Non-Technical Letter

A car owner can use our model to predict the direction and even the amount of change in gas prices one week in advance, that could help him or her decide whether he should buy half a tank of gas, a full tank of gas, or none at all in a particular week.

Basically, the car owner must learn the crude oil price six months before the week that she's trying to make a prediction about. Then she should learn the current USD-TRY exchange rate, meaning one week before the week he's trying to make a prediction about. The car owner should multiply these two numbers and multiply the product with 0.007099. Then he should add 4.389 to the found number. This gives the predicted gas price for the next week. Comparing this with the current week's gas prices, the car owner must assess whether the price is going to decrease or increase in the following week.

Basically, if the price is going to go up, the customer must buy either half a tank of gas or full tank of gas so that he doesn't have to pay for gas with a higher price the next week. If it is going to decrease, he shouldn't buy gas at all if he has enough in the tank for that week. The rationale is that if the prices are going to decrease, he should wait to buy gas with a lower price to save money.

A more intricate process of deciding on how much gas someone should buy, which involves the factors of how much the car owner uses his car, how much gas there is initially in the tank, etc. is in the report.

SUMMARY

The fluctuations in the gas prices have been a frustrating factor for every people who drive a car. Although knowing future the gas price in advance is impossible, every people would love to have a model that predicts this unstable price so they can pay the least amount of money by filling their gas tanks in the right time. In this report, we are attempting to create the mentioned model by observing what and how the gas price depends on.

Our goal was to create a model that predicts the change in the gas prices one week in advance so that the customers will know whether to buy gas or not in a particular week. We accomplished this by first pondering and researching the potential factors that affect the gas price. The most significant factors affecting the gas prices appeared to be the crude oil price (six months before the week that's being assessed) and the USD-TRY exchange rate (one week before the same week).Then we represented the relationship between these factors and the actual gas prices in the first 6 months with an equation and a model.

After the equation and the model was complete, we tested them with the actual gas prices in the last 6 months by considering these two cases: the consumer drives 100 km per week and the customer drives 200 km per week, and in both cases a full gas tank provides fuel for 400 km travel. We created an algorithm for both of these cases that determined how much gas a customer should buy in a particular week depending on the predicted change in gas prices as well as the amount of the car usage of the customer.

Introduction

Gas prices fluctuate on a daily basis, and car owners could benefit just by basing their decisions of gas purchase on the fluctuation of prices. If a car owner completely fills his/her tank with the lower prices if he predicts the prices to go up, and fills only a part of his/her tank with a higher price if he predicts the prices to go down the following week so that he can buy the same amount of gas with less payment; in the long run, he can save a considerable amount of money.

Of course, the prediction of a price change, let it be gas or any other commodity, is hard - even by the standards of economists. What this paper is trying to achieve is to

provide people with a simple model that will help them predict and use gas price changes as accurately as possible in order to save money.

Clarification/Restatement

A model is required to predict gas price changes for the following week. This model is to consider two cases of fuel consumption separately:

- Case 1: The consumer drives 100 km per week.
- Case 2: The consumer drives 200 km per week.

These cases are to be considered with the same model, whose predictions will be used differently for the two cases. This model is basically a model of the gas prices for any week, and it has to be a kind of model that can be used by any customer - not including any unknowable variables or constants. This model is to be built with certain procedures:

- The model is to be built using the data of gas prices for the first 6 months of 2018 for Beşiktaş, a large region in İstanbul, and is to be tested using the gas prices of the last 6 months of 2018 for the same region.
- The problem also requires us to find out if there is an upper limit on kilometer driven that changes the decision for buying weekly gasoline.

Assumptions

- The gas tank of any car holds 50 liters of fuel, and the cars consume 1 liter per 8 kilometers driven. Thus, a full gas tank provides fuel for 400 km travel.
- A consumer can buy gas only once in a week.
- The temperature change is always minimal. Significant changes in temperature can have an effect on the gas prices, but this effect cannot be included in the model, since the change that the temperature brings about is uncertain -it can be in both directions in any amount that is not easy to calculate. Minimal temperature changes, however, don't generally have an effect on the gas prices, so it's safe to assume that the temperature change is always minimal, and this assumption can harm the model in cases where there is an extreme change in temperature, which are rare.
- Political events, terror attacks, war definitely have an effect on gas prices, but in the model, it's assumed that these factors aren't significant on their own. They have the potential to affect exchange rates, crude oil prices, etc. which are actually included in our model. So the effect of these are included indirectly in the model, but not directly, as that would be near impossible to calculate.
- The consumers have access to crude oil price data of the past months and current USD exchange rates.
- It takes six months for crude oil from abroad to be bought, transported, processed to car fuel.

Hypothesis and Variables

Gas in Turkey is usually exported from abroad. Thus, the crude oil (main precursor of almost all car fuels) prices are very significant in the determination of gas prices. As it takes a long time for crude oil to be converted into gas, the crude oil prices 6 months earlier affect the gas prices today, since the gas that is sold is made from the crude oil bought six months ago. So the **first variable** in our model is C, the crude oil price in USD/L exactly six months before the week that's being assessed.

Besides crude oil, the current USD-TRY exchange rate has a significant effect on the gas price fluctuations. This has a faster impact on the gas price than the crude oil price does, but it is still not instant. In our model, the **second variable** is determined

to be U, USD-TRY exchange rate in TRY/USD exactly one week before the week that's being assessed.

The gas price in TRY/L for any week (G) is linear to the product of the crude oil price 6 months before that particular week (C) and the USD-TRY exchange rate one week before the same week (U). The model is expected to look like:

G=kCU+z,

k being the proportionality constant and z being the constant term appropriate to the model.

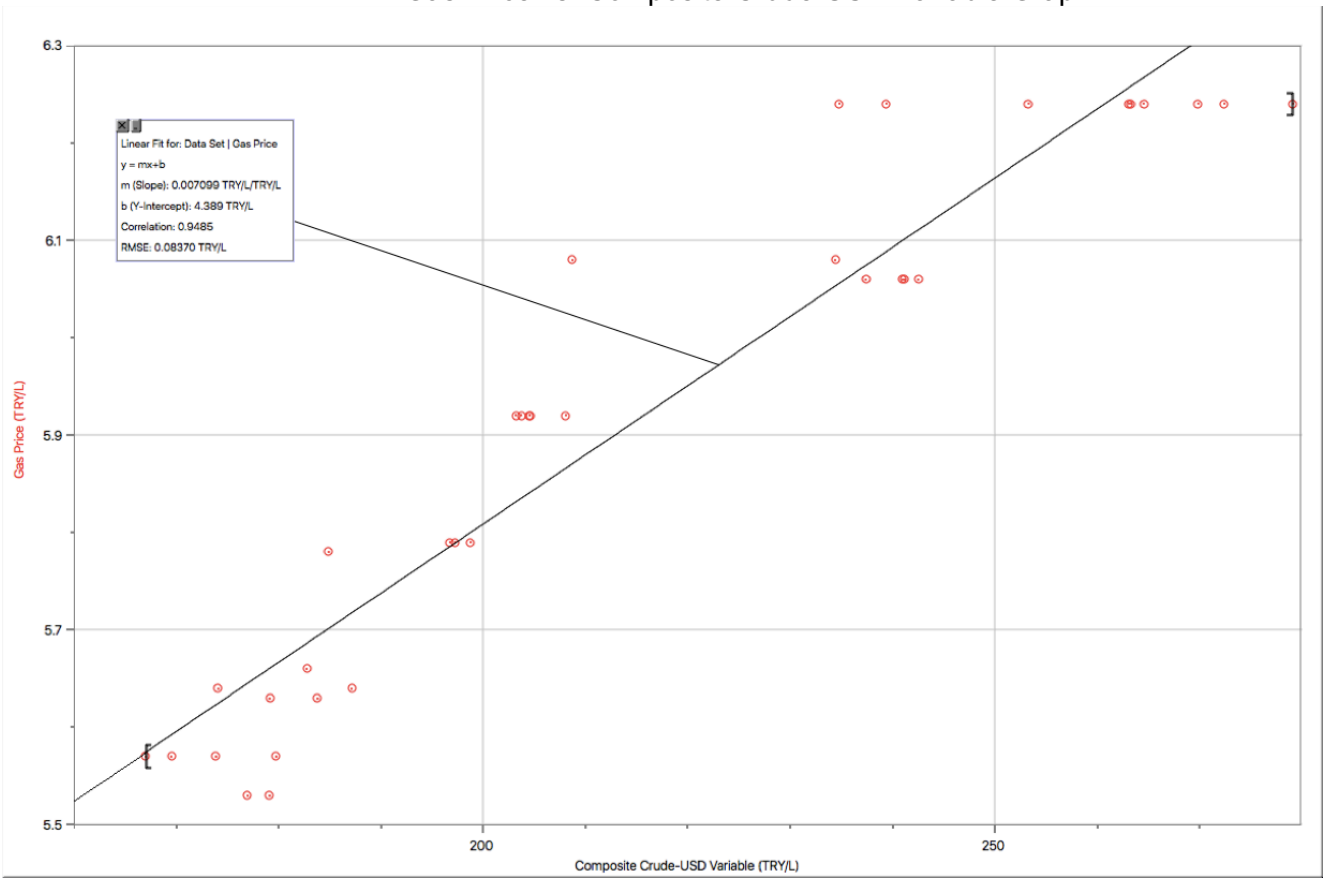
Model

Using the gas price data (see Appendix A) for the first six months of 2018 in Beşiktaş, the appropriate model is determined to be:

G=0.007099(C*U)+4.389

The graph of the modeling function is below, demonstrating a positive correlation between the actual gas prices and our composite variable

Gas Price vs. Composite Crude-USD Variable Graph



Using the Model for the Two Cases:

Case 1)

The consumer drives 100 km per week.

- After plugging in appropriate data for C and U in the model function finding G, it will be understood whether the gas price increases or decreases the next week.
- There are three initial subcases:

- Subcase 1: The consumer has an empty tank.
  - The consumer should fill up a half tank no matter what. Because if the price is going up for the next week, there is still a possibility that it will go down again for the week after the next week. In hope of this possibility, the consumer shouldn't fill up all the tank but fill up half a tank, which is enough for two weeks of travel in Case 1. If the price is predicted to decrease, the consumer should buy half a tank of gas that week and half a tank of gas again the following week if the prediction comes out to be true, so that he minimizes the amount of money he pays for gas.
- Subcase 2:The consumer has a quarter full tank.
  - If the gas price is predicted to increase next week, he must buy half a tank of gas, because next week he will have to pay for gas with a higher price if he doesn't buy any gas this week.
  - If the gas price is predicted to decrease next week, he shouldn't buy any gas. He will use up the quarter full tank this week and buy gas with a lower price next week.
- Subcase 3: The consumer has half a tank.
  - If the gas price is predicted to increase next week, there are two subsubcases.
    - If the change in the gas price is very high, the consumer must fill up the rest of the tank. Because if the change is high, it is reasonable to surmise that the week after the following week, gas price may continue to increase.
    - If the change in the gas price is low, the consumer shouldn't buy any gas. Because there's a chance that the week after the next week, the prices may decrease. The consumer must consume the rest of the tank in two weeks. If it is predicted that the price won't go down in that week after the initial week, the consumer must readjust his decision based on the subcase 2, where he as a quarter full tank.
  - If the gas price is predicted to decrease next week, there are two subsubcases.
    - If the change in the gas price is very high, the consumer shouldn't buy any gas. Because it is reasonable to surmise that the gas price may continue to decrease in the following weeks if there's a considerable amount of change. So the consumer must wait for a lower gas price to buy gas.
    - If the change in the gas price is low, he still shouldn't buy any gas, but for another reason. The gas price may as well increase in the following weeks, but since the consumer will be able to buy gas with a lower price in the next week and he already has enough gas for that week, he must wait for the next week to buy gas.

Case 2)
The consumer drives 200 km per week.

- Firstly, since this customer drives for 200 km, equal to a half-tank fuel consumption, the customer won't have a choice of not buying gas. Only if he already has a full tank, he won't be able to add to the tank anyway. If he has a half-tank, he can either choose not to fill anything (to fill the tank next week)

or fill the last half of the tank. If he has an empty tank, he can choose to fill up half the tank or the full tank, but he can't choose not to buy gas.

- After plugging in appropriate data for C and U in the model function finding G, it will be understood whether the gas price increases or decreases the next week.
- Dividing the case into two initial subcases,
    - Subcase 1: The consumer has an empty tank.
        - If the gas price is predicted to increase next week, the consumer must buy a full tank of gas this week, so that he doesn't have to buy gas next week with a higher price.
        - If the price is predicted to decrease next week, the consumer must buy half a tank of gas this week, so that he doesn't have to pay for an additional half a tank of gas while he can buy it the next week with a lower price.
    - Subcase 2: the consumer has half a tank.
        - If the gas price is predicted to increase next week, the consumer must buy half a tank of gas this week and thereby fill the whole tank so that he doesn't have to pay for gas with higher prices the next week.
        - If the price is predicted to decrease next week, the consumer shouldn't buy gas this week. He must consume the rest of the tank that week and return to the subcase 1.

To address the effect of the upper-bound of kilometers driven per week, it can be said that there is no set upper-bound (as long as it is equal to or less than what the tank can hold, as fuel intake is weekly in our scenarios.) However, as the kilometers driven per week increase, there are fewer and fewer possibilities and purchasing options. For example, if the amount of kilometers driven exceeds half the tank's capacity, then the consumer has no choice but to fill the tank on certain weeks. This limit of options might be constricting and detrimental in an ideal model; however, in a model based on real-life data such as ours, there are inaccuracies. Therefore, purchasing strategies that are available to drivers who drive less each week might prove to be ineffective as the calculations may prove wrong. Thus, in a real-life model, this upper-bound may not have a distinguishable effect on the consumer's budget.

The rationale for using the variables C and U was already explained in Hypothesis and Variables section. The reason that their multiplication is used in the model is because:

1. G is predicted to have a linear relationship with each variables; the rational way to form the model according to this hypothesis is to multiply the variables.
2. The crude oil prices and exchange rates affect the gas prices similarly and they both have a power of 1. Even if their effects on the gas prices were actually different, the difference would not be big enough, for instance, to claim that the power of one of them is 2 while the power of the other one is 1.
3. The dimensional analysis of our model yields positive results. The multiplication of C (USD/L) and U (TRY/USD) is equal to a number with the units TRY/L. Since G also has units of TRY/L, the units match up in this equation. The multiplication of C*U with a dimensionless number (coefficient) and adding a constant doesn't change its units.
   (USDL)*(TRYUSD)=(TRYL)

Strengths of the model:

- There is a high correlation between the composite variable values that were calculated and the gas prices that were obtained (for the appropriate dates,) which suggests that the general trend and the integral variables were successfully identified in our model.
- Albeit the differences between actual gas prices and gas prices calculated from our values, the affirmation of the general trend allows the consumer to use the model in order to consistently determine at least the direction of the change that would reasonably occur in the subsequent weeks, which in itself gives significant insight regarding the appropriate course of action. For example, from the comparisons between the calculated and actual gas prices in the last 6 months (see Appendix B,) it is evident that the model predicts the oil price within a close range (usually with a difference no larger than 0.15) of the actual oil price on that date. Furthermore, even in cases where the gas prices aren't accurately calculated (such as the third case in Appendix B,) the trend is still positively identified, informing the consumer on whether or not the prices will drop compared to the current prices.

Weaknesses of the model:

- It is virtually impossible to accurately calculate the gas price by using variables that are volatile by nature: crude oil prices and dollar exchange rates. Therefore, even though a considerable portion of our calculated gas prices were within a small range of the actual gas prices for the dates chosen for testing (from the last 6 months of 2018,) our calculations occasionally yielded poor results that did not accurately predict the continuation (or disruption) of the trend.
- There are other variables that can be considered - that haven't been considered - in creating such a model. Even though most evidence, and the correlation present in our model, points to crude oil prices and dollar exchange rates as the crucial variables involved, other factors such as extreme temperatures, political instability, and corporate finances can be (and most likely are) at play.
- There are cases (such as the third case in Appendix B) where the gas price isn't accurately predicted by plugging the oil-dollar composite variable into the function, and this can be attributed to factors other than the key factors we are considering.

Appendix A

Crude Oil Prices, Dollar Exchange Rates, and Gas Prices for Dates Appropriate to the Model In the First 6 Months of 2018 In Beşiktaş

* The date provided is the date at which the gas price was at the reported value. The other variables, as explained in the model, are from the appropriate dates set. Crude oil prices are from 6 months behind of the given date, and dollar exchange rates are from 1 week behind the given date.

** The gas prices have been obtained from the archives of Opet™ and are those of the Unleaded 95 fuel ("Kurşunsuz 95"). The archives - and thus this table - are limited in the number of dates provided within the range considered.

Date*	Crude Oil Price (USD/L)	Dollar Exchange Rate (TRY/USD)	Composite Oil-Dollar Variable (TRY/L)	Gas Prices** (TRY/L)
01.01.2018	47.07	3.8182	179.722674	5.57
06.01.2018	44.23	3.7764	167.030172	5.57
09.01.2018	45.04	3.7635	169.50804	5.57
12.01.2018	46.54	3.736	173.87344	5.57
16.01.2018	48.48	3.77	182.7696	5.66
25.01.2018	49.04	3.7694	184.851376	5.78
09.02.2018	48.82	3.7645	183.78289	5.63
10.02.2018	47.59	3.7645	179.152555	5.63
14.02.2018	46.78	3.7824	176.940672	5.53
24.02.2018	47.87	3.7416	179.110392	5.53
28.02.2018	45.96	3.7877	174.082692	5.64
14.03.2018	49.3	3.796	187.1428	5.64
21.03.2018	50.63	3.8852	196.707676	5.79
22.03.2018	50.55	3.9026	197.27643	5.79
23.03.2018	50.66	3.9236	198.769576	5.79
27.03.2018	51.88	3.9268	203.722384	5.92
28.03.2018	52.14	3.9222	204.503508	5.92
29.03.2018	51.56	3.9409	203.192804	5.92
12.04.2018	50.6	4.0435	204.6011	5.92
13.04.2018	51.45	4.0441	208.068945	5.92
14.04.2018	51.6	4.0441	208.67556	6.08
08.05.2018	57.2	4.0983	234.42276	6.08
09.05.2018	56.81	4.1791	237.414671	6.06
10.05.2018	57.17	4.2428	242.560876	6.06
11.05.2018	56.74	4.2476	241.008824	6.06
12.05.2018	56.78	4.2476	241.178728	6.06
15.05.2018	55.7	4.298	239.3986	6.24
17.05.2018	55.22	4.252	234.79544	6.24
22.05.2018	56.83	4.4568	253.279944	6.24
25.05.2018	58.95	4.4879	264.561705	6.24
26.05.2018	58.67	4.4879	263.305093	6.24
29.05.2018	57.99	4.6538	269.873862	6.24
30.05.2018	57.3	4.8714	279.13122	6.24
31.05.2018	57.4	4.7462	272.43188	6.24
02.06.2018	58.06	4.5315	263.09889	6.24

Appendix B

Calculated Gas Prices and Actual Gas Prices Comparison (Last 6 Months of 2018)
*The gas price is calculated by plugging in the composite variable of the corresponding date into the modeling function.

Date	Calculated Gas Price* (TRY/L)	Actual Gas Price (TRY/L)
20.11.2018	6.48	6.39
27.11.2018	6.32	6.09
24.10.2018	7.08	6.93
17.11.2018	6.54	6.58
18.07.2018	6.72	6.24
04.09.2018	7.70	6.87

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