University Student Electrical Consumption Comparison and Analysis

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Abstract: This study examines monthly electrical consumption patterns as characterized primarily by student status, student traits, housing unit characteristics and price levels. Within the study conclusions are reached as to how monthly consumption habits vary along these factors and to what degree such variations occur. Possible applications of the results can be used in implementing more effective conservation efforts in student occupied rentals, by informing landlords of the potential benefits. Such benefits are due to understanding student occupants and their consumption habits of electricity.

Approved: ____

Prof. Bill Harbaugh　　　　　　Date

Introduction:

With the recent rise in global warming awareness, conservation initiatives and increasing energy prices, models of electricity consumption are becoming increasingly more valuable. Within such consumption models, habits of specific population groups can lead to greater insights, largely depending on which groups are seen as being important to specific regions. In a college town such as Eugene analysis on the consumption patterns of college students compared to the general population may prove to be particularly beneficial to those with interest in the matter, such as the Eugene Water and Electric Board (EWEB).

Our research was aimed at attempting to forecast the monthly electrical consumption of University of Oregon students, as compared to non-students, controlling for dwelling characteristics which we felt may have some effect. The purpose of our research was to model student consumption based on a wide array of variables, ranging from class (student year in school) standing to the market value of the dwelling unit. After accounting for all of the variables, it is possible for more accurate forecast models of consumption to be made, given such calculated attributes. Ultimately we suspect that better defined student consumption patterns will assist in increasing the efficiency of any conservation based initiatives.

The reasoning as to why we feel our results may be of some use to EWEB, or any other parties interested in electrical consumption by students, stems from our thoughts on the nature of student consumption. Initially, we held the belief that students, due to their nature, differed in their electrical consumption as compared to the general population. If true, we felt that knowledge of such differences would be useful to landlords of primarily student housing. With an increased understanding of their student-tenants demand for electricity, landlords could be more able to implement conservation practices by seeing future gains.

<u>Literature Review:</u>

Starting in the 1970's a good deal of research began to be focused on energy conservation. One aspect of this was in seeing how tenant and landlord electrical use varied by who was paying the bill. The results of research done during this period leaned towards advocating individual unit sub-metering for greater efficiency as opposed to entire complex master-metering. Change advocated by this research caused landlords to shift from including electricity in the rent to the tenant being responsible for their own individual electricity bill. The idea behind this change was to put the conservation incentive solely on the consumer in order to implement demand side management (DSM). This DSM, simply put, is to say that consumers if forced to pay for each kWh of use, will use only the amount they need and conserve the amount they would have otherwise been using, had they not been charged (marginal cost equal to zero).

Stemming from this research was the formation of the Public Utility Regulatory Policies Act (PURPA) in 1978, which requires all new constructed multi-family housing units to be individually sub-metered. Policy impacts such as PURPA demonstrate the importance of research surrounding energy conservation and what results such research can lead to. Energy

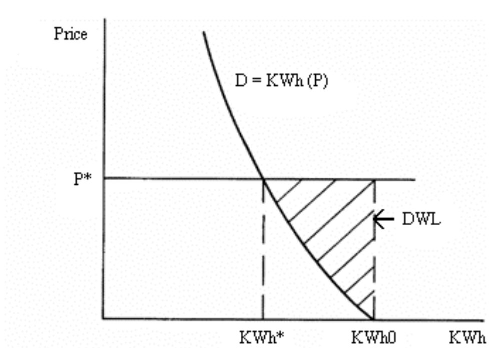

Figure 1

conservation is increasingly becoming more of a concern and in doing so is establishing a higher demand and importance for better insights into public electricity consumption patterns and preferences.

Economic analysis conducted by Vincent Munley, Larry Taylor and John Formby (1990) looked at the sub-metering versus master-metering assessment. In their research they found that there was a deadweight loss that occurred in comparing utilities included and non-utilities included plans. Utilities included plans, in this case, are termed to be plans that include an additional charge which is usually determined by the landlord to be around what they believe the average cost of electricity to be for each unit. In comparing the two it was observed that a tenant whose rental contract included the utilities would, in

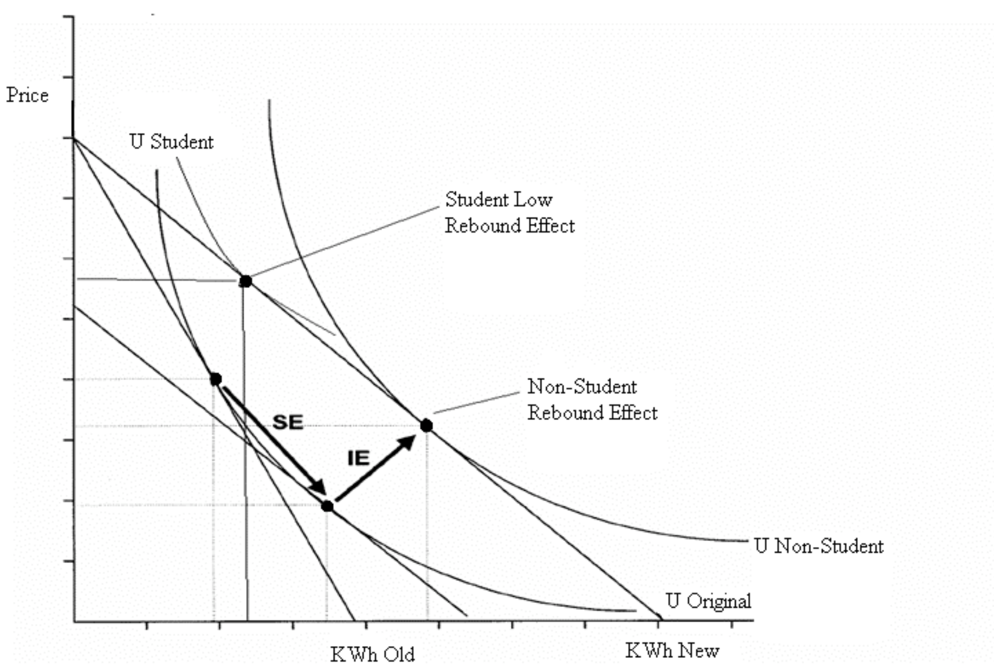

Figure 2: Insulation reduces the cost of achieving a given temperature, as a change in the slope of the Budget Constraint. Given this reduction, people respond by choosing a warmer temperature. This reduces the conservation effects of the warming unlike students who already set the temperature high.

all likelihood, act as though their marginal cost for electricity consumption was zero; tenants whose contracts did not include utilities valued electricity at their optimal preference, because they were responsible for paying the bill. According to the research, the differences in these preferences were found to create a DWL in utilities included plans. This DWL was created from the different marginal costs observed by tenants and landlords. Because tenants faced marginal costs for electricity of zero they were believed to consume beyond their efficient optimal preferences, hence creating the DWL as shown in figure 1.

Within our study one of our goals was to measure how electricity conservation levels differed based on whether or not the consumer was a college student. To measure the amount of conservation we used a method presented by Mathias Binswanger (2001). Binswangers' method attempted to see if consumption changes were related to substitution or income effects. Observations of these effects figured into our determination of whether or not students experience any combination of the two, in the form of rebound effects related to their parents paying their utility bills for them. The rebound effect can be described as diminishing the levels of conservation that are usually thought to result from a decreased cost of warmth from insulation effects and price and income effects. An example of a rebound effect is shown in Table 1, in the case of two different units, one with proper insulation and one without. The starting point in this case is the non-insulated unit with a temperature of 68°. Once the unit becomes properly insulated the tenant will turn up their thermostat to 72°, since they are still using less energy (7.5 kWh) then when they were at 68° without insulation (10 kWh). The rebound effect that can be summed up in this case is that instead of staying at 68° after their unit was insulated; the tenant shifted their thermostat to 72° which reduced the amount of

Electricity Consumption		
Temperature	Insulation	
	No	Yes
68 deg.	10 KWh	5 KWh
72 deg	15 KWh	7.5 KWh

Table 1

conservation from what should have been 5 kWh to only 2.5 kWh. When the price of staying warm goes down from new renovations such as proper insulation, consumers could then feel enticed to increase the temperature of their thermostat (as shown in the previous example). The increase in electricity consumption associated with increasing the temperature is the rebound effect from a lower price of warmth.

Students whose parents pay their electricity bills for them do not consider costs of electricity in their consumption, thus creating a zero marginal cost condition. Due to this condition these students have therefore chosen a point of satiation as shown in figure 3 for their consumption level. Such a consumption level would mean that the rebound effect of implementing conservation directed renovations on a rental could be much less than that of a non-student; because students do not face the price of warmth and are therefore not responsive to changes in that price.

Counter to the prior mentioned research conducted in support of ideas like DSM and sub-metering to further electricity conservation, research has also been done in

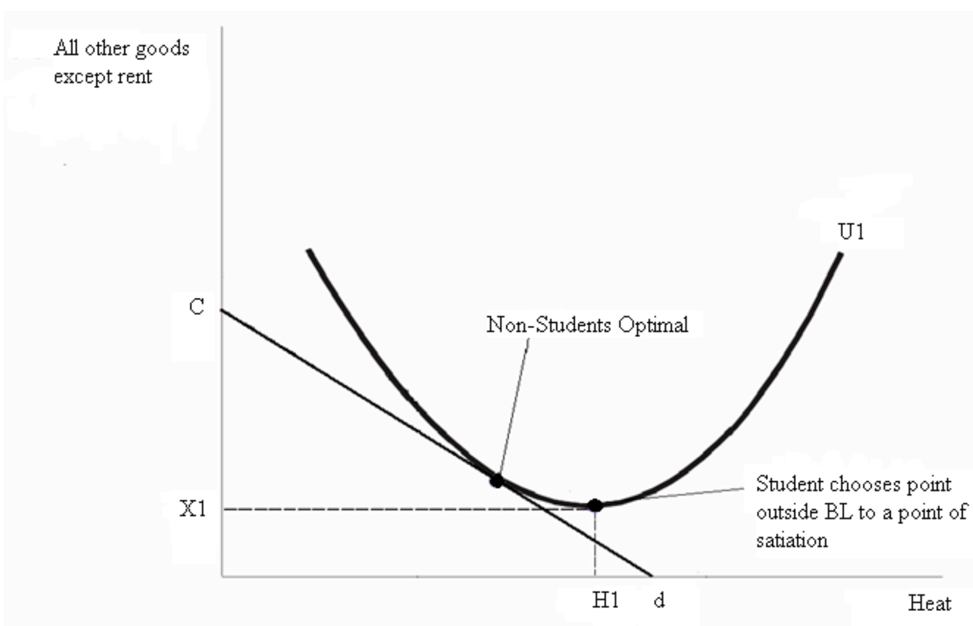

Figure 3: Non-students choose an optimal point when faced with MC = PC, but students who face MC = 0 will make a choice outside the Budget Constraint.

support of alternative measures such as master-metering. Arik Levinson and Scott Neimann (2003) looked at landlords' potential to gain from master-metering. Addressing possible gains to landlords leads us into multiple questions regarding incentives and ability levels of landlords to capture such additional gains. More specific to our situation is the effect student consumers might have on these gains, mainly what the effect of their zero marginal cost for electricity will have. Ability of landlords to capture further gains is one of the main driving forces behind our research because it can assist in determining optimal amounts of conservation schemes, such as renovation subsidies.

Levinson and Neimann's research is explained by looking at two apartments, one with full insulation and the other without. Figure 4 depicts two apartments, identical but for the amount of insulation. Apartment A is well insulated and has low heating costs; apartment B is poorly insulated and has high heating costs. If heating costs are known in advance, prospective tenants will be willing to pay at most (a-c) more in rent for apartment A than for apartment B, the compensating variation of moving from B to A.

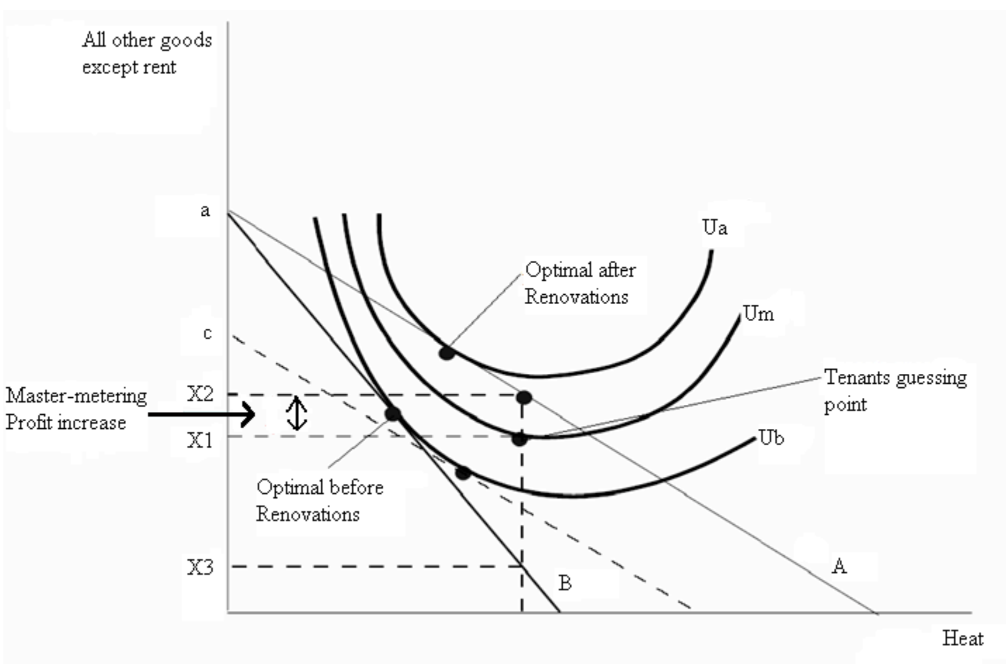

Figure 4: Landlord renovates and master-meters. Tenant doesn't know the optimal point and is left to guess. Landlord increases profit by increasing efficiency over the point that the tenant guesses.

The problem addressed in this matter is that tenants don't always have the ability of knowing which buildings are better insulated, preventing them from having the capability to determine building efficiencies. Such a lack of knowledge leaves the tenant guessing as to what the efficiency levels are. This guessing point which tenants are at leads to a gain for the landlord of (x_2 - x_1) which is the point where landlords charge for rent and what tenants would be willing to pay. These profitable gains could be seen as an incentive to the landlord to increase conservation by implementing more renovations that increase efficiency and increase conservation to make more profits.

In our research, because the majority of renters are students, gains to landlords could possibly have even greater gains than compared to a non-student occupied dwelling. A general characteristic that can be placed on student renters is that they are first-time renters, which lends to the assumption that they know little about the rental market and associated general rental costs. Student renters can also be characterized as being less-price responsive, as established in the assumption that students have a zero marginal cost for electricity. This zero marginal cost comes from having mom and dad pay the bill after the student has consumed the electricity. Essentially student renter preferences can be loosely described in the assumption that they don't know and don't care; allowing landlords to exploit their consumption levels, through a combination of utilities-included-rent coupled with renovations.

Methodology:

The research focuses on college students and their electrical consumption differences to that of an average household. It covers the addresses of students attending the University of Oregon during the years 1996-2007, which were compiled and matched with the local utility company (EWEB) to see how many kilowatt hours of electricity were consumed by households with student occupants versus dwellings with no student occupants and how responsive each was to price changes. In addition we looked at the student occupants' majors and college class levels in school to see who consumed more electricity and the dwelling itself to see and compare market values and square footages to electrical consumption.

For our analysis the primary goal is to clearly outline incentives for landlords of student multi-family complexes to participate in energy conservation efforts. In order to outline these incentives we must first establish if dwelling units with student occupants use more or less electricity than that of a unit with no student occupants and also see how each respond to price changes. The responses to price changes will give an idea of whether or not sub-metering is more or less efficient for student tenants.

Other research has done similar analysis when looking at electrical consumption and we will follow previously used methods, but address students specifically. Past models base kWh as a dependent variable and use other independent variables like temperature to explain the changes in usage of electricity. Arick Levinson and Scott Niemann use this form in comparing tenants' consumption if landlords pay utilities or not.

Our model will show consumption usage by addresses of where students live compared to addresses where there are no student occupants. The data is in a vertical

Note. When looking at our variables and units of measurement a kilowatt-hour (kWh) is a unit of energy, equal to 3,600,000 joules, or 1,000 watts over a certain period of time, which in the kilowatt-hour it's one hour. It can be described as the amount of energy/electricity that would be transferred at a constant rate of one kilowatt for one hour. This is the unit of measurement that is used by electric utility companies to determine the amount of energy used by the consumer. A megawatt-hour is measured in the same manner with time still being the main factor of measurement and 1,000 kilowatts equaling one megawatt form listing each address once for each month in which electricity was consumed and related to each address by a premise code. We use the xtreg command in Stata which takes each independent premise code variable and its repetitive pattern by monthly electrical consumption into account to compensate for the dwelling itself. This allows us to look at the usage by consumer and not by dwelling unit and focuses specifically on attributes of each address that might be attributing to the tenants consumption (e.g. two students may have identical consumption habits, but one lives in a new apartment and the other lives in an older home with bad insulation).

In running our analysis in Stata we decided that to get the best results it would be optimal to use the xtreg command for the majority of our regressions. The need for us to use the xtreg command arose from our data mainly being of the panel-data variety. Having panel-data, which largely consisted of multiple observations for multiple addresses over time, just using a general Ordinary Least Squares (OLS) regression would lead to exaggerations of our resulting variable coefficients.

Within our data are approximately 120 monthly consumption observations for each included address (10 years x 12 months). Using the xtreg command, we were able to have all observations allocated to their respective addresses while accounting for unique consumption characteristics of each specific address. This results in a more precise estimate for the consumption of dwellings at which a student lives. From this allocation we were then able to derive regression results explicitly across addresses, as well as time-series results for individual addresses.

Data:

The research was based on data received from EWEB, the Regional Land Information database (RLID) and the University of Oregon. Our research approach looks at the data in three different manners: one is the consumption of all residential EWEB customers compared to an address at which a student customer lives, second we look at the 2006 students and where they live, to see what commonalities that address has with certain students that live in it (e.g. freshman, sculpting, undergrad), and last we looked at the RLID data mixed with the student data to see unique patterns with respect to the dwelling structure itself (e.g. market value, sqft., etc.). The figure below shows the flow of the data process.

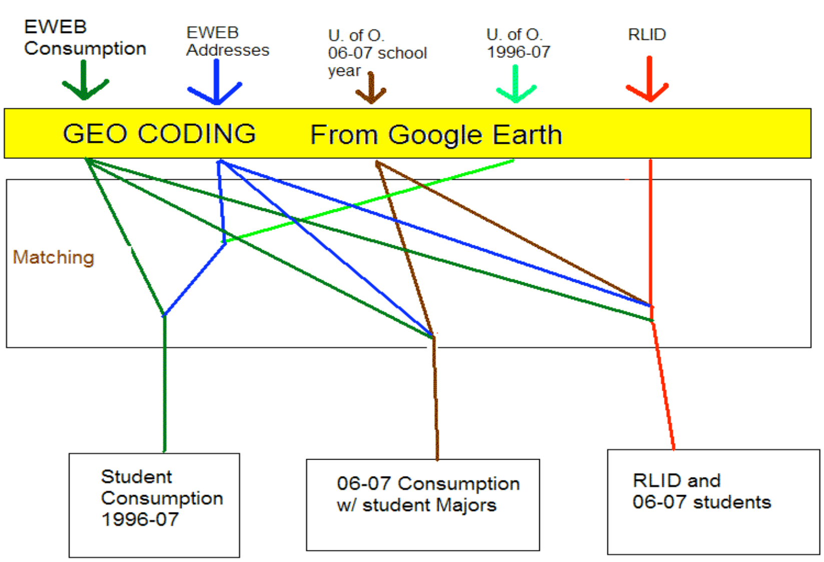

Figure.5 shows the flow of data and its matching process.

Before being able to regress and obtain a conclusion we first needed to sort through the various different sets of data we were given. Eugene Water and Electric

Board provided two discs; one was labeled "Consumption" and the other labeled "Shield Factor". The shield factor CD included a map of how to use its vast information access spreadsheet, but due to the amount of data and limited time we were unable to include it in our analysis.

The information on the consumption disc consisted of addresses, monthly kilo-watt usage and meter read date for approximately 90,000 addresses of residential customers. All together there were 10,293,125 entries encompassed by the dates of Jan. 1 of 1996 to April 15th 2007. The consumption data came in two separate access files: the first was of the consumption data with meter read date, monthly (96-07) kWh consumption and the customer ID number (premise code); the second was a file that had addresses of customers and customer ID numbers. The addresses came in a uniform format consisting of street number, street name, street type (e.g. st, lane, loop, dr…etc), unit number or letter, city and customer number all in a separate column. For privacy purposes we would use the address file to match the student addresses on a private computer, of which would give us a customer ID number to then be matched in the larger consumption file.

The University of Oregon gave us two different sets of data; the first was a notepad document listing addresses of students, unit #, zip code, city, their year in school, major and if they were an undergrad or graduate student, for the year 2006. Total number of entries was 13,496. Once separated into categories such as dorms, P.O boxes, actual dwelling addresses and entries where the student put a name instead of an address. The entries were 2120, 621, 9984 and 771, respectfully. The addresses in the data set were pulled from the U. of O. duckweb, where students have individual online accounts and can update their mailing addresses and other personal information as they move from one apartment to another. It also has information on permanent addresses. The student data would need to be matched with EWEB's, which only covered Eugene and parts of Springfield, therefore we limited the student data to the following zip codes: 97324, 97390, 97401, 97402, 97403, 97404, 97405, 97408, 97412, 97413, 97419, 97424, 97426, 97427, 97430, 97431, 97434, 97437, 97438, 97439, 97446, 97446, 97446, 97448, 97451, 97452, 97453, 97454, 97455, 97456, 97461, 97463, 97477, 97478, 97480, 97487, 97488, 97489, 97490, 97492, 97493 and 97498.

Once we imported the data into Microsoft Excel we observed a non-uniform address format for the students. Unfortunately, the self-entry of addresses by students created a formatting matching problem for us as many students would enter the same address in a multitude of different ways. The unit number and type were especially problematic. This, because the duckweb allows the students to enter the unit, space, room or apartment number of their mailing address into one cell labeled "#". Many students must misinterpret the entry format, as they often enter the dwelling unit number in with the street address number cell. This made a need for all the addresses to be re-separated into two groups, those with a unit number in the "unit #" cell and those with the unit in the street address cell. We then separated out all unit numbers from the street address cells by using "If statements", "find and replace" and "text to columns" functions in Excel. This gave us all the unit numbers in the same column in Excel and all of the addresses in another column. The addresses were then used in a Geo-coder to make all addresses formatted uniquely similar from the same program (Google Earth).

The different formatting of the addresses created a matching problem, as Microsoft Access would not recognize a matched pair of addresses unless they were entered in exactly the same way. To ensure that the EWEB, U. of O., and the RLID data where of the exact same format, we used the following web address: http://www.gpsvisualizer.com/geocoder/. In order to use the site for batch file we saved the site in the browser as a HTML file and reopened it in notepad. We then used a Gmail account to acquire an API key from Google. We typed in the API key into notepad and changed the relapse time for addressing to .0000005 from .5 and set the Google addressing limit to 50,000. After that we saved the file and reopened it in a web browser. Once the site was up and running, we cut and pasted all of the addresses from EWEB, U. of O. and RLID (each at different times) into the Geo-coder and waited overnight for the program to return the addresses in a new, unique format which included latitude and longitude coordinates. We then cut and pasted the addresses back into Excel and Access programs with the associated data and ran checks to ensure the data was placed in the correctly ordered cells.

Originally, we used the 2006 student data to make the assumption that: if a student lives in that address now then it has probably been a student address for the last ten years. We abandoned that assumption when U. of O. gave us the second batch of data entries, which included dates from 1996-2007. The new U. of O. data was processed through the same program as listed above in geo-coding to ensure unique formatting of addresses. The second set of U. of O. data consisted of students' addresses in the same format as the first set, only without data like major and class, instead there were new parameters included like the date the students registered their addresses and a start and end date that correlated with each student's affiliation with the University. The new student data set also included an ID #, which was randomly chosen by the University for each student, allowing us to see each student's dates of a move-in or move-out of an apartment and the addresses of that apartment, while keeping identification confidential. Due to time and a desire to get additional data from U. of O., we did not track each individual student in our regressions, instead we used their date of living at each apartment to indicate in the EWEB consumption data (dummy variable "student") whether a student lived in a given address during a given month.

We then matched all of the U. of O. student data with the EWEB address data by matching the new-unique formatted addresses and the unit numbers/letters to each other and marking it as yes/no(1,0) in Access if a match was found. This would mark the EWEB data with the dummy variable for student if a student lived in that address and leave as a "0" if a student did not live there. The match was based on the criteria that the EWEB "read-date" was between the students move-in and move-out dates. This would give us a match for each student to the precision of the month of which the student moved in and out of the address, based on the student changing their mailing address on the university website.

In creating a dummy variable to match consumption and student data, the data does not reflect more than one student living in the same address (i.e. roommates or even family members), the data would only show if it is a student address or not. At this point there is an assumption made that all occupants of student addresses are students. The problem with this assumption is that there could be some students living in their parents' house and therefore the electrical consumption that would be marked as student is really that of mostly non-student occupants (family). This assumption was felt to be adequate because if a normal household consumption was miss-marked as a student's, then it would cause our results to be under-estimated as apposed to over-estimating. Therefore, if we could see an effect even with the possibility of under-estimating, we would still notice an influential effect in our proposed model.

The total number of cells that were affected in the consumption data from the student matching was 552,356 meaning that the minimum amount of students that perfectly matched the EWEB consumption addresses during the students move-in and move-out dates was 31,102. Once an address was marked as being a student address, for each month over 10 years, the data was then ready to have prices included.

The prices of a kWh from EWEB (for prices of 1996-2007) were supplied over the phone and involved everything from flat rate to surcharges and then to tiered pricing. EWEB's pricing involved a base charge that was $5.00 form 1996-2000 and then a price that was determined on the kWh usages. The general pricing layout is found in figure 6 below. In 1996-2000 EWEB charged a flat rate of $.04015 per kWh with the exclusion of 98 & 99 where the price dropped to .04104 per kWh.

In 2001, tiered pricing was introduced and set its steps at: the first 800 kWh usages to be at a price of $.03127; the next 2,000 kWh of usage was charged at a rate of $.04569 per KWh; and any usage over 3,000 kWh was charged at $.06181. Included in the price was a surcharge of .00338 per total KWh and a delivery fee of $.0251 per total usage of kWh. EWEB also increased its base charge to $5.50. The largest increases can be seen in the chart by those consuming over 3,000 kWh as they had more than 100% price increase during this time period. The 2002 pricing included not just the tiered pricing, but also discriminated by season (winter or summer) and is still used today. The pricing discrimination entails the following: winter is considered the months Nov. 1st-April 31st and summer is May 1st – Oct. 31st. If consumption was during a winter month, tiered pricing followed the above layout of 800, 2200 and 3000 kWh, but if it was during a summer month, the break down reduced to 800, 900 and 1700 kWh and would have that years pricing associated to each tiered level and then calculated by a winter or summer usage amount. The 2002 pricing remained the same as 2001 with only the new summer limitation of 1,700 kWh of usage allowed before the higher tiered price was charged. In 2003 the only price or mechanism to change was the price of the delivery charge which dropped to $.02451.

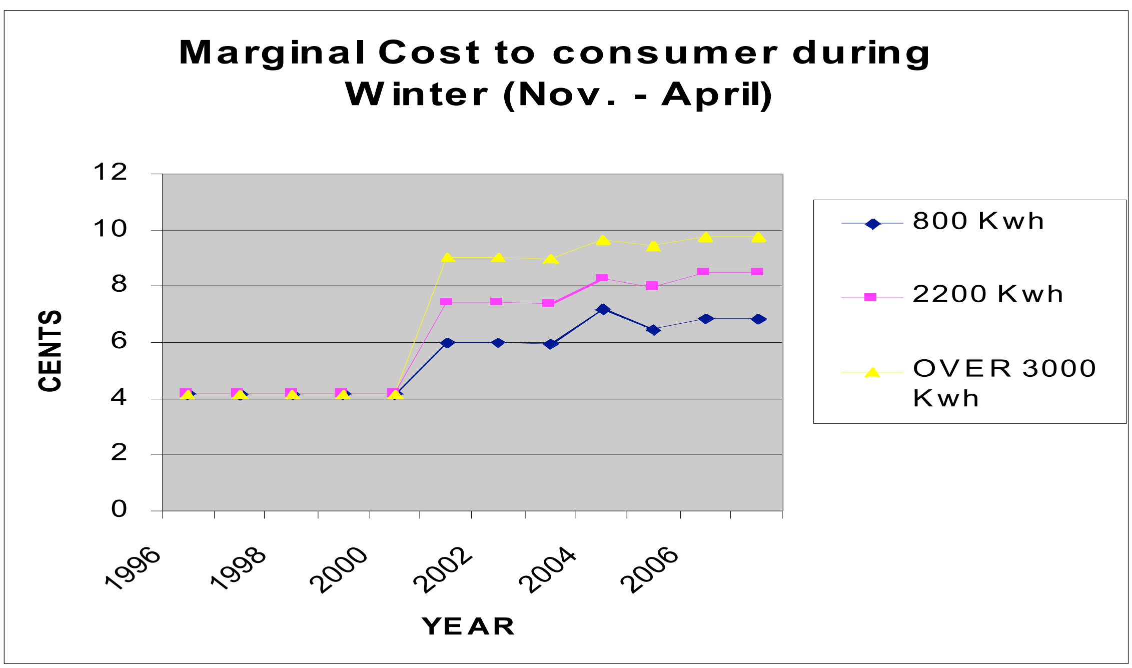

Figure 6: Chart show marginal cost to consumer per kilo-watt hour of electricity used during 1996-2007. The pricing for summer would be the same with different limitation of (800, 900 and 1700 Kwh).

In 2004 the base charge increased to $6.00 and the surcharge was curtailed completely. The delivery charge increased to $.02671 and the three-tiered pricing increased to the following: first 800 kWh was $.04051; second 2,200 or 900 kWh (winter, summer respectively) was $.05564 and anything over 3,000 or 1,700 kWh (winter, summer respectively) was $.06996. In 2005 rates dropped. The first 800 kWh was .03782, the next 2200 or 900 kWh (winter, summer respectively) was $.05295 and anything over 3000 or 1700 kWh (winter, summer respectively) was at a rate of $.06727.

The 2006-07 prices had an increase in the base fee to $6.50 and the delivery charge increased to $.02748. The three-tier pricing is as follows: the first 800 kWh is $.04068; the next 2200 or 900 kWhs are charged at $.05742 and anything over 3000 or 1700 kWh is charged $.06983. EWEB's prices, once approved, are implemented at the first of November each year. That puts each year's winter pricing overlapping into the next year.

Once the data was properly matched and separated into three different observations we were able to convert the Access files into Stata for a final analysis.

Results:

Student Consumption 1996-2007

First we looked the average amount of consumption by each group, dwellings with students and those without. The averages can be seen in the density graph in figure.7. We observed that student addresses consumed about 800 kWh/month and non-student dwelling consumed about 1000 kWh/ month. EWEB stated the average usage is about 1050 kWh/month, which then gave us an idea of what limits to put on cutting our outliers. Cut out of the data were any amounts of consumption below 100 kWh and above 5,000 kWh.

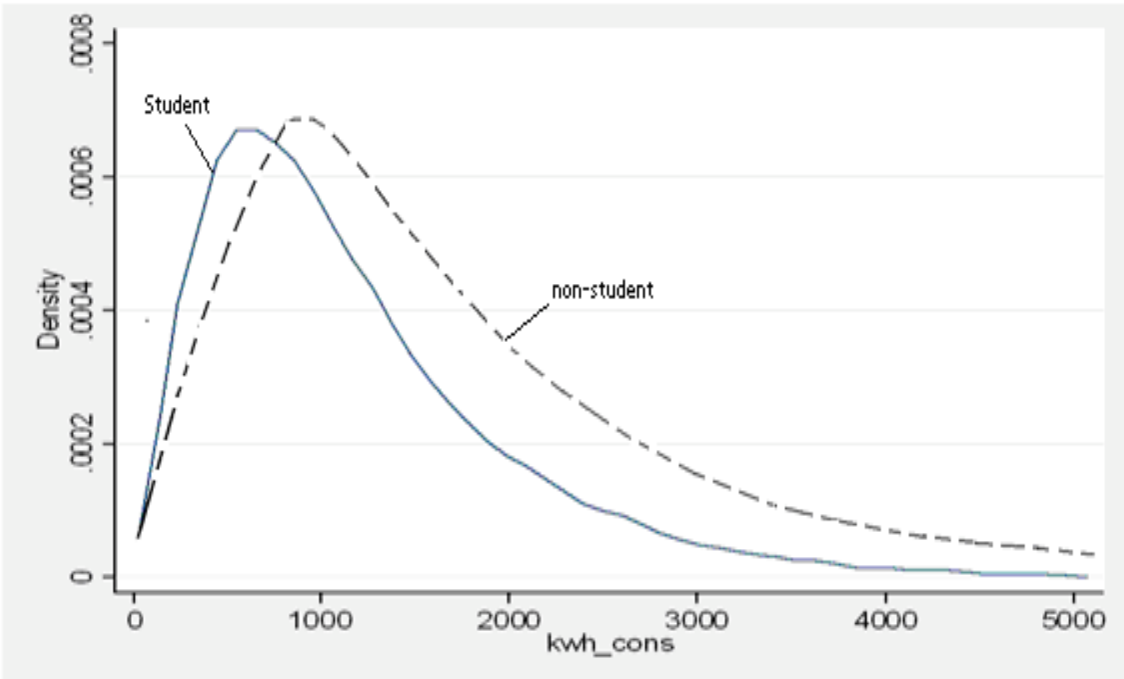

Figure.7 shows student (Blue) and non-student (Black) electrical usage data density.

Once the data was trimmed of any outlying observations, we wanted to see how responsive dwellings with students versus those without were to price changes. In 2000-2001 prices at EWEB changed to a tiered pricing scheme (as seen in figure.6). This change, more than doubled the price of electricity for those consuming over 3,000 kWh, at this point in EWEB's pricing history. We decided to focus on the time period 2000-01, in order to see the effect of the price increase, because increases that followed were very small and our results would not have been as apparent in seeing responses. We ran our regression to take into account the amount of electricity that a dwelling uses when a student is living there compared to a non-student dwelling, as well as how responsive dwellings with non-students are to the price increases during the 2000-2001 time period.

We also then looked at how addresses with students responded to the price increase. The results can be seen in figure.8.

Number of Observations	142812				
Number of Groups	55739				
R-Squared	0.1081				
Observations per Group (min)	1				
Observations per Group (avg)	2.6				
Observations per Group (max)	33				
kwh_cons	Coefficient	Standard Error	z-stat	P>|z|	[95% Confidence Interval]
Price_population	-123.047	4.156408	-29.6	0	[-131.1935, -114.9006]
student_consum	-352.4273	7.510041	-46.93	0	[-367.1467, -337.7079]
Price_stud	72.56645	6.368571	11.39	0	[60.08428, 85.04862]
_constant	1223.832	3.919677	312.23	0	[1216.15, 1231.514]

Figure.8 shows the responsiveness to price changes for dwelling with and without student occupants.

Dwelling units with at least one student occupant consumed much less electricity than homes without student occupants, but when the price increased drastically units with no student occupants reduced consumption 120 kWh on average. Units with student occupants only reduced consumption by 51 kWh on average. Therefore units with students do reduce consumption with price increase, but are much less responsive than dwellings with no students. We attribute these results to our original hypothesis that students consume to a point of satiation because their marginal cost of electricity is zero, due to parents paying the bills.

Understanding the responsiveness to prices can intuitively be seen in figure 9, which shows both the dwelling units budget constraint and utility of student and non-student occupied residencies. The non-student occupied dwelling is at an original point of A, once the price of a kWh increases, a substitution effect can be seen, which then lowers consumption by equalizing the new budget constraint to the past utility of electrical use. The new budget constraint (B2) now includes the higher prices of electricity and therefore the occupant gets a lower utility and consumption falls from its original quantity to the new optimal on the B2 constraint, at point C. The student occupied dwellings kWh usage is shown with the dash quantity levels on figure 9. In this chart you see that the amount of electricity used drops more for the non-student than the student occupied dwellings.

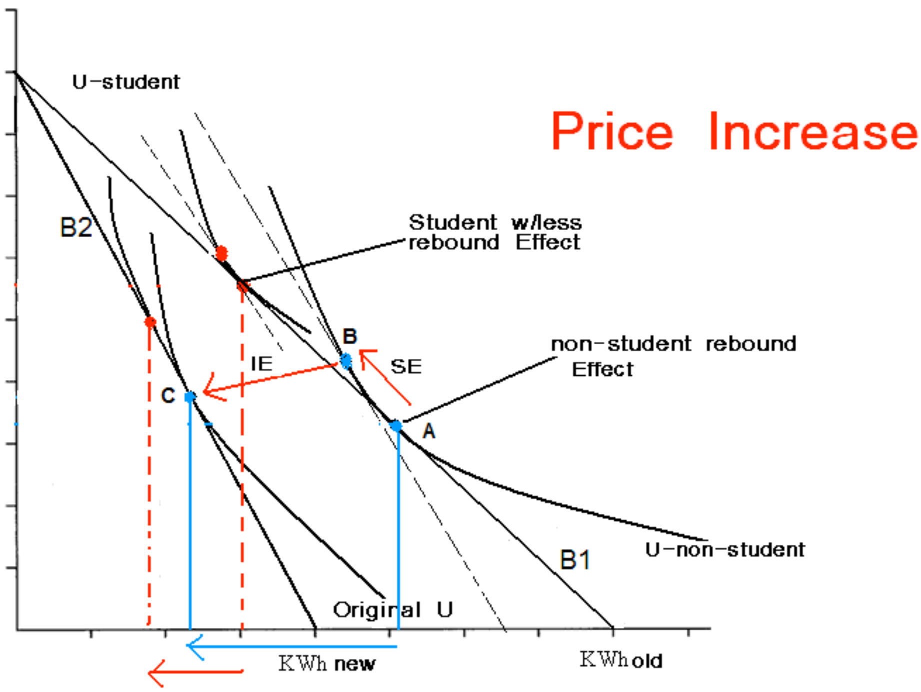

Figure 9 shows the substitution and income effects

The responsiveness to changes in price allows us to see the change in demand that occurs from consumers. In figure 10 is shown a model that represents both the non-student and student occupied dwellings demand for electricity. Designed through the correlation with the Price Increase chart (figure 9), figure 10 shows that dwellings with student occupants have a steeper demand curve than that of the non-student occupants. A steeper demand curve implies that dwelling units with student occupants have a more inelastic demand for electricity than do units with non-student occupants. More elastic meaning that the student dwellings reduce consumption by less than the quantity of kWh reduced by non-student dwellings. This is shown in the figure 10 as student quantity (SQ1) is reducing to SQ2 and non-student quantity (Q1) dropping to Q2.

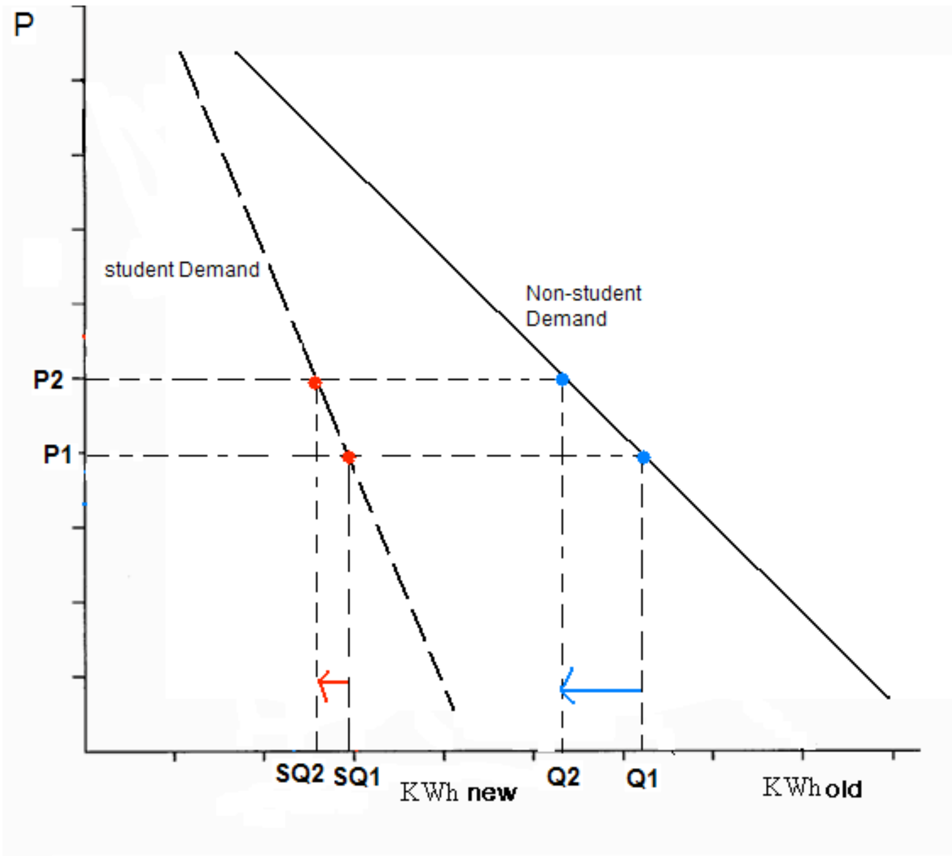

Figure 10 shows elasticity's of demand for dwelling units with and without students

The results explain how a landlord could possibly profit form renting to student occupants. Student occupants are more inelastic to price increases than non-student occupants and therefore if conservation renovation were implemented into the property (insulation, new furnace….etc) and the landlord included electricity in the rental amount fee, there would be a savings in kWhs used. The savings of kWhs used, with no price decrease in rent after conservation renovations are made, could be retained by the landlord as profit and an incentive to make the units more energy efficient. This would be in addition to the fact that student occupants consume less electricity than that of non-student occupants, but rents are gauged across the rental market without distinguishing between the two.

Consumption by Major and Class Level 2006-2007

The student and consumption data for 2006-2007 school year was first made to address each major individually by creating a dummy variable for each. In merging the data each address would have had multiple entries if more than one student lived at the same address. The multiple addresses come to be a problem when the students have different majors and are different classes (year in school). To avoid the problem we collapsed that data to compute fractional amounts for each major and class, which then weighs that proportion on each major and class.

In the regressions we decided to run, we wanted to explain consumption patterns of University of Oregon undergrad students from various colleges within the university. In these regressions we observed consumption patterns of students from the College of Arts and Sciences, Charles H. Lundquist College of Business, School of Architecture and Allied Arts, School of Journalism and Communication, School of Music and Dance, and International Programs. Within these groups of students we focused on sophomores, juniors, and seniors. We made the decision to exclude freshman from our analysis due to limited consumption data stemming from the fact that so many live on campus in the dorms.

To set up our regressions we needed to get all of our data into a table that included variables such as a residential premise code, monthly electricity consumption in kWh, student class standing and student major. With these variables we then had to generate dummy variables for each individual major included within our data. Once the dummy variables had been generated we were able to use them to create separate variables for each of the major colleges that the respective majors fell into. The college variables we created are listed in Table 2.

College (Subset, if applicable)	Included Majors
College of Arts and Sciences (Science)	Physics, Math, Human Physiology, General Science, Environmental Studies, Computer and Information Science, Chemistry, Biology, Biochemistry, Marine Biology, Geology, Geography
College of Arts and Sciences (Social Science)	Sociology, School Psychology, Psychology, Political Science, Ethnic Studies, Economics, Anthropology, International Studies
College of Arts and Sciences (Humanities)	Women and Gender, Theater Arts, Russian and East European Studies, Romance Languages, Religious Studies, Philosophy, Medieval Studies, Linguistics, Humanities, History, English, East Asian Studies, Creative Writing, Comparative Literature, Classics, Asian Studies
College of Business	Public Policy Management, Planning, Marketing, Management, Finance, Business, Accounting
School of Journalism & Communication	Journalism, Communications
School of Architecture and Allied Arts	Sculpture, Printmaking, Photography, Painting, Multimedia Design, Metalsmithing, Landscape Architecture, Interior Architecture, Fibers, Digital Arts, Ceramics, Art, Architecture
School of Music and Dance	Music, Dance
International Programs	Spanish, Russian, Japanese, Italian, German, French, Chinese

Table 2 lists all majors included in the University of Oregon Schools

Once the initial setup had been completed we were ready to conduct some of our regressions and get some results. The first observation we wanted to address was how monthly electricity consumption varied by sophomores, juniors and seniors in the major University of Oregon programs. Our results show a steady decrease in monthly consumption with each additional year in college (figure 9). Possible explanations for these results might be attributed to expanding financial independence of students the longer they are in school; unfortunately, no definitive answers could be drawn from our data about these consumption patterns.

Class Standing	Average Monthly Consumption
Average	601.13 KWh
Sophomore	722.30 KWh
Junior	687.40 KWh
Senior	681.25 KWh

Table 3 shows class standings of students and their corresponding consumption levels

In addition to varying monthly consumption by class standing, another reasonable assumption that could be drawn from the data would be varying monthly consumption by major. For example one might expect an Environmental Studies major to have greater conservation habits, and therefore lower monthly electricity consumption than a Business major. As reasonable as that assumption sounded, it was not supported statistically within our data. In running our regression comparing consumption by different majors across all classes we were unable to find any economically or statistically significant differences between different majors. We attribute these results to one of two hypotheses, the first of which being that differences in consumption strictly come from differences in class standing, as shown above, and at each class standing students are very similar across majors. A second hypothesis for our results would be a possible problem with our data caused by identifying premises with roommates that were all college students. College students more often tend to have roommates that are in their same class as opposed to being in their same major; which is why with the roommate problem it was more difficult for us the extract monthly consumption levels by students in each specific major.

Number of Observations	11230				
Number of Groups	1665				
R-Squared	0.0086				
kwh_cons	Coefficient	Standard Error	z-stat	P>|z|	[95% Confidence Interval]
dsophomore	121.1733	29.80287	4.07	0	[62.76072, 179.5858]
djunior	86.27884	24.12907	3.58	0	[38.98674, 133.5709]
dsenior	80.12807	20.12253	3.98	0	[40.98674, 119.5675]
_constant	601.1271	16.58749	36.24	0	[568.6162, 633.638]

Figure.9 Shows sophomore, Junior and senior electrical consumption differences.
* only includes students included in cas_science, cas_soc_science, cas_hum, business, j_school, aaa and music.

Consumption by structure

In comparing the RLID data with the student addresses we looked at how consumption varied among students and non-students in terms of dwelling characteristics. Specific characteristics we wanted to focus on were the market value, the amount of square-footage and the number of bedrooms for each residence; all of which we had available in our RLID data. Using our monthly consumption data provided by EWEB along with our RLID and student datasets we were able to combine the three into one unique dataset. In creating this new dataset we encountered a problem in attempting to match up the data across the three tables. Unfortunately this problem led us to be extremely limited in identifying students that had corresponding consumption and RLID information; out of the 30,804 premises only 84 were identified as premises with at least one student resident. We believe this is due to the RLID data being limited to residential dwellings and not apartment buildings (commercial), in which many of the students lived.

In spotting some large outliers, we decided to trim a few of the extremes out of the data. The adjustments made to the data were, to drop all residences with more than 6 bedrooms and to drop any observations that included market values or monthly electricity consumption amounts that were less than or greater than the 5th and 95th percentiles; which for this dataset were $95,081 and $383,822, and 225 kWh and 3041 kWh, respectively.

With the trimmed down data we then ran regressions on how monthly consumption was effected by variables such as average temperature, date of usage, square-footage, number of bedrooms, and the market value of each residence. Results from these regressions yielded some interesting results. Unfortunately due to our statistically insignificant ratio of students to non-students, few were very worthwhile. Results we were able to pull from the data primarily revolved around differences in consumption effects for students and non-students based on dwelling market value and square footage differences.

Number of Observations	5285				
Number of Groups	42				
R-Squared	0.3006				
Observations per Group (min)	2				
Observations per Group (avg)	125.8				
Observations per Group (max)	155				
lnkwh_cons	Coefficient	Standard Error	z-stat	P>|z|	[95% Confidence Interval]
lnavg_temp	-2.613606	0.0551439	-47.4	0	[-2.721686, -2.505526]
lnmarket_value	-0.6077305	0.2230191	-2.73	0.006	[-1.04484, -0.170621]
_constant	23.77732	2.758855	8.62	0	[18.37006, 29.18458]

Figure 10 shows percent changes in consumption as explained by monthly average temperature and the market value of the dwelling for students

Number of Observations	367398				
Number of Groups	27409				
R-Squared	0.2088				
Observations per Group (min)	1				
Observations per Group (avg)	13.4				
Observations per Group (max)	158				
lnkwh_cons	Coefficient	Standard Error	z-stat	P>|z|	[95% Confidence Interval]
lnavg_temp	-1.581621	0.0053279	-296.86	0	[-1.592063, -1.571178]
lnmarket_value	0.0926787	0.0096257	9.63	0	[0.0738127, 0.1115447]
_constant	12.03535	0.117336	102.57	0	[11.80538, 12.26533]

Figure 11 shows percent changes in consumption as explained by monthly average temperature and the market value of the dwelling for non-students

Number of Observations	5285				
Number of Groups	42				
R-Squared	0.3623				
Observations per Group (min)	2				
Observations per Group (avg)	125.8				
Observations per Group (max)	155				
kwh_cons	Coefficient	Standard Error	z-stat	P>|z|	[95% Confidence Interval]
avg_temp	-24.77691	0.4545761	-54.51	0	[-25.66787, -23.88596]
sqft	-0.2148725	0.0669461	-3.21	0.001	[-0.3260846, -0.0836605]
_constant	2319.77	144.2331	16.08	0	[2037.079, 2602.462]

Figure 12 shows changes in consumption as explained by monthly average temperature and the square footage of the dwelling for students

Number of Observations	367374				
Number of Groups	27407				
R-Squared	0.3139				
Observations per Group (min)	1				
Observations per Group (avg)	13.4				
Observations per Group (max)	158				
kwh_cons	Coefficient	Standard Error	z-stat	P>|z|	[95% Confidence Interval]
avg_temp	-32.50286	0.0830277	-391.47	0	[-32.66559, -32.34013]
sqft	0.1242087	0.0047659	26.06	0	[0.1148677, 0.1335497]
_constant	2728.628	9.469304	288.16	0	[2710.069, 2747.188]

Figure 13 shows changes in consumption as explained by monthly average temperature and the square footage of the dwelling for non-students

Figures 10, 11, 12 and 13 show percent and absolute changes in monthly electricity consumption based on monthly average temperature, dwelling market value and square footage variables. From these results we were able to draw a modest conclusion in that students have a somewhat more restricted budget than non-students. Our conclusion, based on our findings, shows that while the average consumer increases their monthly electricity consumption with increases in both the market value and square footage of their dwelling, student consumers do not. Simply put, we are concluding from our results that student consumers differ in their consumption from non-students based on increased budget constraints for students.

<u>Conclusion:</u>

Households with at least one college student occupant did indeed consume less electricity than that of a household with no student occupants. The dwelling with the student however did not respond as drastically as the households without student occupants, to price increases of a Kilo-watt hour.

Focusing on just students and which major or class would lead to a larger consumption of electricity; our results showed that no one major consumed more than another, but class year in school did make a difference. Sophomores use a greater amount of electricity than juniors and seniors use a fraction less than juniors. This shows us that student's electrical consumption habits are not based on major, even though we might have thought certain majors to be more conscientious and consume less electricity, this was not shown to be the case. It also shows that the longer a student lives away from home and parents, the more aware of their electrical use they become.

The results show that sub-metering units with student occupants does not avoid the deadweight loss found in figure.1. Students continue to maintain the zero marginal cost and therefore consume to a point of satiation as parents pay the electricity bill. The ability to know and understand students' demand for electricity can be used as a tool to show landlords of student apartments, the gains available by master-metering and increasing the apartment's insulation factor and other conservation renovations. Profits to landlords are due to conservation renovations made on dwellings, which would reduce the amount of electricity needed to maintain the same electrical usage as before the renovations were implemented. The reduction in electricity, from the renovation, creates a drop in the cost of electricity as the apartment buildings total cost of electricity would have decreased as renovation reduces electricity needed. The saved cost from renovations can then be retained by the landlord and therefore thought of as an incentive to landlords to make conservation renovation to student occupied dwellings. Electrical consumption would then decrease by enticing landlords, of primarily student dwellings, with profitable incentives in order to make renovations of which would reduce overall electrical demand.

Appendix:

VARIABLES	DESCRIPTION	EXPECTED SIGN
kwh_cons	amount of monthly consumption in KWh	+
prem_code	identification code given to each individual premise	+
avg_temp	average temperature for month	-
student	takes on value of 1 if resident is student, 0 otherwise	-
sqft	square footage of the premise	+
market_value	market value, in dollars, of the premise	+
no_bedrooms	no of bedrooms	+
year_built	year the premise was built	+/-
d(year)	takes on value of 1 if year equals (year), 0 otherwise	+/-
d(month)	takes on value of 1 if month equals (month), 0 otherwise	+/-
dbed(#)	takes on value of 1 if number of bedrooms equals (#), 0 otherwise	+/-
d(major)	takes on value of 1 if student major equals (major), 0 otherwise	+/-
cas_science	includes all students having majors within the science subset of the College of Arts and Sciences	+/-
cas_soc_sci	includes all students having majors within the social science subset of the College of Arts and Sciences	+/-
cas_hum	includes all students having majors within the humanities subset of the College of Arts and Sciences	+/-
business	includes all students having majors within the Business School	+/-
j_school	includes all students having majors within the Journalism School	+/-
aaa	includes all students having majors within the Allied Architecture and Arts School	+/-
music	includes all students having majors within the School of Music and Dance	+/-
law	includes all students in the Law Program	+/-
language	includes all students with foreign language majors	+/-
d(class level)	takes on value of 1 if class level equals (class level) 0 otherwise	+/-
ln(variable)	log value of a variable	+/-
yearstud	interaction term equaling year * student	+
price_population	change across all observations due to price changes	-
student_consum	difference in consumption by students as compared to non-students	-
price_stud	change across all student observations due to price changes	+/-

References:

Binswanger, Mathis. “Technological Progress and Sustainable Development: What about the Rebound Effect?” *Ecological Economics*. 36 (2001): 119-132.

Dinan, T.M., 1987 “An Analysis of the Impact of Residential Retrofits on Indoor Temperature Choice.” Oak Ridge National Laboratory, Oak Ridge.

Levinson, Arik and Scott Niemann. “Energy Use by Apartment Tenants When Landlords Pay for Utilities.” *Resource and Energy Economics*. 2004, 26(1): 51-75.

Munley, V.G, L.W. Taylor and J.P Formby. 1990. “Electricity Demand in Multi-family, Renter-Occupied Residences. *Southern Economic Journal*. 1990, 57(1): 178-94.