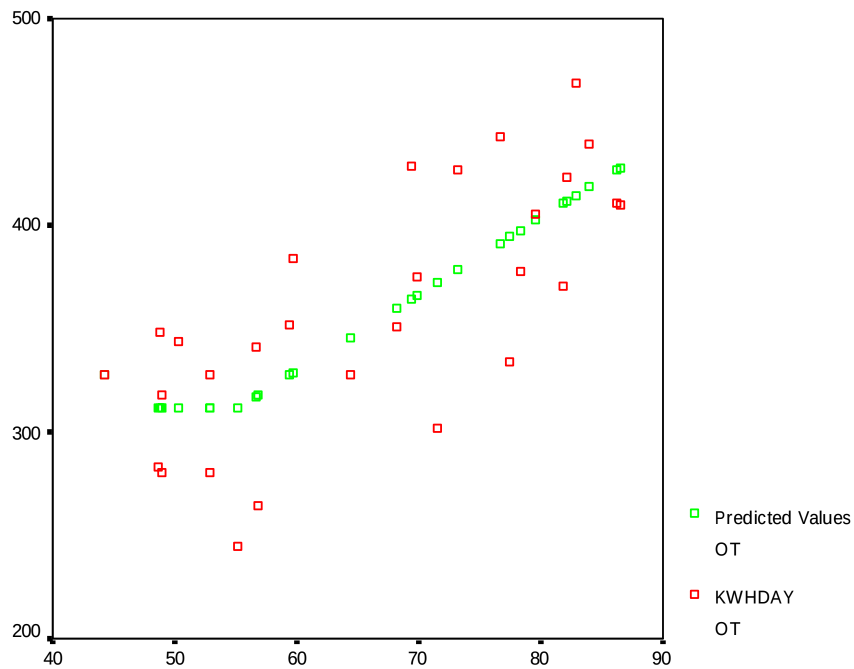

Fig. A.1 Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 101056.

Table A.2. Analysis of Variance from Parabola Regression Model for the Convenience Store Number 101056. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.741[a]	.550	.515	41.05662

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	53509.06	2	26754.532	15.872	.000[a]
	Residual	43826.80	26	1685.646		
	Total	97335.87	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	309.824	241.960		1.280	.212
	OT	-1.914	7.567	-.444	-.253	.802
	OT2	3.848E-02	.057	1.184	.674	.506

a. Dependent Variable: KWHDAY

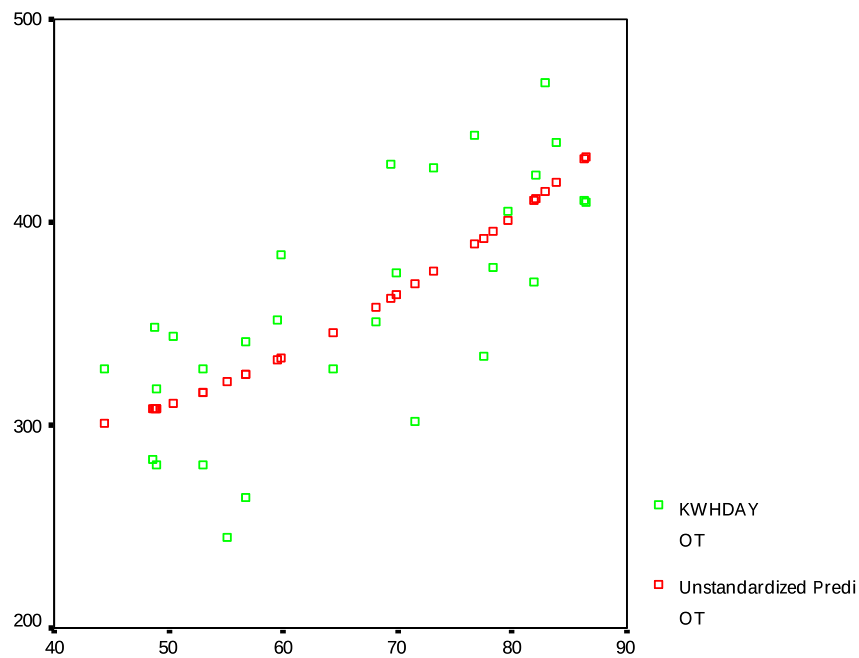

Fig. A.2 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 101056.

Table A.3 Analysis of Variance from Segment Regression Model for the Convenience Store Number 117218.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	8570740.40228	1714148.08046
Residual	22	12429.25132	564.96597
Uncorrected Total	27	8583169	.65360
(Corrected Total)	26	52436.51936	

R squared = 1 - Residual SS / Corrected SS = .76297

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	514.37182992	12.300160959	488.86285737	539.88080246
B_2	2.963307410	.401623338	2.130391586	3.796223234

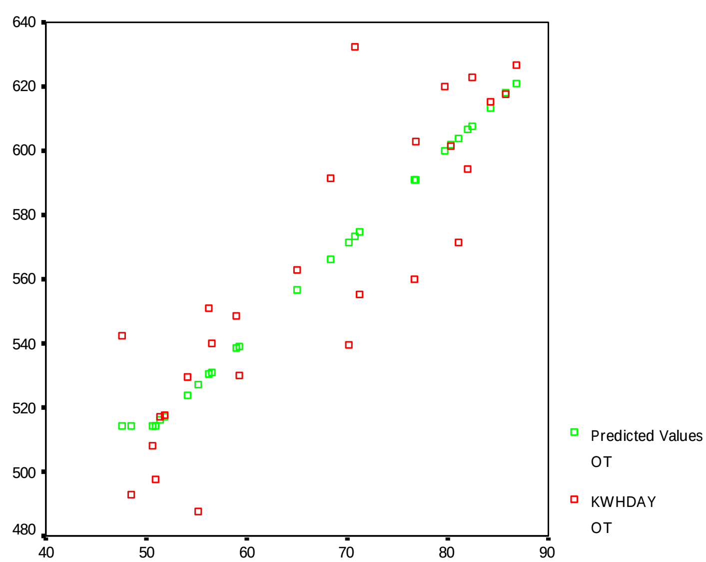

Fig. A.3 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 117218.

Table A.4 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 117218. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.869[a]	.756	.736	23.09022

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39640.72	2	19820.360	37.175	.000[a]
	Residual	12795.80	24	533.158		
	Total	52436.52	26			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	353.660	163.624		2.161	.041
	OT	3.344	5.040	.997	.663	.513
	OT2	-3.19E-03	.038	-.128	-.085	.933

a. Dependent Variable: KWHDAY

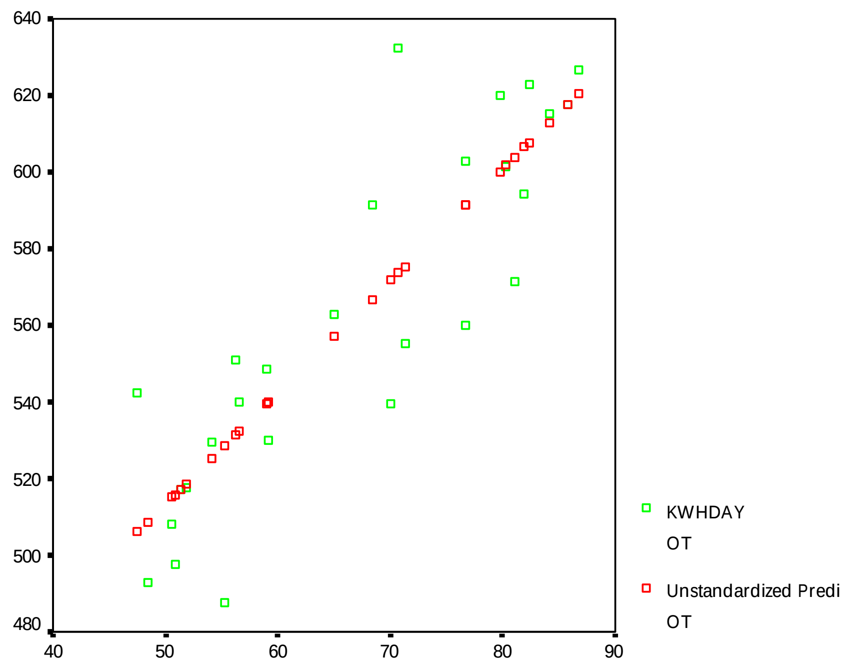

Fig. A.4 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 117218.

Table A.5 Analysis of Variance from Segment Regression Model for the Convenience Store Number 120400.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	32589191.3010	6517838.26020
Residual	23	33169.98141	1442.17310
Uncorrected Total	28	32622361.2824	
(Corrected Total)	27	147407.89039	

R squared = 1 - Residual SS / Corrected SS = .77498

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	1028.3242857	10.149500708	1007.3284438	1049.3201276
B_2	9.675763338	1.676544809	6.207566160	13.143960516

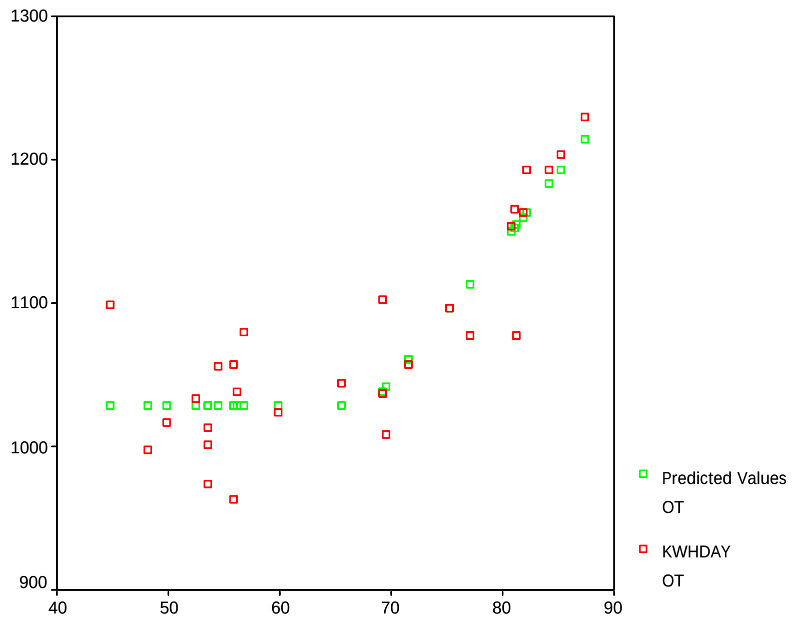

Fig. A.5 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 120400.

Table A.6 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 120400. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.894[a]	.799	.783	34.41961

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1830.872	226.448		8.085	.000
	OT	-28.058	6.979	-5.089	-4.020	.000
	OT2	.242	.052	5.894	4.656	.000

a. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	117790.1	2	58895.073	49.713	.000[a]
	Residual	29617.74	25	1184.710		
	Total	147407.9	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

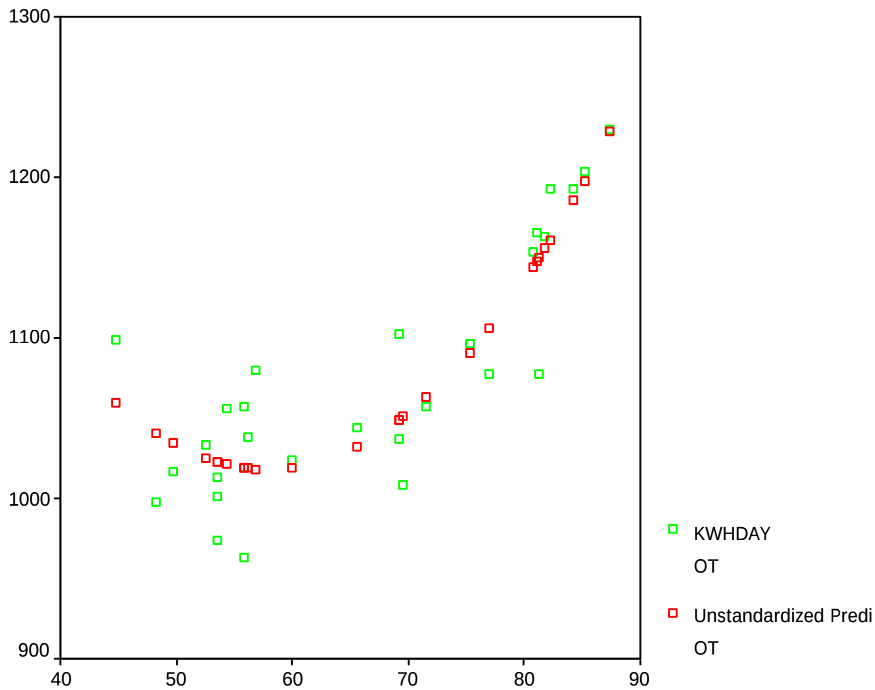

Fig. A.6 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 120400.

Table A.7 Analysis of Variance from Segment Regression Model for the Convenience Store Number 120424.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	4301304.66985	860260.93397
Residual	23	4778.75535	207.77197
Uncorrected Total	28	4306083.42520	
(Corrected Total)	27	21426.29627	

R squared = 1 - Residual SS / Corrected SS = .77697

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_2	2.225202453	.449102551	1.296163043	3.154241863
B_0	367.73333333	4.161049265	359.12554710	376.34111956

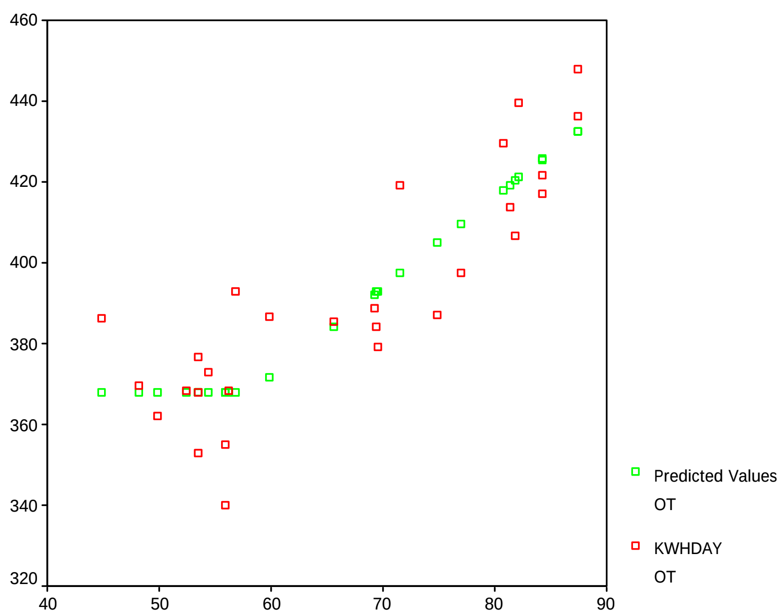

Fig. A.7 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 120424.

Table A.8 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 120424. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.889[a]	.790	.773	13.42406

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16921.16	2	8460.582	46.950	.000[a]
	Residual	4505.132	25	180.205		
	Total	21426.30	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	516.978	84.964		6.085	.000
	OT	-5.742	2.605	-2.783	-2.204	.037
	OT2	5.565E-02	.019	3.641	2.883	.008

a. Dependent Variable: KWHDAY

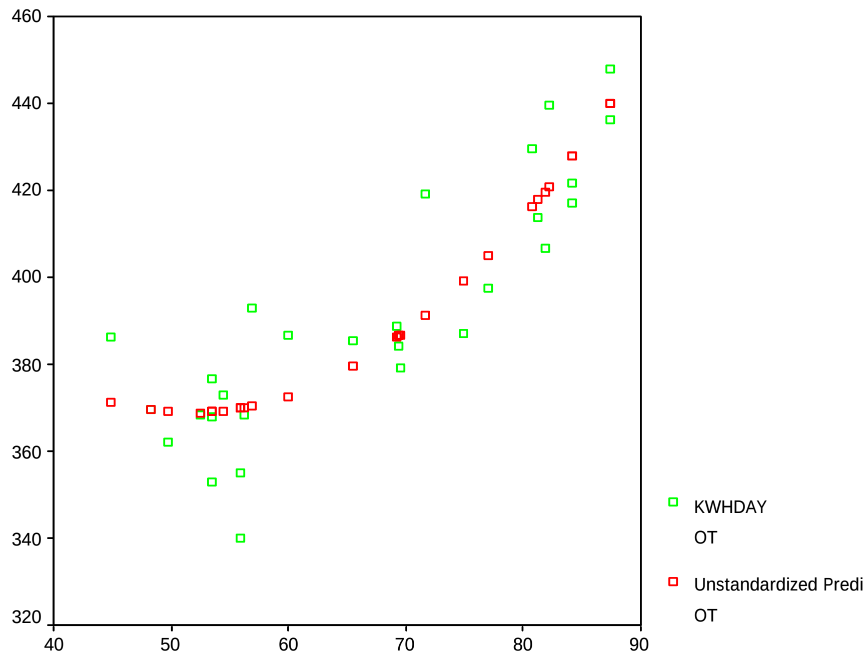

Fig. A.8 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 120424.

Table A.9 Analysis of Variance from Segment Regression Model for the Convenience Store Number 133124.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	10223193.8433	2044638.76865
Residual	22	30553.06634	1388.77574
Uncorrected Total	27	10253746.9096	
(Corrected Total)	26	232991.73781	

R squared = 1 - Residual SS / Corrected SS = .86887

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	487.08333333	21.515697703	442.46250733	531.70415934
B_2	6.680283751	.638333134	5.356461856	8.004105646

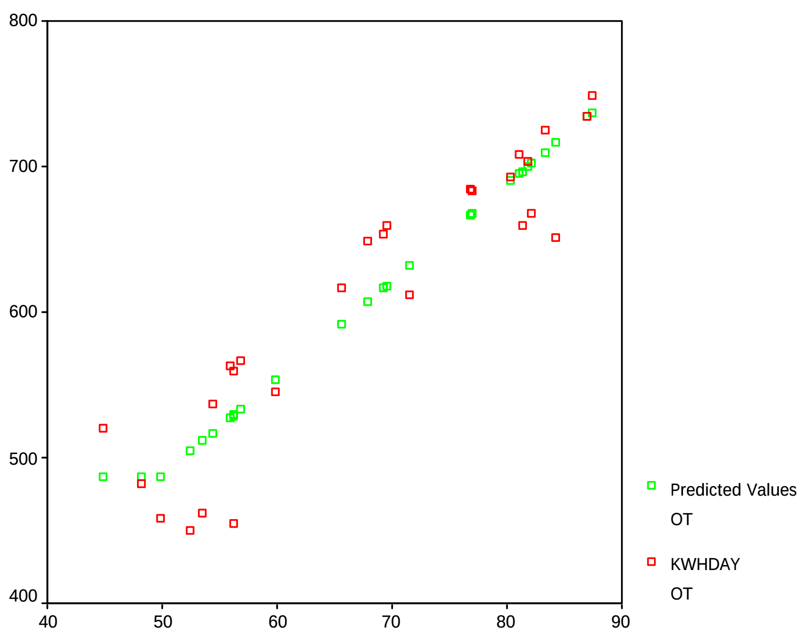

Fig. A.9 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 133124.

Table A.10 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 133124. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	.858	.846	37.14328

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	199880.8	2	99940.392	72.440	.000[a]
	Residual	33110.95	24	1379.623		
	Total	232991.7	26			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	36.761	239.282		.154	.879
	OT	10.620	7.335	1.527	1.448	.161
	OT2	-3.11E-02	.054	-.603	-.572	.573

a. Dependent Variable: KWHDAY

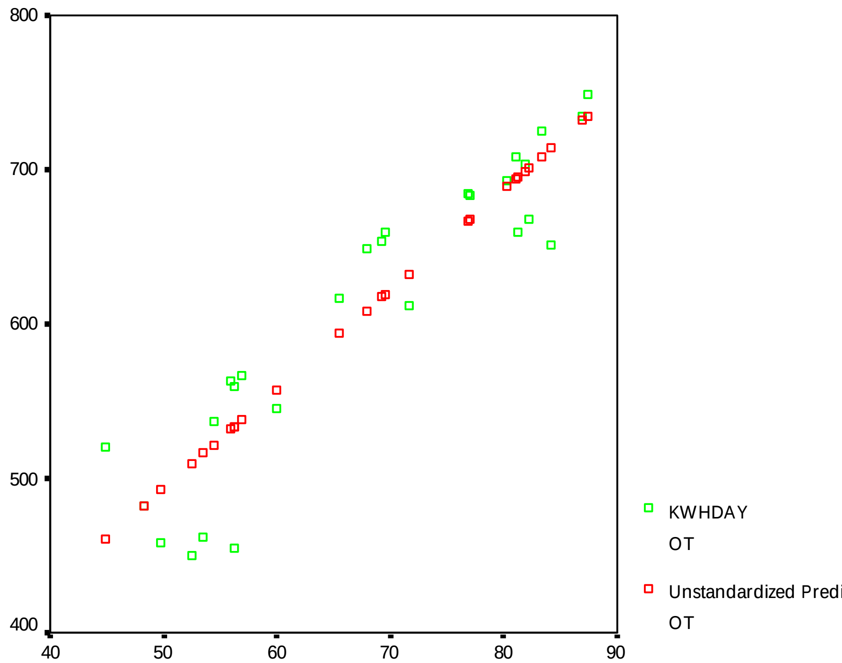

Fig. A.10 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 133124.

Table A.11 Analysis of Variance from Segment Regression Model for the Convenience Store Number 135916.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	9655663.54006	1931132.70801
Residual	24	24312.46534	1013.01939
Uncorrected Total	29	9679976.00540	
(Corrected Total)	28	43144.30574	

R squared = 1 - Residual SS / Corrected SS = .43648

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	545.84131037	14.372425078	516.17808293	575.50453782
B_2	1.793052185	.514560177	.731052176	2.855052194

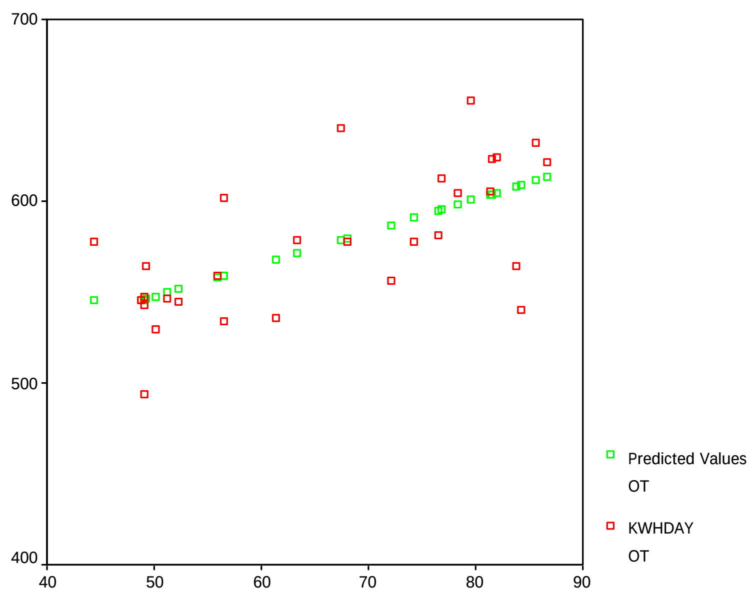

Fig. A.11 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 135916.

Table A.12 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 135916. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.650[a]	.423	.378	30.94746

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18242.93	2	9121.463	9.524	.001[a]
	Residual	24901.38	26	957.745		
	Total	43144.31	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	428.180	187.466		2.284	.031
	OT	2.754	5.901	1.005	.467	.645
	OT2	-7.38E-03	.045	-.356	-.165	.870

a. Dependent Variable: KWHDAY

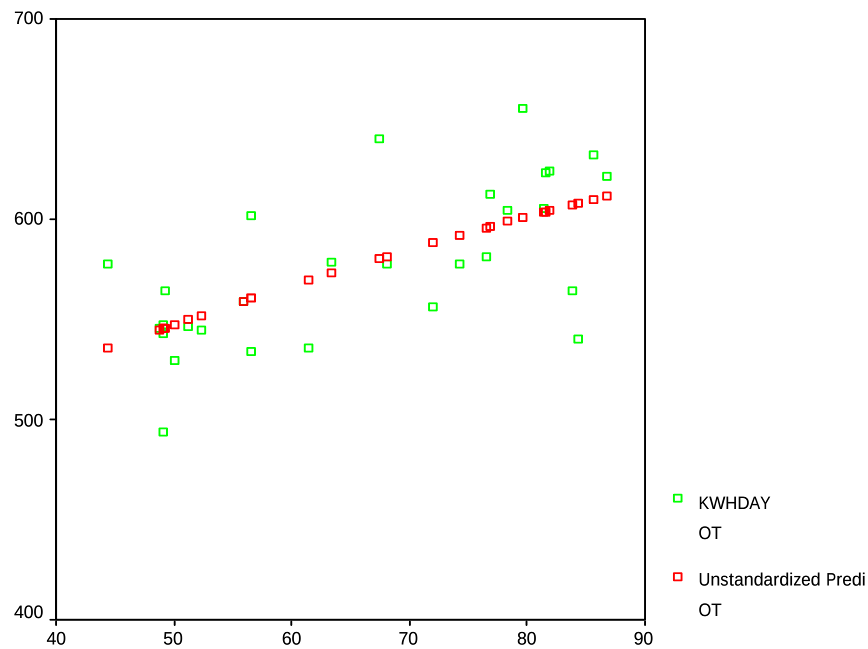

Fig. A.12 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 135916.

Table A.13 Analysis of Variance from Segment Regression Model for the Convenience Store Number 171034.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	13918297.3885	2783659.47771
Residual	24	16221.49877	675.89578
Uncorrected Total	29	13934518.8873	
(Corrected Total)	28	107477.34702	

R squared = 1 - Residual SS / Corrected SS =   .84907

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	632.23241340	8.221288112	615.26450869	649.20031811
B_2	4.879998183	.607718644	3.625728547	6.134267819

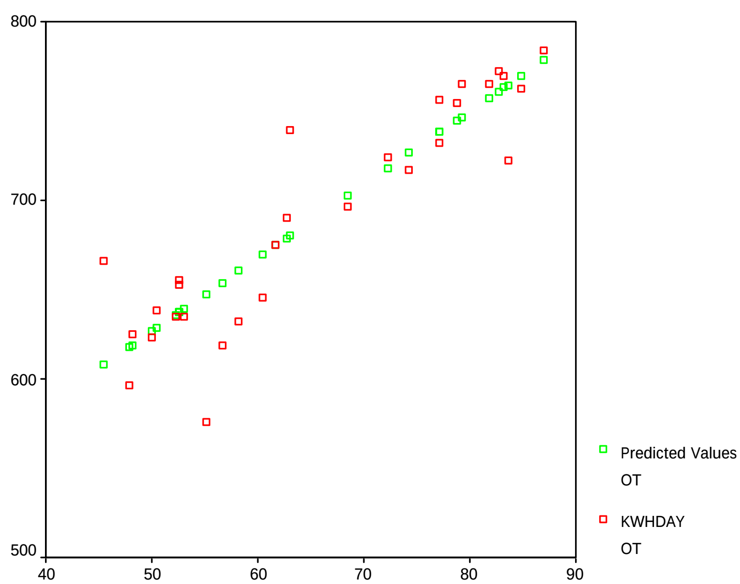

Fig. A.13 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 171034.

Table A.14 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 171034. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.909[a]	.826	.813	26.81179

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	88786.68	2	44393.338	61.754	.000[a]
	Residual	18690.67	26	718.872		
	Total	107477.3	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	537.393	170.813		3.146	.004
	OT	.468	5.318	.103	.088	.931
	OT2	2.736E-02	.040	.806	.685	.499

a. Dependent Variable: KWHDAY

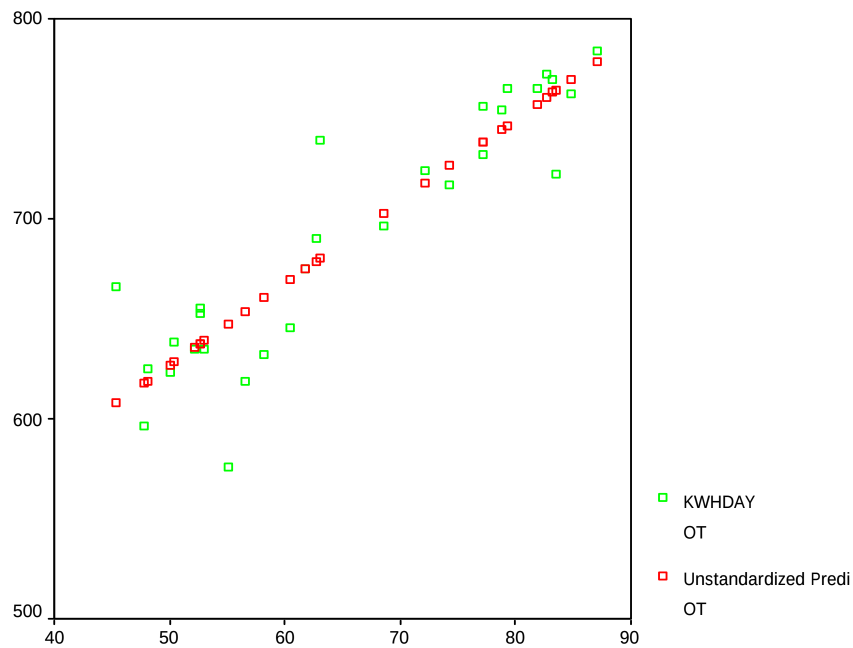

Fig. A.14 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 171034.

Table A.15 Analysis of Variance from Segment Regression Model for the Convenience Store Number 119818.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	5098732.02147	1019746.40429
Residual	23	40783.18713	1773.18205
Uncorrected Total	28	5139515.20860	
(Corrected Total)	27	39477.13704	

R squared = 1 - Residual SS / Corrected SS =   -.03308

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	400.00000000	.000000000	400.00000000	400.00000000
B_2	2.020833944 4	8.366876735	-98.03367371	102.07534159

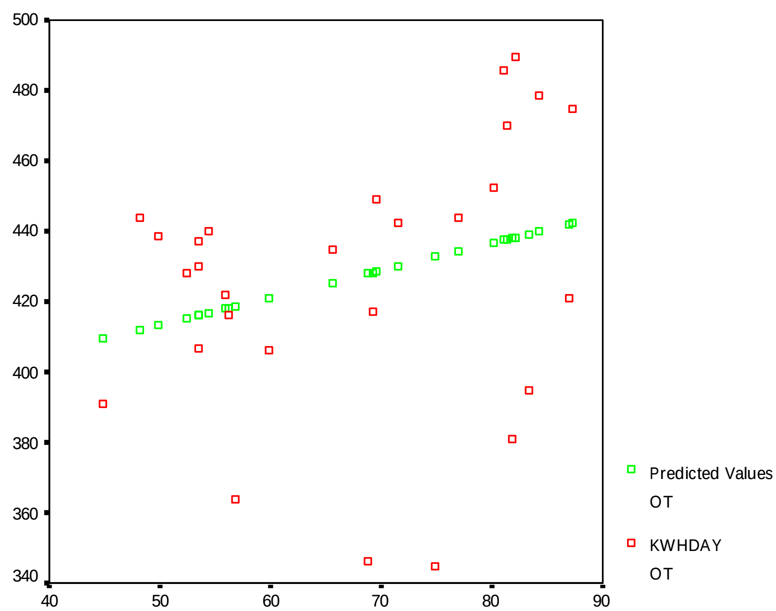

Fig. A.15 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 119818.

Table A.16 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 119818. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.368[a]	.135	.066	36.95479

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5335.717	2	2667.858	1.954	.163[a]
	Residual	34141.42	25	1365.657		
	Total	39477.14	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	680.408	236.700		2.875	.008
	OT	-8.706	7.276	-3.112	-1.196	.243
	OT2	7.056E-02	.054	3.397	1.306	.203

a. Dependent Variable: KWHDAY

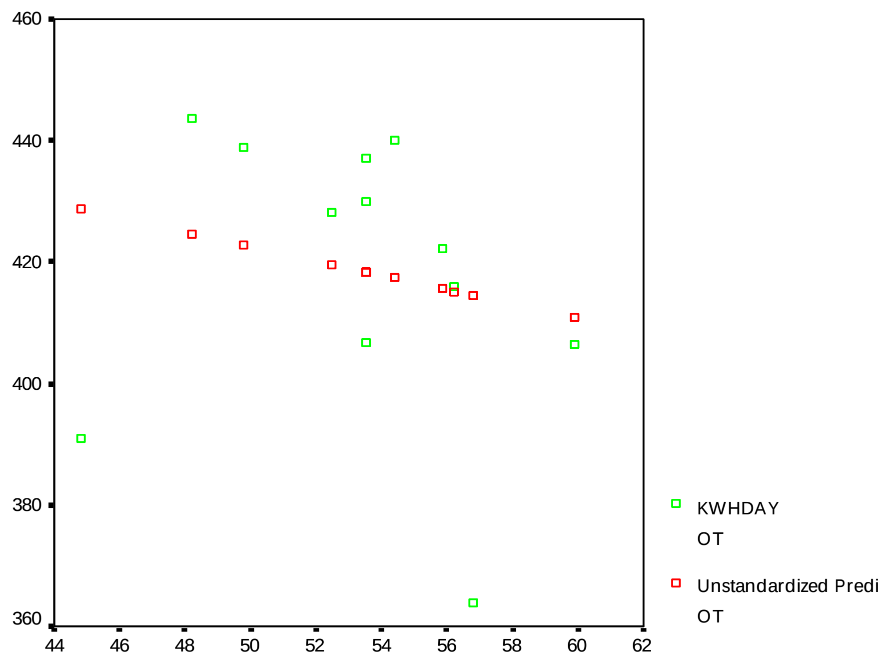

Fig. A.16 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 119818.

Table A.17 Analysis of Variance from Segment Regression Model for the Convenience Store Number 133130.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	13845443.5088	2769088.70175
Residual	23	58561.58543	2546.15589
Uncorrected Total	28	13904005.0942	
(Corrected Total)	27	77623.67614	

R squared = 1 - Residual SS / Corrected SS = .24557

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	649.30500000	.000000000	649.30500000	649.305000
B_2	1.880509132	.687278412	.458765415	3.302252849

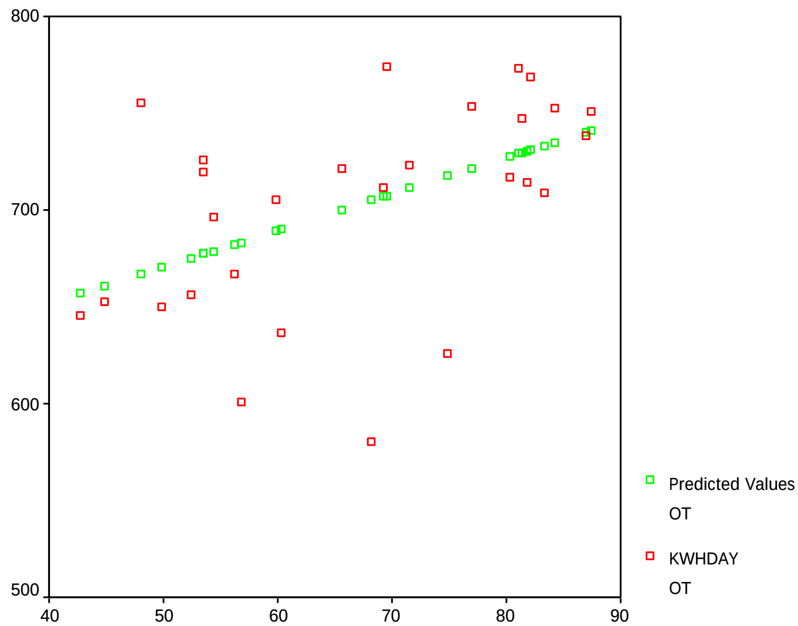

Fig. A.17 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 133130.

Table A.18 Analysis of Variance from Parabola Regression Model Convenience Store Number 133130. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.519[a]	.270	.211	47.61285

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20949.09	2	10474.543	4.620	.020[a]
	Residual	56674.59	25	2266.984		
	Total	77623.68	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	804.437	253.611		3.172	.004
	OT	-5.312	7.910	-1.400	-.672	.508
	OT2	5.427E-02	.059	1.902	.912	.370

a. Dependent Variable: KWHDAY

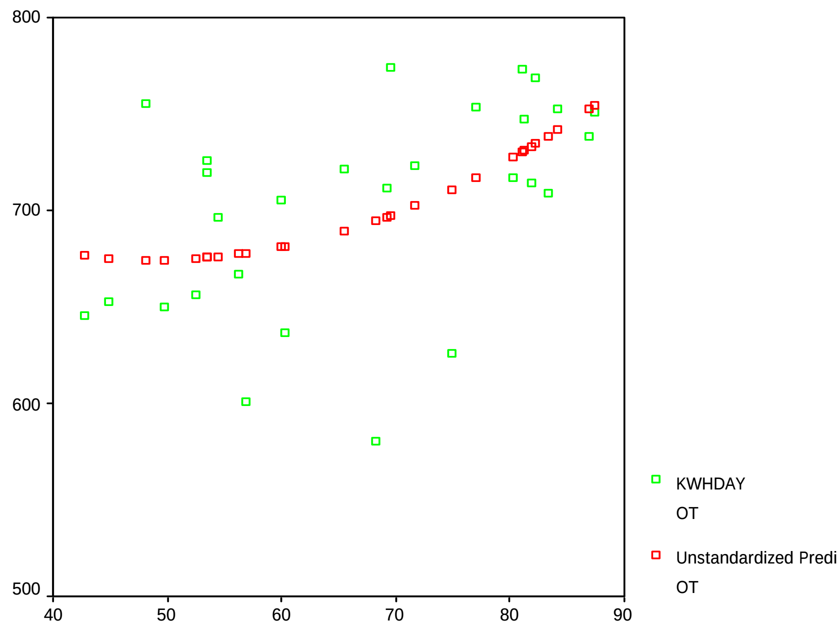

Fig. A.18 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 133130.

Table A.19 Analysis of Variance from Segment Regression Model for the Convenience Store Number 151242.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	3013191.73851	602638.34770
Residual	23	2063066.08389	89698.52539
Uncorrected Total	28	5076257.82240	
(Corrected Total)	27	2063066.08389	

R squared = 1 - Residual SS / Corrected SS =   .00000

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_2	4.000000000	.000000000	4.000000000	4.000000000
B_0	328.04571429	56.599635721	210.96044710	445.13098147

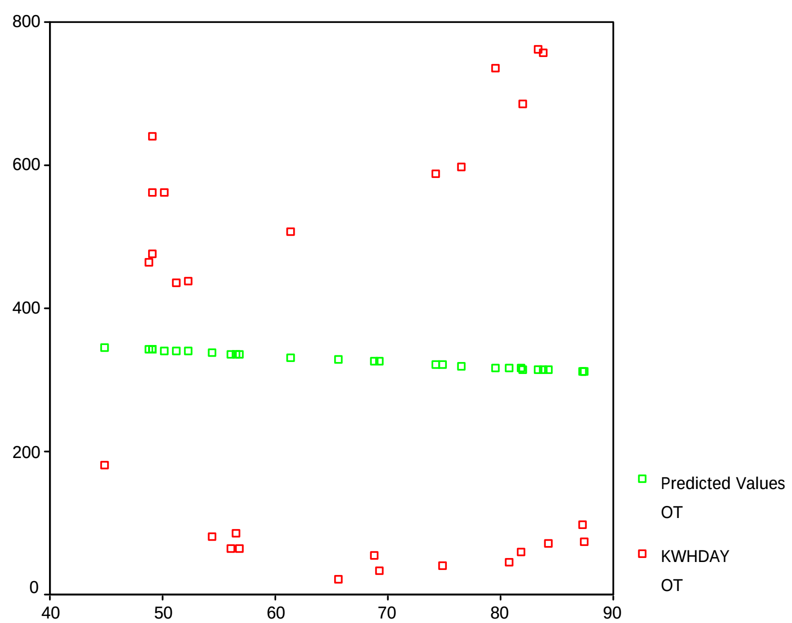

Fig. A.19 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 151242.

Table A.20 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 151242. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.203[a]	.041	-.036	281.28778

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	84995.75	2	42497.877	.537	.591[a]
	Residual	1978070	25	79122.813		
	Total	2063066	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2106.024	1720.186		1.224	.232
	OT	-55.068	53.673	-2.900	-1.026	.315
	OT2	.407	.402	2.864	1.013	.321

a. Dependent Variable: KWHDAY

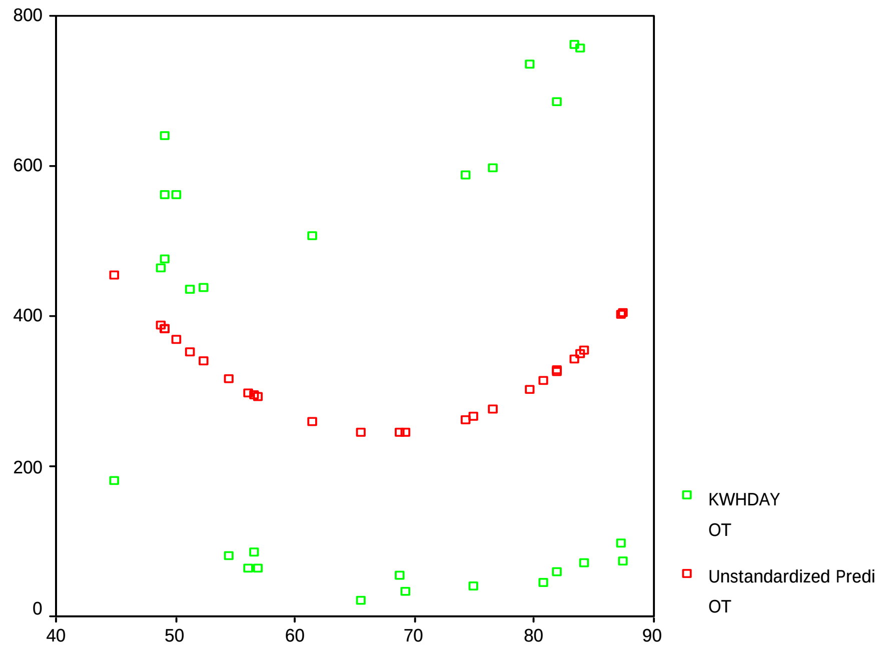

Fig. A.20 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 151242.

Table A.21 Analysis of Variance from Segment Regression Model for the Convenience Store Number 171040.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	26971120.0134	5394224.00267
Residual	23	116864.71253	5081.07446
Uncorrected Total	28	27087984.7259	
(Corrected Total)	27	143308.96687	

R squared = 1 - Residual SS / Corrected SS = .18453

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_2	2.339830734	1.025643783	.218124917	4.461536551
B_0	900.00000000	.000000000	900.00000000	900.00000000

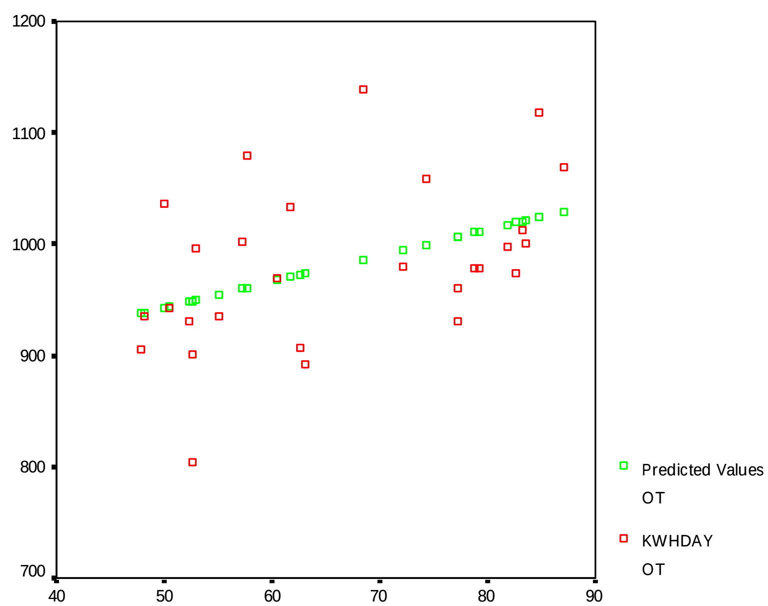

Fig. A.21 Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 171040.

Table A.22 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 171040. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.431[a]	.186	.120	68.325

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26600.64	2	13300.320	2.849	.077[a]
	Residual	116708.3	25	4668.333		
	Total	143309.0	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	737.793	486.129		1.518	.142
	OT	5.076	14.981	.932	.339	.738
	OT2	-2.04E-02	.112	-.503	-.183	.856

a. Dependent Variable: KWHDAY

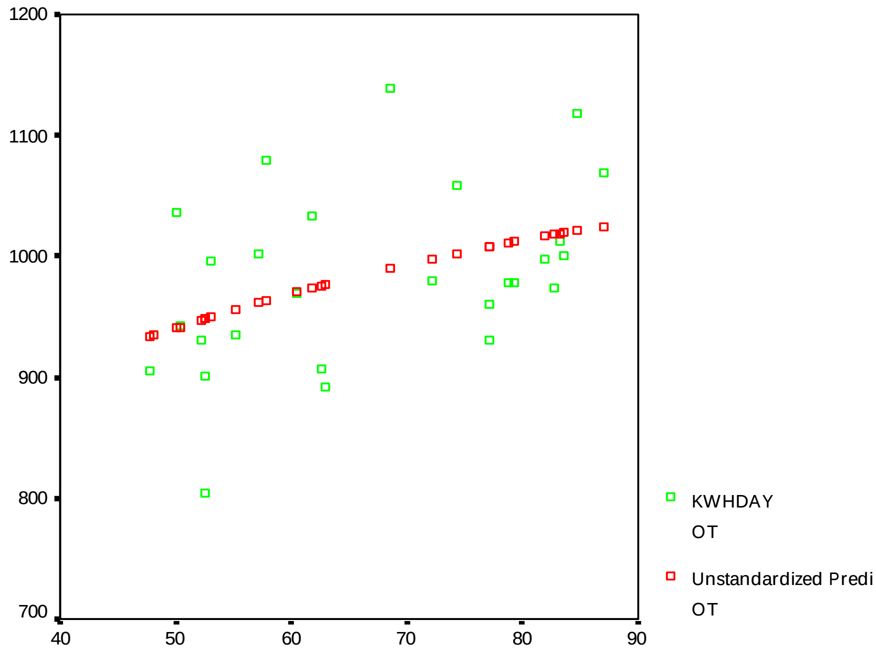

Fig. A.22 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 171040.

Table A.23 Analysis of Variance from Segment Regression Model for the Convenience Store Number 173446.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	28282987.1306	5656597.42611
Residual	24	165603.19784	6900.13324
Uncorrected Total	29	28448590.3284	
(Corrected Total)	28	176524.08570	

R squared = 1 - Residual SS / Corrected SS = .06187

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	910.00000000	.000000000	910.00000000	910.00000000
B_2	1.442397104	1.146527899	-.923920177	3.808714384

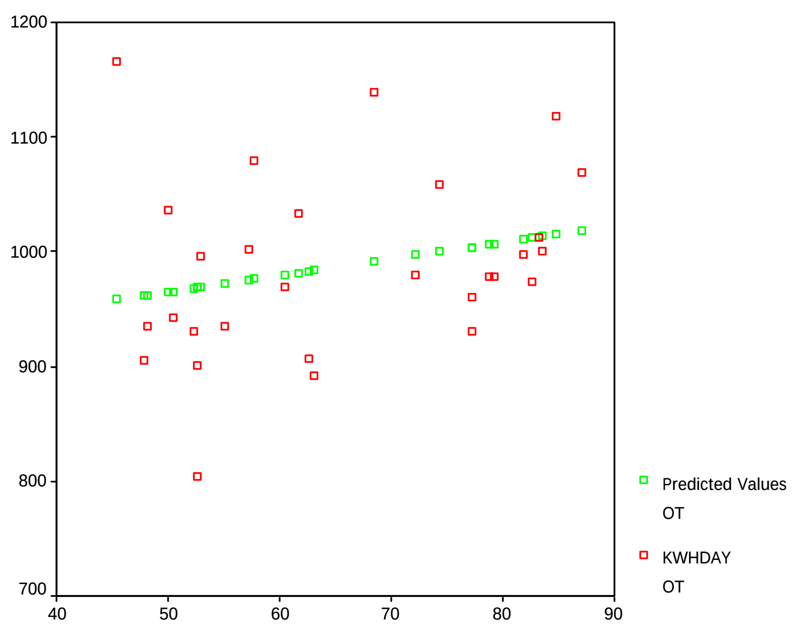

Fig. A.23 P Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 173446.

Table A.24 Analysis of Variance from Parabola Regression Model Convenience Store Number 173446. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.312[a]	.097	.028	78.27891

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17206.82	2	8603.411	1.404	.264[a]
	Residual	159317.3	26	6127.587		
	Total	176524.1	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1392.452	498.557		2.793	.010
	OT	-14.240	15.521	-2.456	-.917	.367
	OT2	.118	.116	2.711	1.013	.320

a. Dependent Variable: KWHDAY

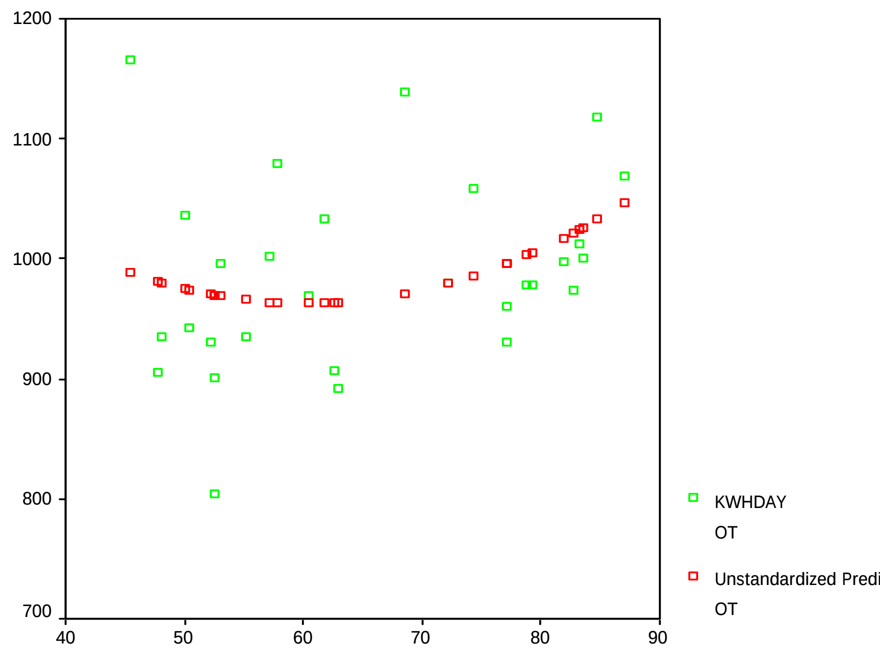

Fig. A.24 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 173446.

Table A.25 Analysis of Variance from Segment Regression Model for the Convenience Store Number 187564.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	30636452.9826	6127290.59653
Residual	23	97263.59606	4228.85200
Uncorrected Total	28	30733716.5787	
(Corrected Total)	27	115599.66312	

R squared = 1 - Residual SS / Corrected SS = .15862

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	700.00000000	.000000000	700.00000000	700.00000000
B_2	1.927877367	.925843423	.012624323	3.843130411

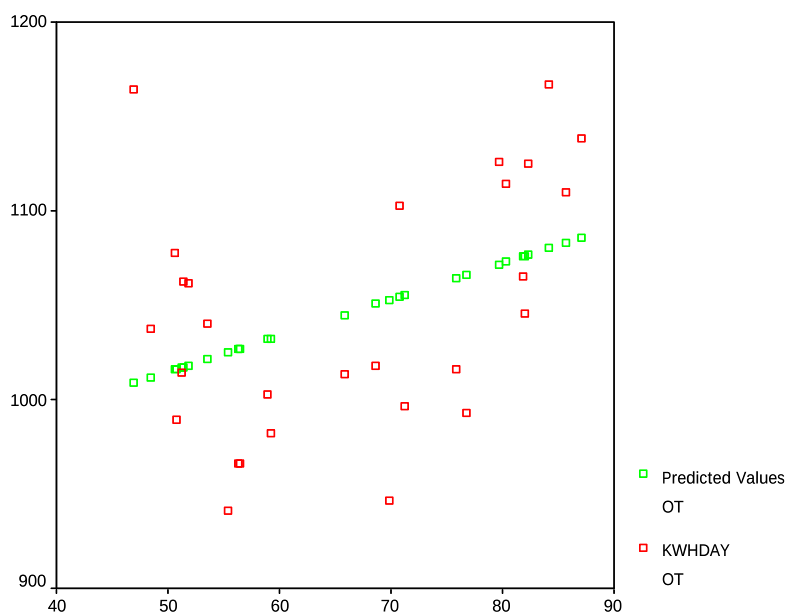

Fig. A.25 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 187564.

Table A.26 Analysis of Variance from Parabola Regression Model Convenience Store Number 187564. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.749[a]	.561	.526	45.06028

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	64838.94	2	32419.469	15.967	.000[a]
	Residual	50760.72	25	2030.429		
	Total	115599.7	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2374.894	307.465		7.724	.000
	OT	-43.450	9.504	-8.976	-4.572	.000
	OT2	.339	.071	9.396	4.786	.000

a. Dependent Variable: KWHDAY

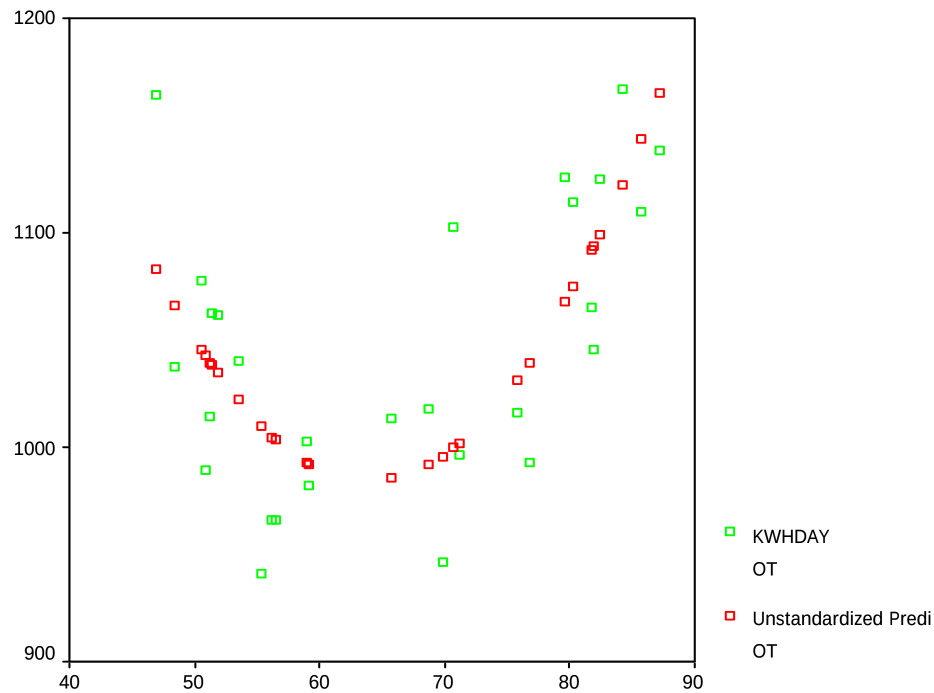

Fig. A.26 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 187564.

A.1.2 No base group

Table A.27 Analysis of Variance from Segment Regression Model for the Convenience Store Number 108000.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	14575345.7216	2915069.14432
Residual	23	12807.37201	556.84226
Uncorrected Total	28	14588153.0936	
(Corrected Total)	27	128253.92097	

R squared = 1 - Residual SS / Corrected SS = .90014

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	659.90916667	6.812013050	645.81744403	674.00088930
B_2	7.048190381	.801666591	5.389816685	8.706564076

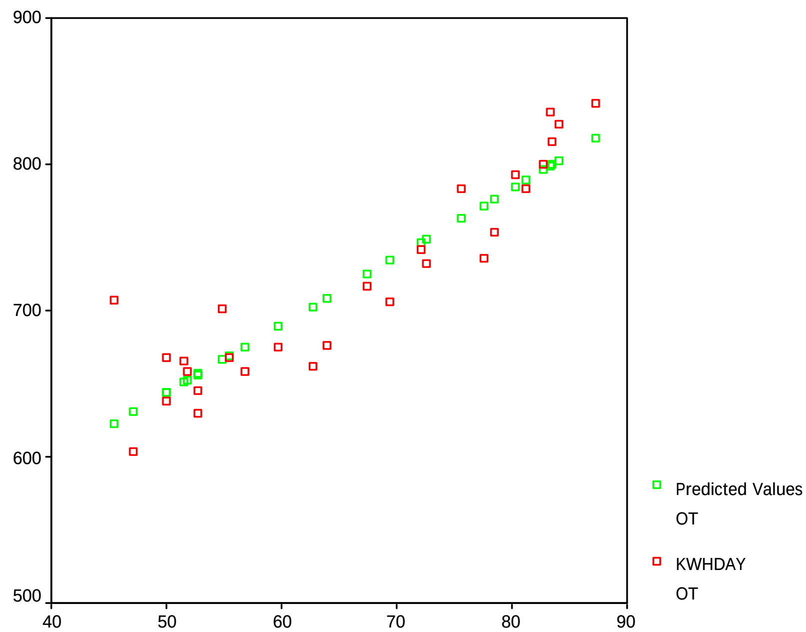

Fig. A.27 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 108000.

Table A.28 Analysis of Variance from Parabola Regression Model Convenience Store Number 108000. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.950[a]	.903	.896	22.26963

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	115855.5	2	57927.753	116.805	.000[a]
	Residual	12398.42	25	495.937		
	Total	128253.9	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	970.508	143.218		6.776	.000
	OT	-12.898	4.455	-2.547	-2.895	.008
	OT2	.132	.033	3.474	3.949	.001

a. Dependent Variable: KWHDAY

Table A.29 Analysis of Variance Table from Segment Regression Model on Data of the Convenience Store Number 115242.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	13345571.3046	2669114.26092
Residual	23	19195.85508	834.60239
Uncorrected Total	28	13364767.1597	
(Corrected Total)	27	109772.88470	

R squared = 1 - Residual SS / Corrected SS = .82513

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	624.26256620	10.213975689	603.13334766	645.39178474
B_2	4.930439861	.671544180	3.541244882	6.319634839

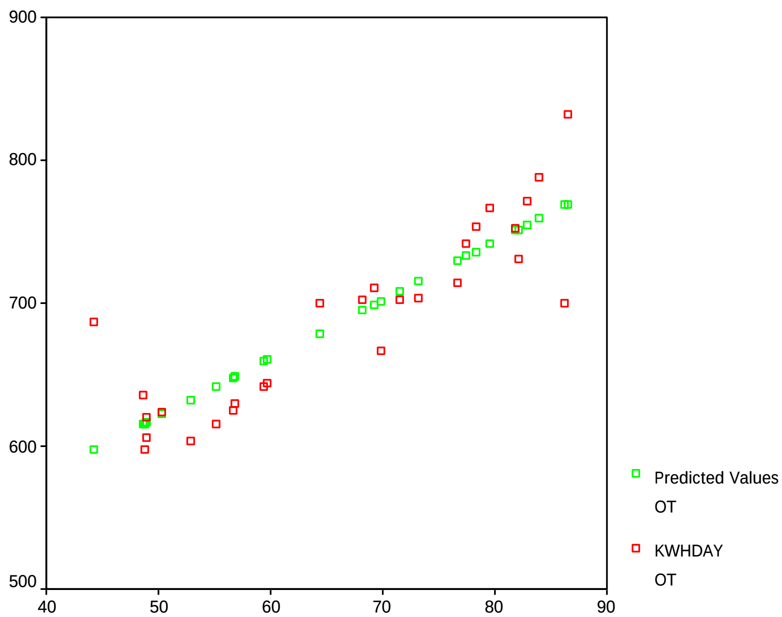

Fig. A.28 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 115142.

Table A.30 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 115142. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.895[a]	.800	.784	29.61323

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	87849.30	2	43924.652	50.088	.000[a]
	Residual	21923.58	25	876.943		
	Total	109772.9	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	747.154	174.490		4.282	.000
	OT	-6.364	5.455	-1.367	-1.167	.254
	OT2	7.910E-02	.041	2.252	1.921	.066

a. Dependent Variable: KWHDAY

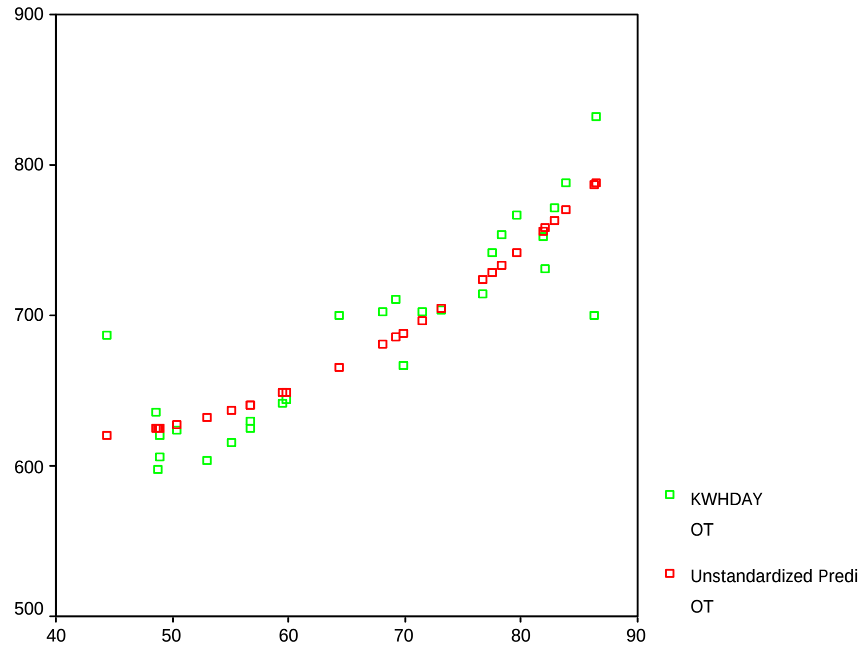

Fig. A.29 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 115142.

Table A.31 Analysis of Variance from Segment Regression Model for the Convenience Store Number 119114.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	3109718.35339	621943.67068
Residual	23	12772.69331	555.33449
Uncorrected Total	28	3122491.04670	
(Corrected Total)	27	28837.59841	

R squared = 1 - Residual SS / Corrected SS =   .55708

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	309.25187533	8.331675191	292.01649204	326.48725863
B_2	1.661036395	.485502868	.656697192	2.665375599

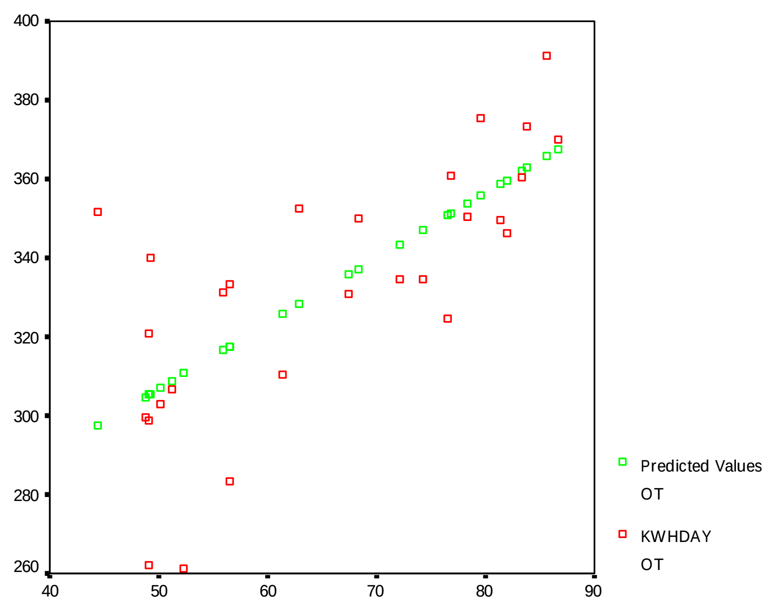

Fig. A.30 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 119114.

Table A.32 Analysis of Variance from Parabola Regression Model Convenience Store Number 119114. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.744[a]	.553	.517	22.70159

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15953.55	2	7976.774	15.478	.000[a]
	Residual	12884.05	25	515.362		
	Total	28837.60	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	411.539	138.862		2.964	.007
	OT	-4.308	4.377	-1.875	-.984	.335
	OT2	4.527E-02	.033	2.603	1.366	.184

a. Dependent Variable: KWHDAY

Table A.33 Analysis of Variance from Segment Regression Model for the Convenience Store Number 125530.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	4	13351246.6735	3337811.66838
Residual	25	44886.39208	1795.45568
Uncorrected Total	29	13396133.0656	
(Corrected Total)	28	76224.18548	

R squared = 1 - Residual SS / Corrected SS =   .41113

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	514.43290920	39.869188102	432.32077924	596.54503916
B_2	2.480181448	.593658367	1.257519154	3.702843742

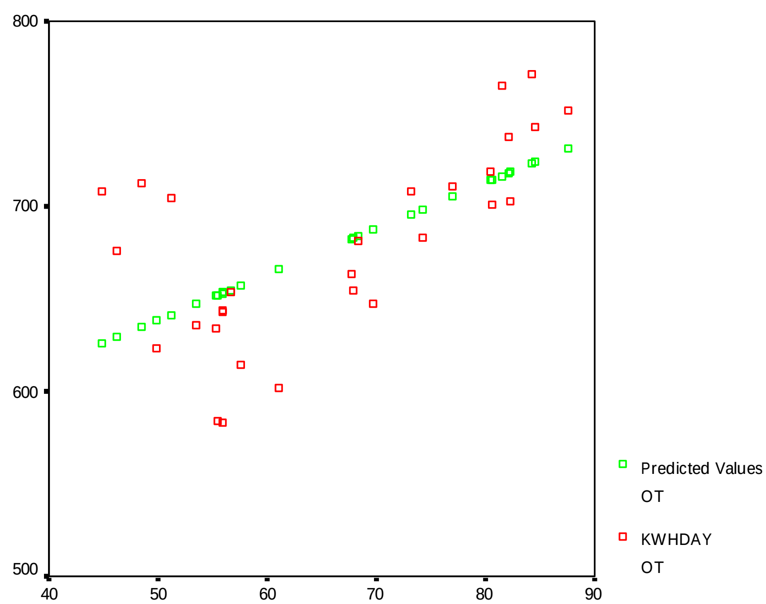

Fig. A.31 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 125530.

Table A.34 Analysis of Variance from Parabola Regression Model Convenience Store Number 125530. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.834[a]	.695	.672	29.88630

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	53001.22	2	26500.609	29.670	.000[a]
	Residual	23222.97	26	893.191		
	Total	76224.19	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1385.657	179.125		7.736	.000
	OT	-24.806	5.556	-6.413	-4.464	.000
	OT2	.205	.042	7.074	4.925	.000

a. Dependent Variable: KWHDAY

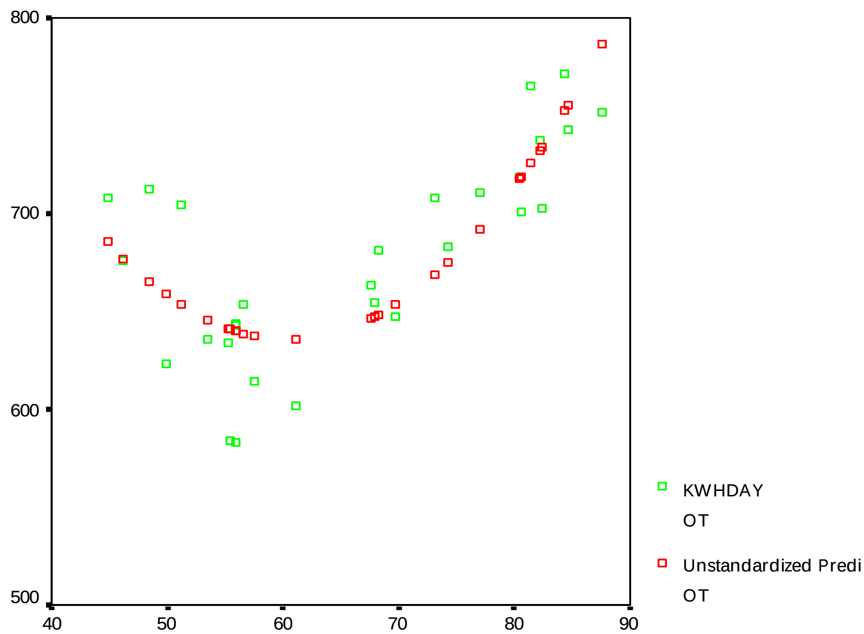

Fig. A.32 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 125530.

Table A.35 Analysis of Variance from Segment Regression Model for the Convenience Store Number 126226.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	9468624.96359	1893724.99272
Residual	23	77387.48871	3364.67342
Uncorrected Total	28	9546012.45230	
(Corrected Total)	27	225096.72007	

R squared = 1 - Residual SS / Corrected SS = .65620

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	447.27000000	.000000000	447.27000000	447.27000000
B_2	5.227528690	.788976502	3.595406445	6.859650934

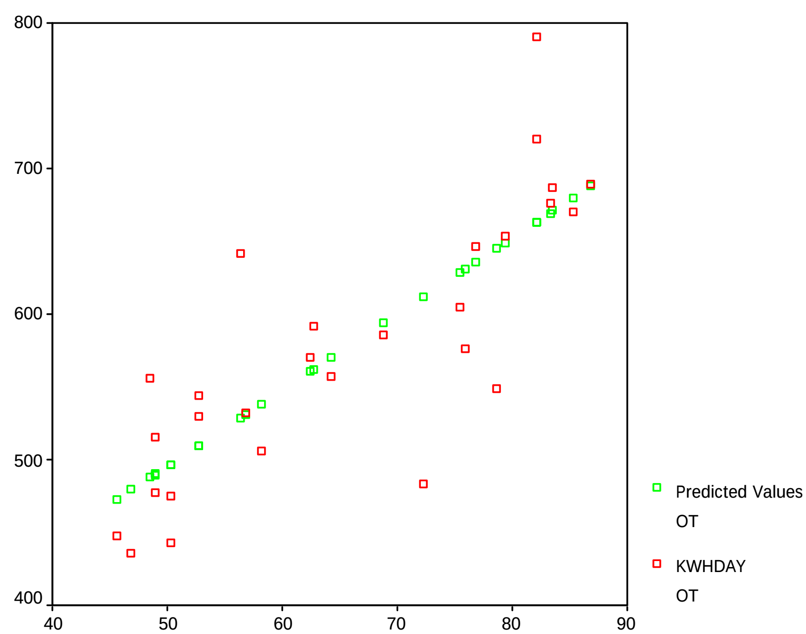

Fig. A.33 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 126226.

Table A.36 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 126226. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.813[a]	.661	.634	55.22507

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	148851.5	2	74425.753	24.403	.000[a]
	Residual	76245.21	25	3049.809		
	Total	225096.7	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	439.471	339.159		1.296	.207
	OT	-1.284	10.666	-.199	-.120	.905
	OT2	4.935E-02	.081	1.012	.612	.546

a. Dependent Variable: KWHDAY

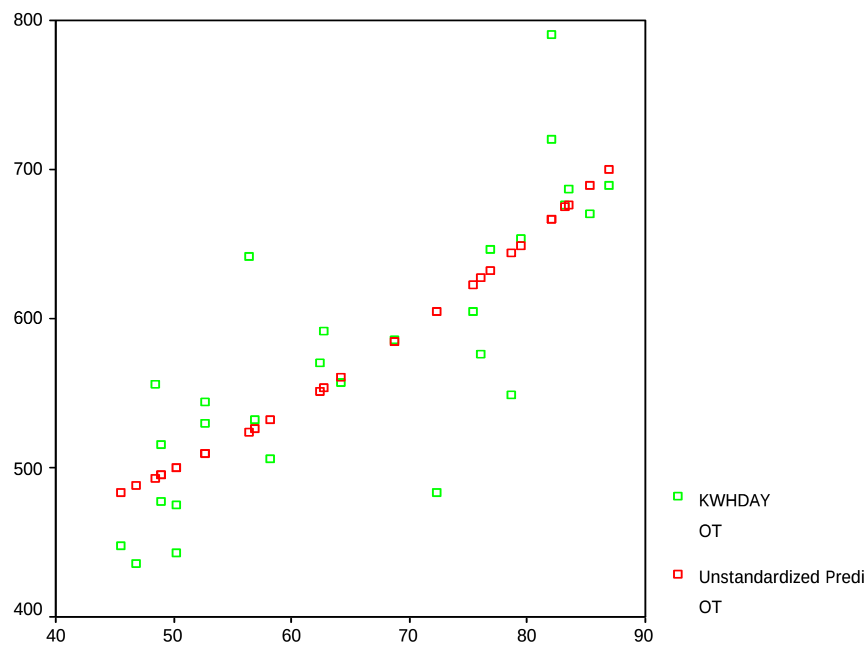

Fig. A.34 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 126226.

Table A.37 Analysis of Variance from Segment Regression Model for the Convenience Store Number 126630.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	33254228.7939	6650845.75879
Residual	24	203916.45235	8496.51885
Uncorrected Total	29	33458145.2463	
(Corrected Total)	28	411035.34630	

R squared = 1 - Residual SS / Corrected SS =   .50390

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	978.58985717	29.148788736	918.42971402	1038.7500003
B_2	6.447074225	2.058890199	2.197733705	10.696414746

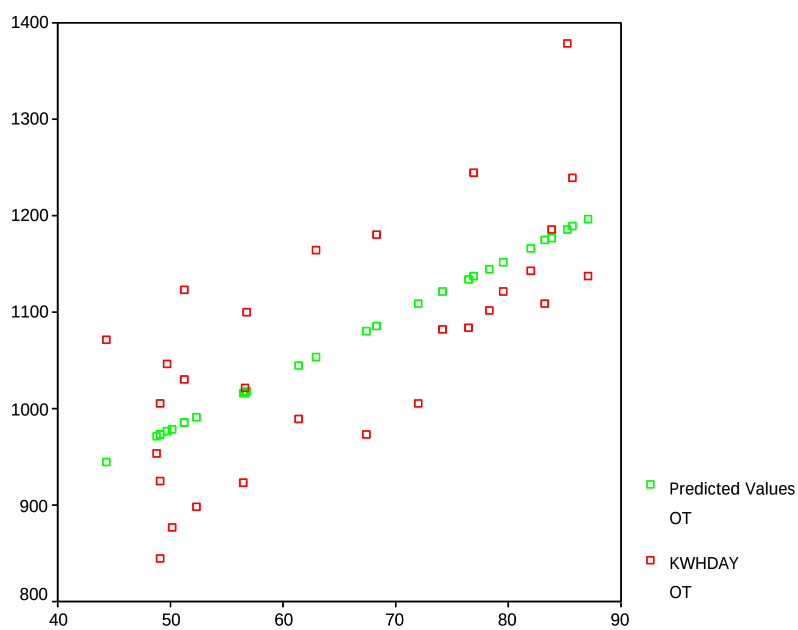

Fig. A.35 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 126630.

Table A.38 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 126630. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.711[a]	.505	.467	88.43462

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	207697.6	2	103848.801	13.279	.000[a]
	Residual	203337.7	26	7820.682		
	Total	411035.3	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1158.069	524.943		2.206	.036
	OT	-9.145	16.488	-1.085	-.555	.584
	OT2	.114	.124	1.789	.915	.369

a. Dependent Variable: KWHDAY

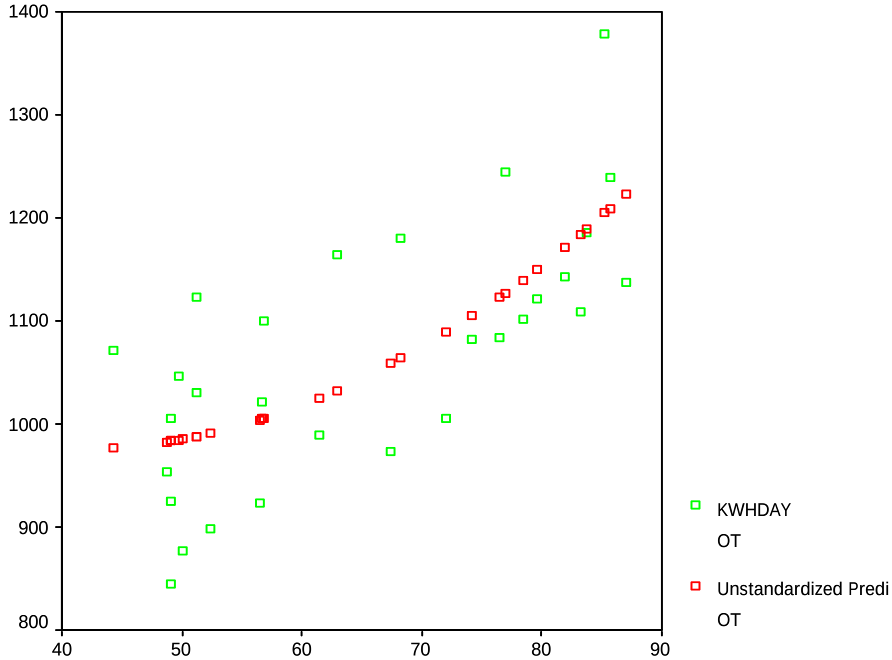

Fig. A.36 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 126630.

Table A.39 Analysis of Variance from Segment Regression Model for the Convenience Store Number 137580.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	5368309.95010	1073661.99002
Residual	23	69108.57870	3004.72081
Uncorrected Total	28	5437418.52880	
(Corrected Total)	27	77185.99450	

R squared = 1 - Residual SS / Corrected SS =   .10465

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	400.00000000	.000000000	400.00000000	400.00000000
B_2	1.269013400	.773984195	-.332094894	2.870121695

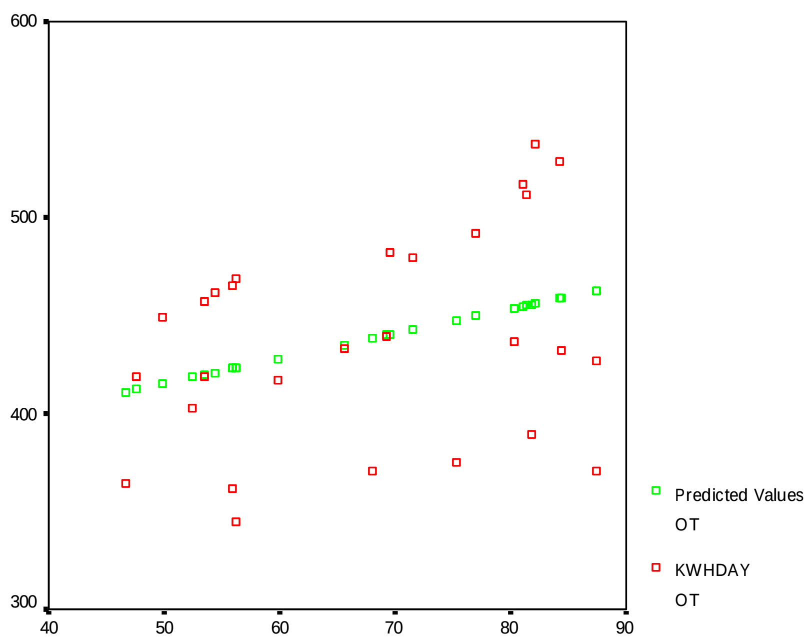

Fig. A.37 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 137580.

Table A.40 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 137580. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.341[a]	.116	.046	52.23638

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8970.015	2	4485.008	1.644	.213[a]
	Residual	68215.98	25	2728.639		
	Total	77185.99	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	157.066	344.488		.456	.652
	OT	7.278	10.532	1.855	.691	.496
	OT2	-4.45E-02	.078	-1.536	-.572	.572

a. Dependent Variable: KWHDAY

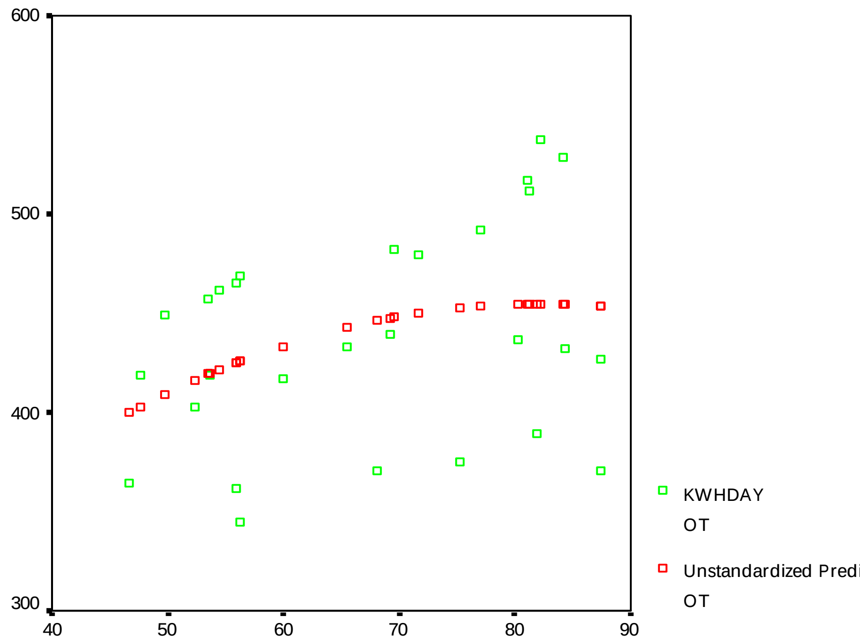

Fig. A.38 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 137580.

Table A.41 Analysis of Variance from Segment Regression Model for the Convenience Store Number 144454.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	8552843.61623	1710568.72325
Residual	23	31811.09447	1383.09106
Uncorrected Total	28	8584654.71070	
(Corrected Total)	27	123243.53227	

R squared = 1 - Residual SS / Corrected SS = .74188

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	492.73566633	10.735808710	470.52695394	514.94437873
B_2	5.812822922	1.371986272	2.974653079	8.650992765

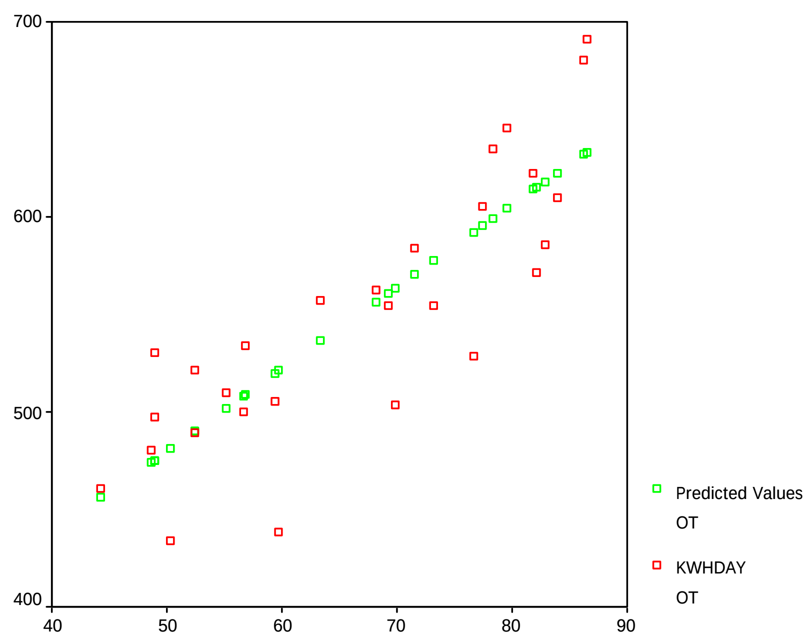

Fig. A.39 Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 144454.

Table A.42 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 144454. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.865[a]	.748	.728	35.21473

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	92241.61	2	46120.804	37.192	.000[a]
	Residual	31001.92	25	1240.077		
	Total	123243.5	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	653.450	212.436		3.076	.005
	OT	-7.870	6.615	-1.580	-1.190	.245
	OT2	9.115E-02	.050	2.433	1.831	.079

a. Dependent Variable: KWHDAY

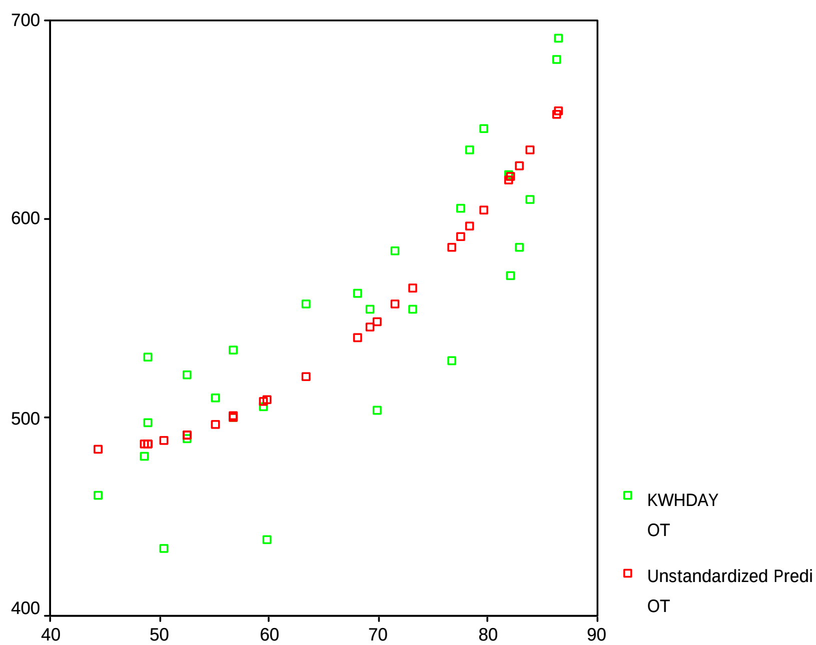

Fig. A.40 Parabola Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 144454.

Table A.43 Analysis of Variance from Segment Regression Model for the Convenience Store Number 146654.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	8557128.17339	1711425.63468
Residual	24	43608.57591	1817.02400
Uncorrected Total	29	8600736.74930	
(Corrected Total)	28	140394.28990	

R squared = 1 - Residual SS / Corrected SS =   .68938

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	378.06000000	.000000000	378.06000000	378.06000000
B_2	4.192878442	.574495953	3.007177072	5.378579813

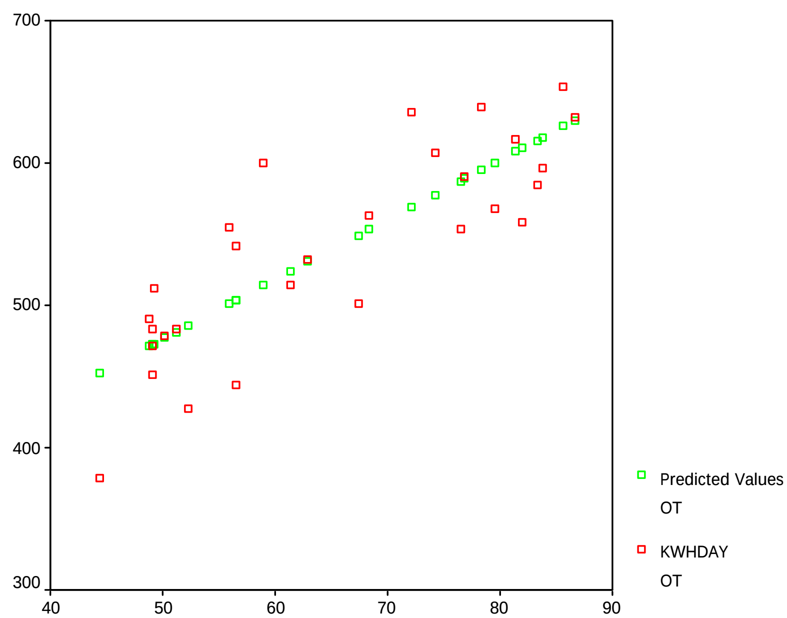

Fig. A.41 Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 146654.

Table A.44 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 146654. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.843[a]	.710	.688	39.53780

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	99750.12	2	49875.058	31.905	.000[a]
	Residual	40644.17	26	1563.237		
	Total	140394.3	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-56.950	237.635		-.240	.812
	OT	14.454	7.471	2.862	1.935	.064
	OT2	-7.78E-02	.056	-2.037	-1.377	.180

a. Dependent Variable: KWHDAY

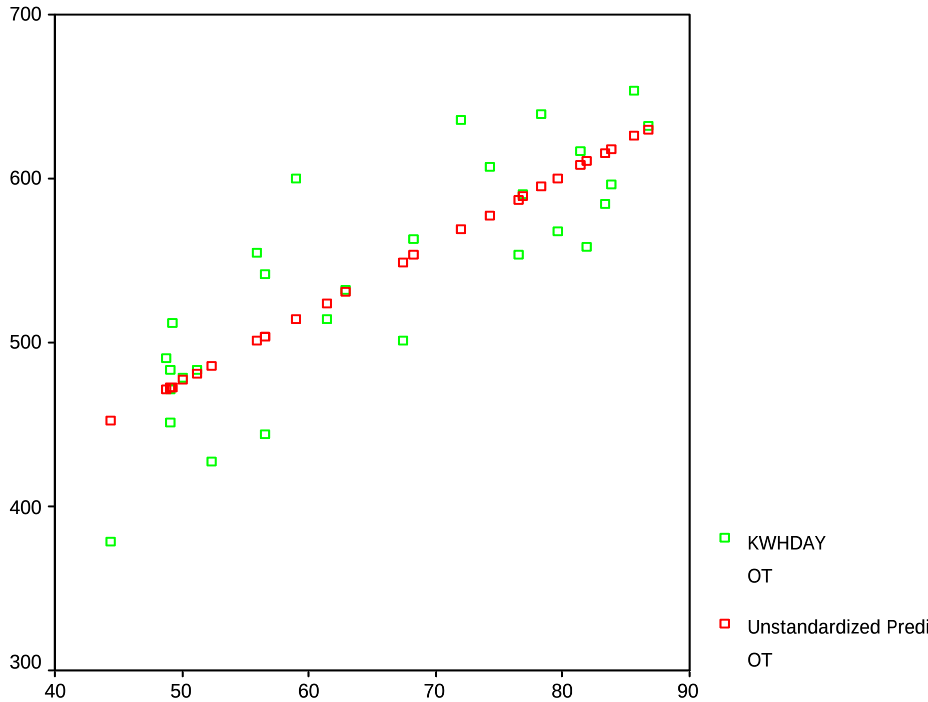

Fig. A.42 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 146654.

Table A.45 Analysis of Variance from Segment Regression Model for the Convenience Store Number 147338.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	9808003.66472	1961600.73294
Residual	23	85594.15848	3721.48515
Uncorrected Total	28	9893597.82320	
(Corrected Total)	27	248671.02914	

R squared = 1 - Residual SS / Corrected SS = .65579

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	515.37750000	17.610331133	478.94775448	551.80724552
B_2	7.709617169	1.994118125	3.584469535	11.834764804

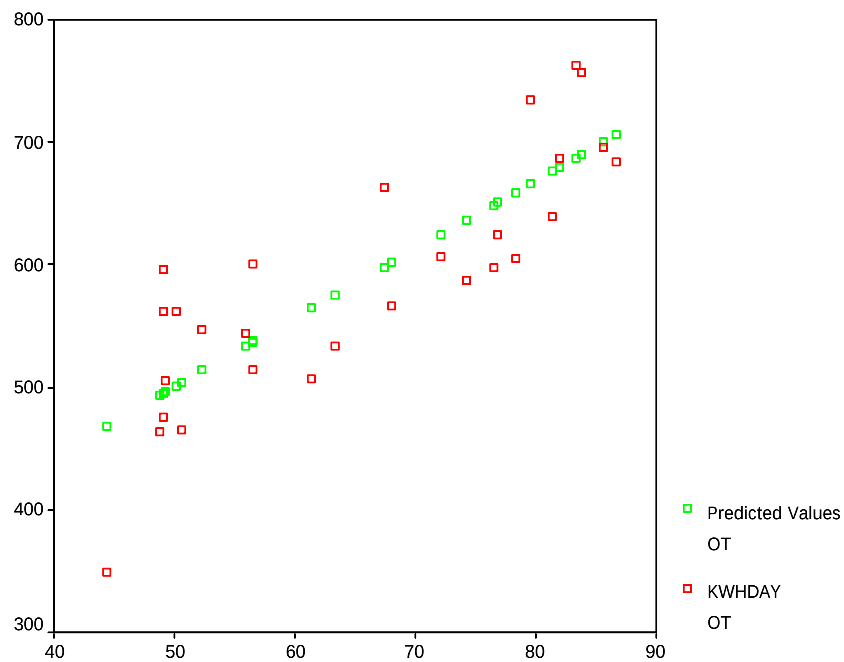

Fig. A.43 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 147338.

Table A.46 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 147338. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.831[a]	.690	.666	55.49145

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	171688.5	2	85844.245	27.878	.000[a]
	Residual	76982.54	25	3079.302		
	Total	248671.0	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	325.724	338.174		.963	.345
	OT	2.259	10.667	.335	.212	.834
	OT2	2.531E-02	.081	.496	.313	.757

a. Dependent Variable: KWHDAY

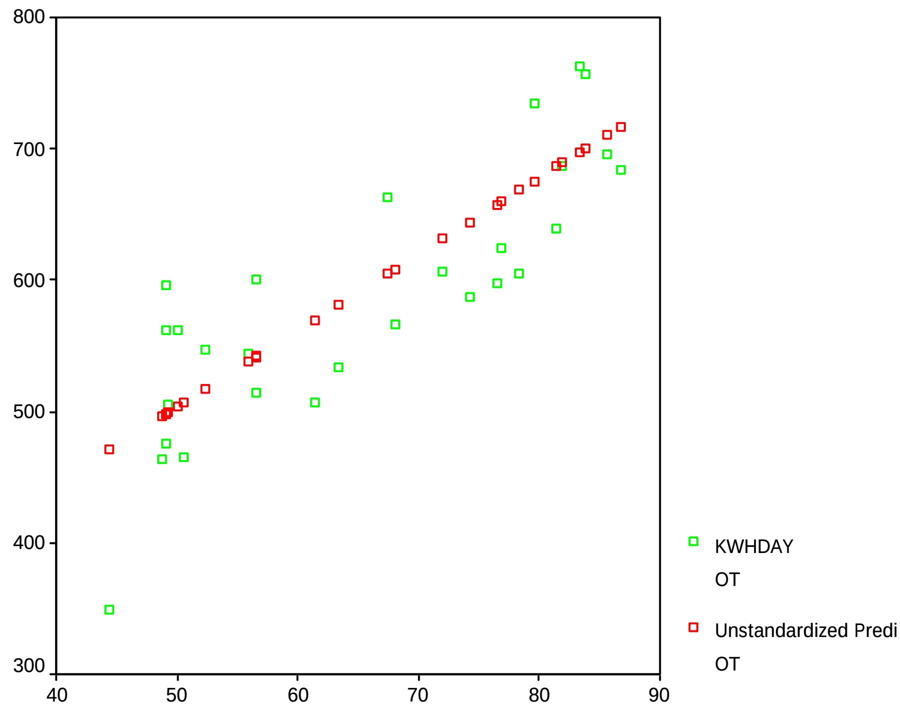

Fig. A.44 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 147338.

Table A.47 Analysis of Variance from Segment Regression Model for the Convenience Store Number 161494.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	1143939.55959	228787.91192
Residual	21	2519.36921	119.96996
Uncorrected Total	26	1146458.92880	
(Corrected Total)	25	6753.33366	

R squared = 1 - Residual SS / Corrected SS =   .62694

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	196.91100000	3.463668034	189.70790800	204.11409200
B_2	1.260886171	.333734625	.566847025	1.954925317

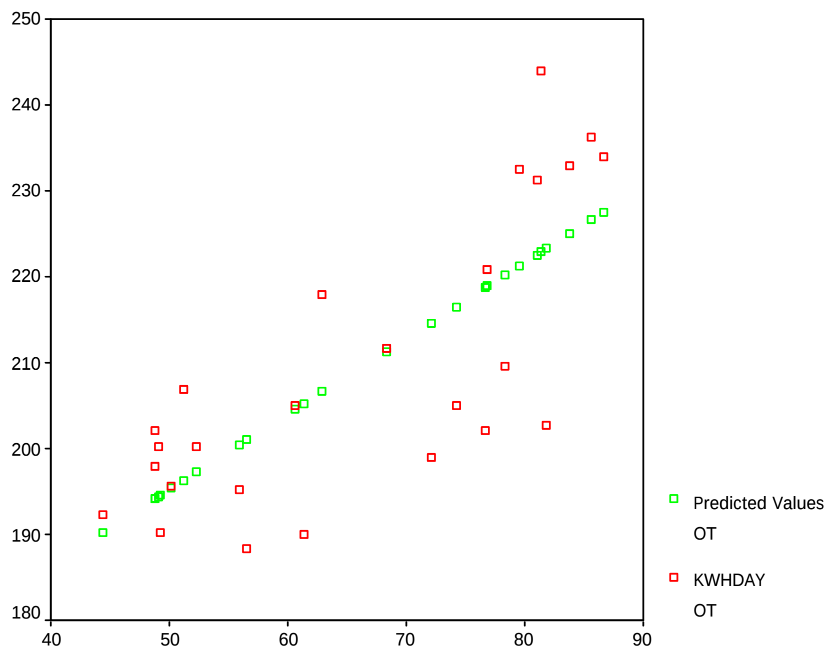

Fig. A.45 Segment Regression Model Plot of Predicted and Actual Values for Convenience Store Number 161494.

Table A.48 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 161494. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.806[a]	.650	.619	10.14272

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4387.213	2	2193.607	21.323	.000[a]
	Residual	2366.120	23	102.875		
	Total	6753.334	25			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	287.854	64.758		4.445	.000
	OT	-3.463	2.041	-2.998	-1.697	.103
	OT2	3.296E-02	.015	3.769	2.133	.044

a. Dependent Variable: KWHDAY

Table A.49 Analysis of Variance from Segment Regression Model for the Convenience Store Number 167260.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	4226997.55504	845399.51101
Residual	23	15029.47526	653.45545
Uncorrected Total	28	4242027.03030	
(Corrected Total)	27	110977.75527	

R squared = 1 - Residual SS / Corrected SS =   .86457

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	288.75270674	.000000000	288.75270674	288.75270674
B_2	4.150376809	.342512881	3.441834931	4.858918687

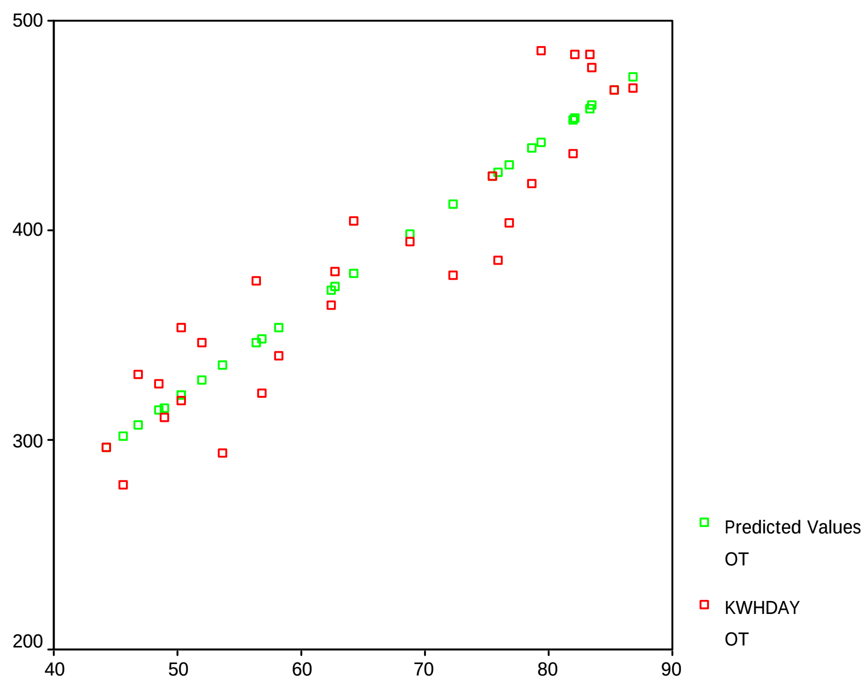

Fig. A.46 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 167260.

Table A.50 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 167260. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.932[a]	.869	.859	24.08120

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	96480.16	2	48240.078	83.186	.000[a]
	Residual	14497.60	25	579.904		
	Total	110977.8	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	242.193	136.946		1.769	.089
	OT	9.044E-03	4.336	.002	.002	.998
	OT2	3.157E-02	.033	.930	.958	.347

a. Dependent Variable: KWHDAY

Table A.51 Analysis of Variance from Segment Regression Model for the Convenience Store Number 167330.

Nonlinear Regression Summary Statistics **Dependent Variable KWHDAY**

Source	DF	Sum of Squares	Mean Square
Regression	5	11005909.2358	2201181.84716
Residual	24	41404.34808	1725.18117
Uncorrected Total	29	11047313.5839	
(Corrected Total)	28	151299.84588	

R squared = 1 - Residual SS / Corrected SS = .72634

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	556.76000000	11.519819610	532.98426088	580.53573912
B_2	6.040155839	1.332193472	3.290643647	8.789668030

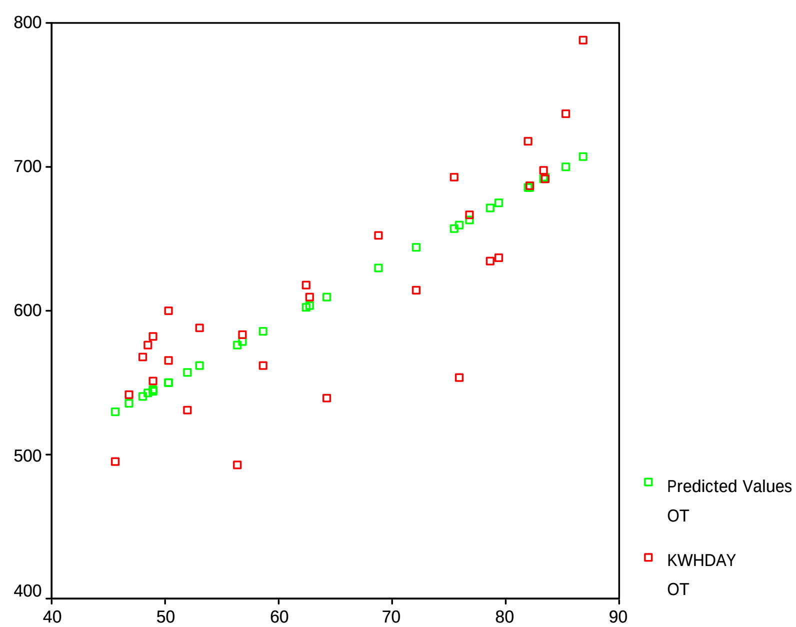

Fig. A.47 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 167330.

Table A.52 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 167330. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.864[a]	.746	.726	38.44389

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	112873.6	2	56436.794	38.186	.000[a]
	Residual	38426.26	26	1477.933		
	Total	151299.8	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	890.549	229.905		3.874	.001
	OT	-13.419	7.265	-2.604	-1.847	.076
	OT2	.135	.055	3.442	2.442	.022

a. Dependent Variable: KWHDAY

Table A.53 Analysis of Variance Table from Segment Regression Model on Data of the Convenience Store Number 170988.

Nonlinear Regression Summary Statistics Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	17193230.6939	3438646.13879
Residual	24	91241.24205	3801.71842
Uncorrected Total	29	17284471.9360	
(Corrected Total)	28	185565.81152	

R squared = 1 - Residual SS / Corrected SS = .50831

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	706.90444444	20.552692224	664.48577253	749.32311636
B_2	4.610000007	1.327785579	1.869585261	7.350414753

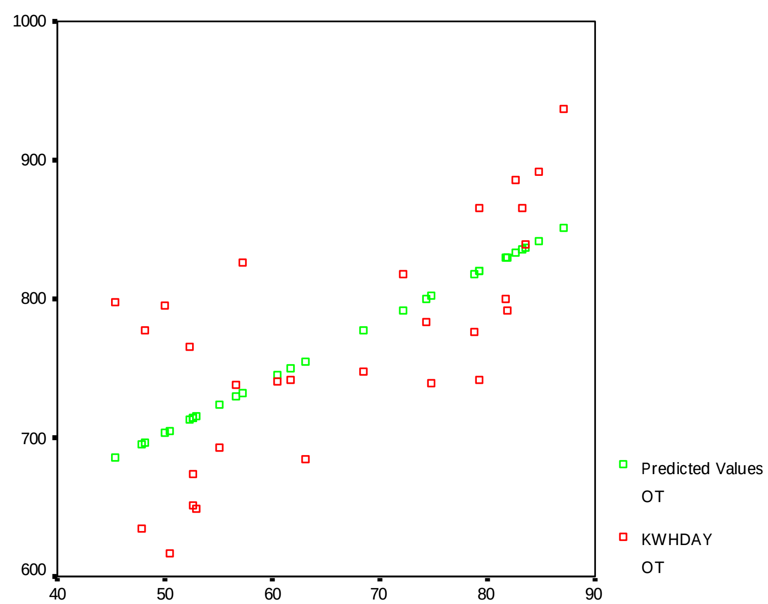

Fig. A.48 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 170988.

Table A.54 Analysis of Variance from Parabola Regression Model for the Convenience Store Number 170988. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.747[a]	.558	.524	56.14493

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	103607.2	2	51803.615	16.434	.000[a]
	Residual	81958.58	26	3152.253		
	Total	185565.8	28			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1342.747	368.331		3.645	.001
	OT	-22.357	11.490	-3.854	-1.946	.063
	OT2	.198	.086	4.548	2.296	.030

a. Dependent Variable: KWHDAY

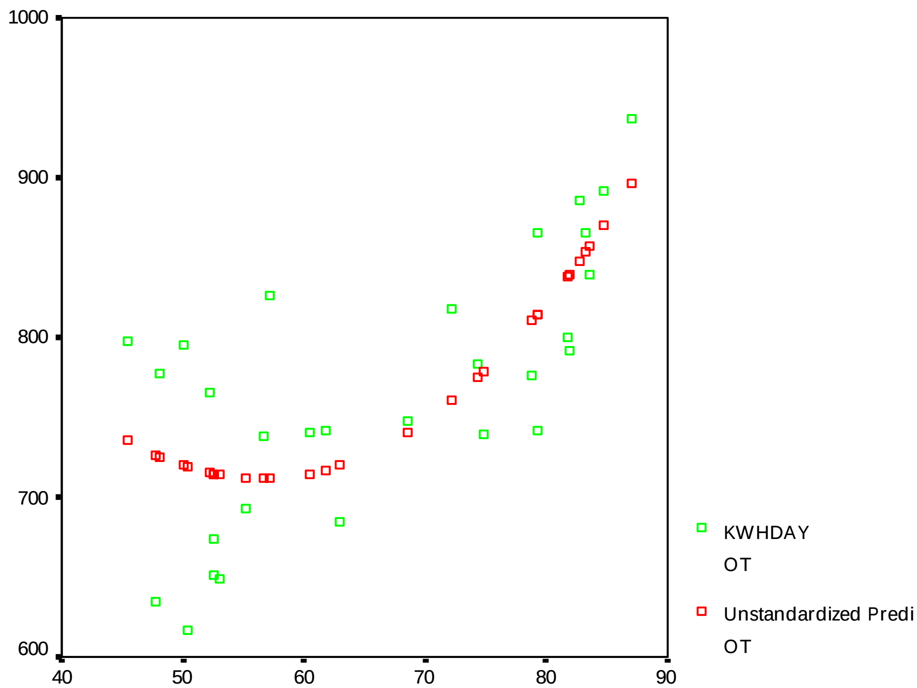

Fig. A.49 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 170988.

Table A.55 Analysis of Variance from Segment Regression Model for the Convenience Store Number 173540.

Nonlinear Regression Summary Statistics   Dependent Variable KWHDAY

Source	DF	Sum of Squares	Mean Square
Regression	5	48296283.6124	9659256.72248
Residual	23	112463.93522	4889.73631
Uncorrected Total	28	48408747.5476	
(Corrected Total)	27	405724.46554	

R squared = 1 - Residual SS / Corrected SS =   .72281

Parameter	Asymptotic Estimate	Std. Error	Asymptotic 95 % Confidence Interval Lower	Upper
B_0	1193.0955750	.000232998	1193.0950930	1193.0960570
B_2	7.857840592	1.491230451	4.772995370	10.942685813

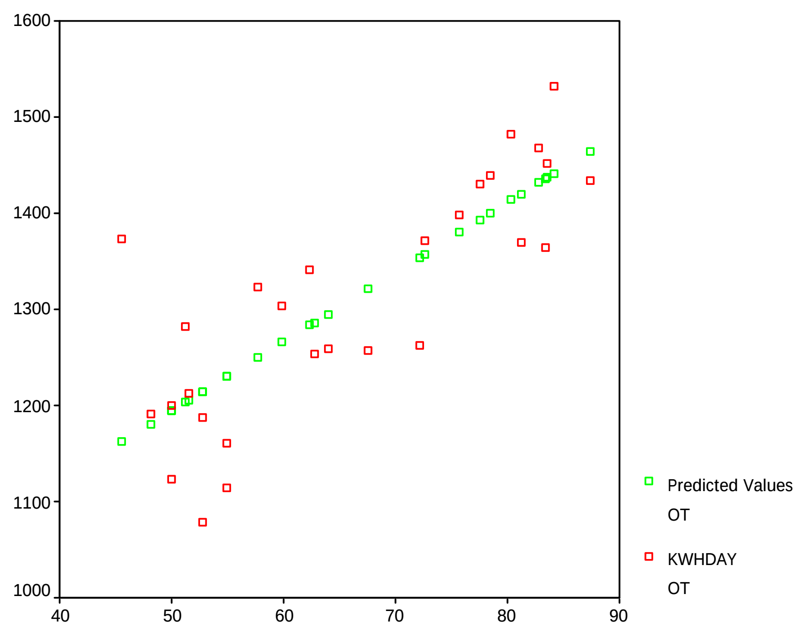

Fig. A.50 Segment Regression Model Plot of Predicted and Actual Values for the Convenience Store Number 173540.

Table A.56 Analysis of Variance from Parabola Regression Model Convenience Store Number 173540. Model Summary, ANOVA, and Coefficients.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.819[a]	.670	.644	73.17137

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	271873.2	2	135936.618	25.389	.000[a]
	Residual	133851.2	25	5354.049		
	Total	405724.5	27			

a. Predictors: (Constant), OT2, OT

b. Dependent Variable: KWHDAY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1520.429	478.975		3.174	.004
	OT	-14.286	14.863	-1.582	-.961	.346
	OT2	.162	.111	2.390	1.452	.159

a. Dependent Variable: KWHDAY

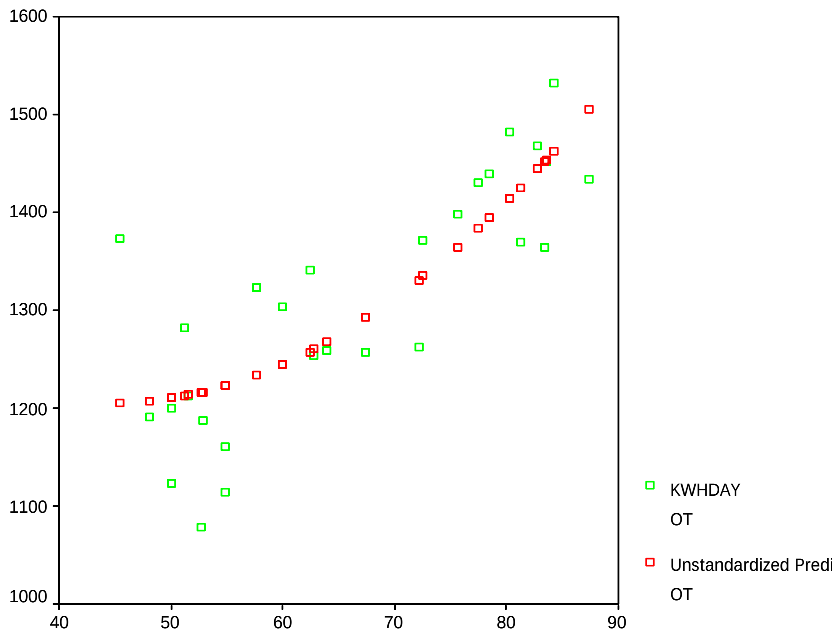

Fig. A.51 Parabola Regression Model Plot of Predicted and Actual Values for Convenience Store Number 173540.

APPENDIX B

APPLICATION PROCESS BY MODEL TYPES

B.1 Multiple regression model

By forecasting the monthly or yearly energy usage for all convenience stores through multiple regression model, the dataset from each store is required and multiplied by constant unstandardized coefficients (B) derived from the first time running the multiple regression through all convenience stores. The convenience store number 101056 used as an example shown in Table B.1. Lastly, the predicted and actual values plot is presented.

Table B.1 Illustration of Actual and Predicted Values Using Multiple Regression Model for the Convenience Store Number 101056.

			B1	B2	B3	B4	B5	B6	B7	B8		
Multiple Regression			0.02415	257.58	-3.79	33.85	3.14	155.301	1.492	97.285	kWh/day	
Month	Store	B0	Area	South	Coolknot	Coeff	OT	West	Lights	East	Actual	Predict
Jan_01	101056	121.045	6579	0	49.92	6.68	50.20	0	73	1	327.32	680.59
Feb_01			6579	0	49.92	6.68	54.5	0	73	1	282.66	694.09
Mar_01			6579	0	49.92	6.68	61.6	0	73	1	264.11	716.38
Apr_01			6579	0	49.92	6.68	67.9	0	73	1	245.06	736.15
May_01			6579	0	49.92	6.68	75.3	0	73	1	301.40	759.38
Jun_01			6579	0	49.92	6.68	81.6	0	73	1	334.03	779.16
Jul_01			6579	0	49.92	6.68	84.6	0	73	1	370.16	788.58
Aug_01			6579	0	49.92	6.68	84.7	0	73	1	410.37	788.89
Sep_01			6579	0	49.92	6.68	79.7	0	73	1	438.91	773.20
Oct_01			6579	0	49.92	6.68	70.5	0	73	1	351.17	744.32

Multiple regression model

kWh/day = 121.045 + 0.02415 Area + 257.58South

- 3.79Coolknot + 33.85Cooleff + 3.14OT + 155.301west

+ 1.492Lights + 97.285East

B.2 Segment regression model

The monthly through a year prediction results are analyzed by segment regression models with the three input variables: B_0, B_2, and T-Cool. Those are varied from store to store and derived from the fist time running with segment regression model. The following is an example from convenience store number 101056.

Table B.2 Illustration of the Slope (B_0) and Coefficient (B_1) by Using Segment Regression Model for the Convenience Store Number 101056.

Segment Regression							
Month	Store	B0	B2	Tcool	OT	Actual	Predict
Jan_01	101056	311.27597	3.72	55.10	50.20	327.32	311.28
Feb_01					54.5	282.66	311.28
Mar_01					61.6	264.11	335.44
Apr_01					67.9	245.06	358.86
May_01					75.3	301.40	386.37
Jun_01					81.6	334.03	409.79
Jul_01					84.6	370.16	420.95
Aug_01					84.7	410.37	421.32

Segment regression model

$$kWh/day = 311.276 + 3.718\ ((T_{avg}\text{-}T_{cool}),0)$$

B.1.3 Parabola regression model

The monthly through a year prediction results are analyzed by parabola regression models with the three input variables: B_0, B_1, and B_2. Those are varied from store to store, and derived from the fist time running with parabola regression model. The following is an example from convenience store number 101056.

Table B.3 Illustration of the Slope (B_0) and Coefficient (B_1) by Using Parabola Regression Model for the Convenience Store Number 101056.

		B0	B1	B2		
Parabola		309.824	-1.914	0.03848		
Month	**Store**		**OT**	**OT**	**Actual**	**Predict**
Jan_01	101056		50.20	2520.04	327.32	310.712
Feb_01			54.5	2970.25	282.66	319.806
Mar_01			61.6	3794.56	264.11	337.936
Apr_01			67.9	4610.41	245.06	357.272
May_01			75.3	5670.09	301.40	383.885
Jun_01			81.6	6658.56	334.03	409.863
Jul_01			84.6	7157.16	370.16	423.307
Aug_01			84.7	7174.09	410.37	423.767
Sep_01			79.7	6352.09	438.91	401.707
Oct_01			70.5	4970.25	351.17	366.142

Parabola regression model

$$\text{kWh/day} = 309.824 - 1.914*\text{OT} + 0.038(\text{OT})*2$$

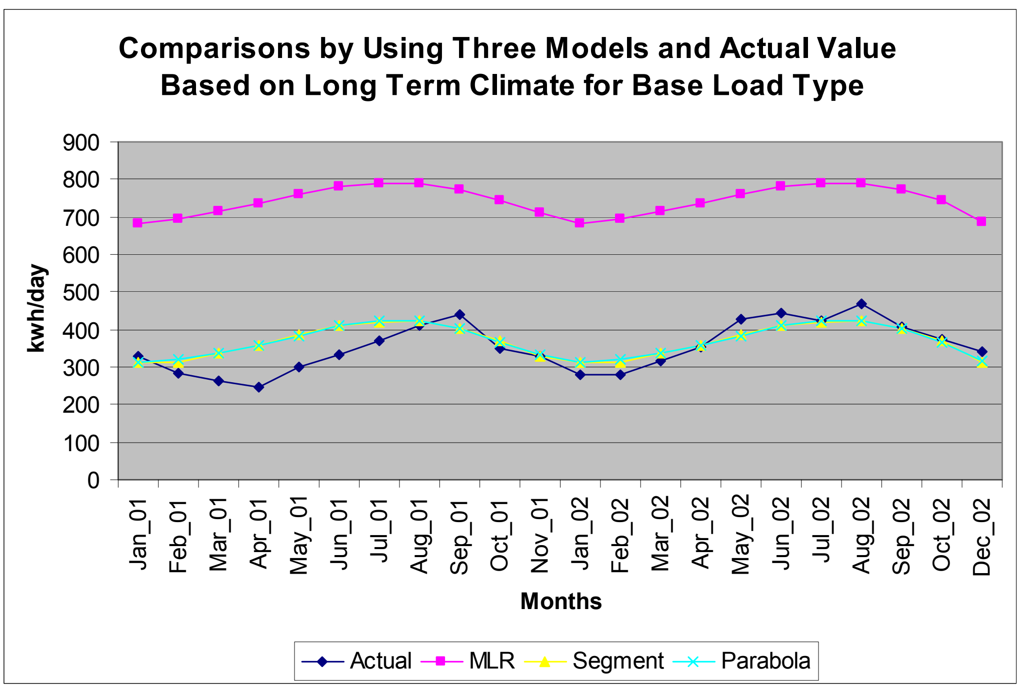

Fig. B.1 Comparison Results Using Three Prediction Models and Actual Value Based on Long Term Climate for Base Load (101056).

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