Assessing the Relationship Between Aviation Kerosene Price and Demand for Air Transportation

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The inflation rate in US has been rising at an extremely fast speed in the recent years, and the cost of energy is the main top driver of US inflation. Gasoline costs surged 50%, and fuel oil costs jumped 41%, according to Jan. 12 data from the US Bureau of Labor Statistics. Overall US inflation rose 7% in 2021.

Even though we could see statistically that the energy cost is a major factor affecting US economics, I am still interested in how does the change in energy cost impact the daily life of human beings. This memo investigates the relationship between aviation kerosene price and the demand for air transportation. Hopefully, this investigation could shed some lights on the way kerosene energy market affects people's transportation needs.

1. Data Description

This analysis relies on two primary data sources. First, I obtained the total number of flight passengers from all carries in all airports in the United States from Bureau of Transportation Statistics (BTS), which is an official government data source for transportation. More passengers would suggest a higher demand for air transportation.

Second, I obtained the price of aviation kerosene in the United Sate using Refiner Retail Price of Kerosene-Type Jet Fuel from the United States Energy Information Administration (EIA). This is an official government website that collects the monthly price of aviation kerosene by survey.

I'm interested in the relationship between aviation kerosene price and the demand for air transportation, so I must match each measurement of numbers of passengers to the aviation kerosene price with respect to year. Aviation kerosene price data contains date, the aviation kerosene price in the US, East coast, West coast, and all the states respectively. By the time I accessed the data, it records the price on the 15th of each month from 15/07/1975 to 15/01/2022. Since I am interested in the change of the price in aviation kerosene in the US, I simplified my data variables to only date, the fuel price in the US, Virginia, and California. The reason why I chose to use the price from the specific cities is that I am wondering if there is a significant difference between the aviation kerosene price across the states and that of the average price of the country. For the passenger's data, I limited the variables to only year and the total number of passengers. Additional summary statistics are shown in the Table 1.

Table 1: Summary Statistics

	MEAN	STD.DEV	MIN	MAX
DATE			2002	2021
PRICE	1.97	0.728	0.720	3.11
PASSENGERS	809776339	138890705	398654991	1052981181

2. Analysis

Economic theory would generally predict that, as aviation price goes up, consumers would choose to purchase less air tickets, and therefore less demand for air transportation. After wrangling the data, I got the visualization in Figure 1.

Figure 1(a)

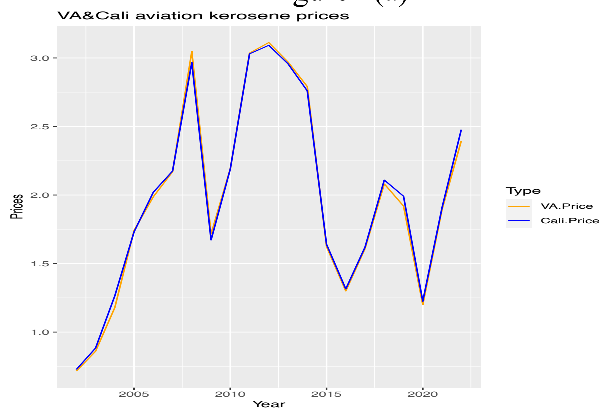
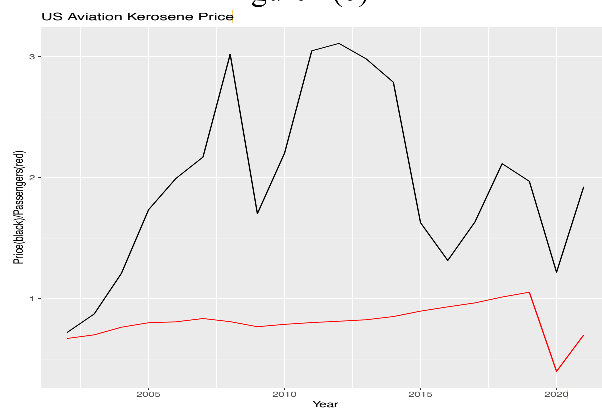


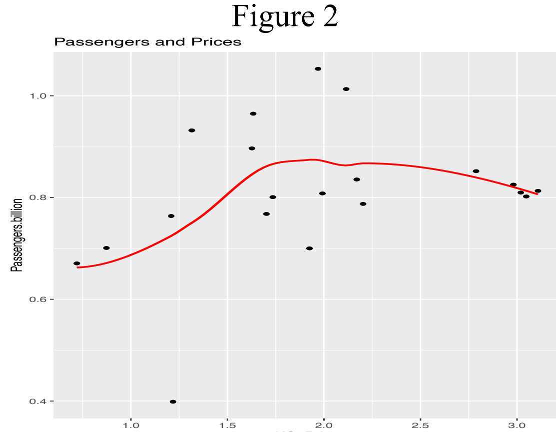
Figure 1(b)



According to Figure 1(a), which is a comparison between the aviation kerosene price in Virginia and California, we could tell that there is no major difference in prices throughout the states. Moreover, Figure 1(b) shows that the price of aviation kerosene in US (black) experienced its peaks in 2008, 2012 and 2018, and fell back in the following year(s) while the number of passengers increased from 2002 to 2019 with a slightly decrease in 2009, and then it had its major fall in 2020 followed by a recovery next year.

Having identified the graphs, I noticed that there is no significant evidence that supports the economic theory, yet on the contrary, the trend of the demand for air transportation is roughly the same as the kerosene prices. Since Figure1(b) only shows the pattern of prices and number of passengers over time, to further identify the relationship between these two variables, I plot the smoothed trend lines of numbers of passengers on the vertical axis against the prices on the horizontal axis (Figure 2). Figure 2 shows that as the price of aviation kerosene increases up to about \$1.9, the number of passengers increases as well; as the price increases further up, the number of passengers decreases. Besides, the scatter points graph shows that there are many outliers when the price ranges from \$1.3 to \$2.2.

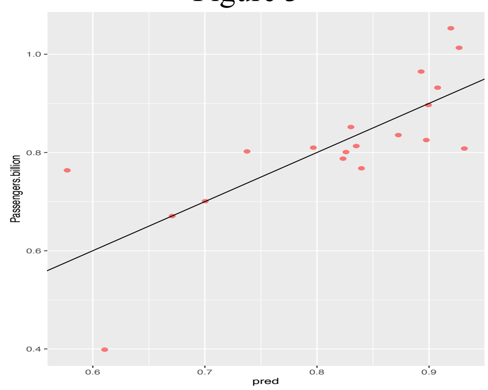
Figure 2



This figure reveals some important fact: First, the price of aviation kerosene and the demand for air transportation is positively related when the price is relatively low, but when the price exceed \$2.0, there is a negative effect on the demand for air transportation. Second, when the price falls into the range from \$1.3 to \$2.2, the graph would not be precise enough to describe the real value of the numbers of passengers. Third, the price that exceed \$2.5 would contribute a negative effect on the demand for air transportation, and from the current fuel market in US, I would predict that the price of the aviation kerosene price will also have a negative relationship with the demand for air transportation. Last, there is a significant outlier when price is around \$1.2, and from Figure 1(b), we could see it's the data in 2020. This is the time when COVID-19 breaks out in US and policies have a major impact on the data this year. Thus, we will ignore the data in 2020 while doing our further analysis.

To quantify the magnitude of the number of airline passengers response to aviation kerosene price, I did a polynomial regression in Figure 3.

Figure 3



Here is the model I used for the regression:

$$Number\ of\ passengers = b_0 + b_1(price) + b_2(price)^2 + b_3(price)^3 + b_4(price)^4 + b_5(price)^5 + b_6(price)^6 + b_7(price)^7 + b_8(price)^8 + b_9(price)^9$$

After comparing and choosing the lowest root mean square error, the values of the parameters are showed below in Table 2.

Table 2

b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9
-1669.59	9884.98	-25034.92	35670.73	-31579.12	18054.61	-6680.79	1546.02	-203.42	11.62

From Figure 3, there are several outliers when the number of the passengers are relatively high or relatively low, suggesting that the model we have is not good at predicting extreme large or small values of passengers.

This analysis is not without its limits. First, aviation kerosene price used in this analysis is average estimation, in fact, there are several different types of kerosene fuel used in the United States for aircrafts. Generalizing the prices of all the types of the fuel into one value is to facilitate the analysis progress. Moreover, the dataset is relatively small, which affects the precision of the regression and causes multiple outliers. Lastly, the aviation kerosene price response mapped out in Figure 2 is only a correlation, not a demand curve. To illustrate, the price of the fuel goes up maybe is due to an increase in air transportation demand. The large price response suggests that the change in price of aviation kerosene may not reflect the change of the demand in air transportation.