No More PET Bottles?
Modeling on Single-Serving Water Bottles Future Usage and Environmental Effects

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Abstract. Nowadays, there are increasing concerns on the protection of environment. Single-serving bottles, made by polyethylene terephthalate mainly, have caused great damages to the harmonious development of human beings, animals and environment. Hence, this paper measures the impacts of single-serving water bottles ban quantitively by constructing sets of models. This project uses AR(p) model to predict the single-serving water bottles usage in future. The result shows that restrictions or bans on single-serving bottles are essential for our earth’s future. There are two major impacts of water bottles: one is the positive impacts (including reducing environmental pollution, reducing energy cost); the other is the negative impacts (including more soft drinks, health cost, and construction cost). The substitution effect model developed by the authors illustrates the influences of the ban on soft drinks as well as tap water. Moreover, the model was applied in the cases of towns, cities and airport, the biggest difference of which is the population density. Due to the limits of tap water, residents in those area with low density are facing high costs to obtain pure water, which causes much bigger inconvenience comparatively. Besides, this paper builds multi-objective model to find the approximate purifier facilities density from the perspective of maximizing carbon dioxide emissions reduction and minimizing costs. The result shows reducing the substitution effect for soft drinks is a good choice of the optimal condition. Besides, enhancing the price of soft drinks is a better method to reduce the negative impacts of a ban on bottled water. In the end, some suggestions are given regarding the water bottle ban, including enhancing soft drinks’ price, advertising the negative impacts of PET bottles to public.

1. Introduction
Polyethylene terephthalate (PET) bottles, which may cause environmental problems, have been controlled by the government to eliminate the negative influences. In 2013, the small town of Concord, Massachusetts, became the first city in United States to forbid the use of plastic bottles [1]. One year later, San Francisco also decided to prohibit use of plastic bottles and San Francisco airport had started to follow the law of the city recently [2]. The advantages of the ban are that the large amount of selling of plastic bottles will prevent the overusing of petroleum, non-degradable plastic disposal, and the harming of water-course. More importantly, the natural resources would not be profit-making tools of private companies. However, the disadvantages of banning bottle waters may worsen issues that are meant to be solves - companies will use other sources to design new type of package, which would cause shortage of more natural sources [3].

Moreover, they will add unhealthy additives into beverages, making the number of fat customers raises. Furthermore, in some areas that are lack of water resources and in some specific circumstances,
such as earthquake and deluge really need bottle water to relief their problems. An ideal ban should increase positive effects and decrease negative effects, which can be spread to other countries and various places. Facing this challenge, differences of airports, cities and towns need to be considered; analyzing and quantifying negative and positive effects of using PET bottles; thinking about environment and cost to achieve multi-objective programming.

2. Problem Restatement
The first problem is to collect data of density of population and information about quality of using bottle water in different places, like airport, town and city, in order to establish a model to analyze the negative effects and positive effects that are created by the ban. The second problem is to identify the difference when the ban is applied in different places, like airport and small town since population is a great factor calculating in the practice of a policy. In airport, great crowd flow may lead to a more successful spread of the ban. In the opposite, while in a small town, the ban can be understood as a sort of experiment to test whether this small group is able to adapt the ban, but it won’t have strong impact in big picture. The original model of town and cities was supposed to realize different scenes from airports. To be simple, it’s reasonable to make airport a city or town containing faster pace and more business opportunities. Practically, there are truly more shops set in an airport. Therefore, the factors of the model were reconsidered to imitate the situation in an airport.

3. Assumptions and Justifications
The followings are the five assumptions and their justifications respectively.

| Assumptions                                | Justifications                                                                                                                                 |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| The PET material of the bottles does no harm to the health of people. | The health of people will be influenced by the Bottled Water Ban in some ways. While discussing the influences, compared to the harm provided by the chemical elements of the domestic sparkling water, the bottles' influence on people is small enough to be ignored. |
| To eliminate the influences of the single-serving bottles ban, the governments or institutions need to install water purifier facilities to satisfy the drinking needs. | Water is demanded by people. While the bottled water is banned, people need other sources of water such as the water purifier. Thus, the government needs to install some water purifiers to meet the demand of purified water, for it is the best source of water when the bottled water is banned. |
| The amount of drinking water per capita is constant or changing slightly. | Firstly, the basic demand of human won't be changed suddenly by policy. Water is a necessary factor of ordinary lives of people. As a result, drinking water is an instinct of people that is hardly changed by bottled water ban. |
| People can reach the same satisfaction by drinking bottled water, purified water as well as soft drinks from the point of reducing the feeling of thirsty. | Potable water is basically the same kind of product everywhere. The substances and chemical compositions of the PET bottled water and the tap water don't have a significant difference between them[4]. What truly make the two products different from each other is the container, not the utility received from water. |
| Barreled water is drunk at home by people and they do not drink it outside their home. | It’s reasonable to ensure this because barreled water will confuse people how long the barreled water has been located here. People usually don’t want to drink water placed too long since they think there must be bacteria inside. The time of the barreled water being placed can only be known by people who placed it. As a result, the theorem is correct. |

4. Model Design

4.1. Changes of Single-serving Bottled Water
The analysis of recent years’ data reveals that the consumption of single-serving bottled water per capita
is increasing while cola consumption decreasing. The trends show an urgency to ban the sale of single-serving bottled water for protecting the earth. The following graph shows the changing of the quantity of drinking water in recent year.

![Figure 4-1 Consumption of Bottled water and Cola](image)

Figure 4-1 shows that the consumption of bottled water per capita is increasing while cola consumption is decreasing. The consumption of bottled water per capita has reached 41.8 gallons in 2018, compared to 27.2 gallons in 2010. Though bottled water has brought great convenience to satisfy people’s drinking, it also caused some nonnegligible influences to the environment, such as damage to animals’ lives, pollution to the land, etc. Hence, the prediction of the consumption of future bottled water is needed to analyze the effects that are created by ban of bottled water to environment and energy. The autoregression method is used to establish the $\text{AR}(p)$ model:

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \epsilon_t$$

Based on the information criteria, the lag order is 2 ($p=2$), and the auto-regressive format above, the future consumption of bottled water per capita without implementing of the ban is calculated. The regression result is shown in the following figure:

![Figure 4-2 bottled water consumption per capita in the following 5 years](image)

Figure 4-2 suggests a non-implementation of the ban of bottled water. The number of per capita for future consumption of bottled number will increase very quickly because the per capita for future drinking water will increase.

### 4.2. Positive Impacts

The positive effects, caused by the establishment of this policy, are the main reason why the government and society focused on decreasing the usage of the Polyethylene terephthalate (PET) bottles. By establishing the ban of selling bottled water, there is a significant reduction of the environmental resources and the energy used throughout the process of manufacturing and transporting the bottled water. Generally, these positive effects are concluded in two parts: environmental benefits (including pollution reduction, carbon dioxide emission reduction, etc.), energy benefits.
4.2.1. **Environmental benefits.** Three kinds of the environmental benefits are calculated and evaluated: the reducing pollution of waste that moves to the nature, the pollution caused by manufacturing, and the pollution caused by transportation. Resources benefit is mainly about reducing the material used to produce the PET bottles which may probably pollute the environment for its nondegradable [5]. Through reducing the production of plastic bottles to decrease the emission of carbon dioxide and other toxic chemicals that will cause global warming Reduction of polluting. (AEB=average energy benefit).

\[
AEB = P_e + P_m + P_t
\]

\[
P_e = \frac{P_{e\text{tot}}}{Q}
\]

\[
P_m = \frac{P_{m\text{tot}}}{Q}
\]

\[
P_t = \frac{P_{t\text{tot}}}{Q}
\]

4.2.2. **Energy benefits.** There are two parts that form the energy benefits. One is the amount of energy that used by the factories to drive the machines that produce the PET bottles can be reduced. The other one is the amount of energy consumed to transport all of the bottled water to the individual stores that includes all kinds of vehicles is diminished [6].

\[
Ae_e = Ae_m + Ae_t
\]

\[
Ae_m = \frac{Ae_{m\text{tot}}}{Q}
\]

\[
Ae_t = \frac{Ae_{t\text{tot}}}{Q}
\]

4.3. **Negative Impacts**

4.3.1. **Substitution effect.** The citizens’ demand of drinking water can’t be satisfied after implementing the ban of bottled water in Concord and San Francisco. Therefore, citizens will consume more cola, tea or water from water dispenser, which is caused by substitution effect between single-serving bottled water and other types of soft drink[7]. The graph is shown in the following part:

![Figure 4-3 The principle of substitute effect](image-url)
The figure shows the substitution effect of bottled water and soft drinks, where $X_1$ represents the amount of bottled water and $X_2$ represents the amount of soft drinks. For simplicity, the binary fact that there are only the banned bottle water and the unlimited water, including soft drinks, purified water, etc. is assumed. After implementing of single-serving water bottled ban, the number of purchasing of bottled water decreases because people buy soft drink instead of purchasing bottled water. With the changing of the amount number of purchasing of bottled water, the tendency of budget line smaller while the indifference curve moves toward to the left. As the figure shows above, under the optimal condition, the demands for soft drinks move from $X_{2(1)}$ to $X_{2(2)}$, which illustrates the consumption of soft drinks increases. In order to measure the substitution effect quantitively, this paper establishes the substitution effect model. The quantity of daily drinking water is constant. This passage will divide drinking water into three parts, including a small bottled spring water, a bottle of domestic sparkling water and a big bottled spring water or tap water. They need to satisfy the following equation:

$$ x_1 + x_2 + x_3 = m $$

Where $x_1$ represents bottled water, $x_2$ represents soft drinks and $x_3$ represents tap water (after water purifier facility processing). Because the bottled spring water is not allowed to be used and bought, the citizens have to purchase domestic sparkling water, cola or tap water in order to ensure their quantity of the daily drinking water. As a result, the amount of non-bottled mineral water, include cola and tap water, will increase. The following equation shows substitution effect between cola and bottled water:

$$ \Delta x_2 = -(1 - f(d, h, p)) \cdot \Delta x_1 $$

In the equation above, $d$ represents availability of water purification facilities, which is calculated by average density. If the convenience of purification facilities become worse, the cost of gaining drinking water increases while the quantity of demand of cola and domestic sparkling water raises. Moreover, $h$ represents people’s attention of health. $p$ represents the price of soft drinks. The quantity of demand of cola become less when people pay more attention to their health, so more substitution effect will move to water dispenser after forbidding the bottled water.

The following equation suggests substitution effect between water dispenser and bottled water:

$$ \Delta x_3 = -f(d, h, p) \cdot \Delta x_1 $$

Considering about the substitution effect between different types of water, the equation about $f$ is mentioned in the following part:

$$ f(d, h, p) = k_1 \cdot \frac{\sqrt{d}}{h(t)} \cdot \frac{p}{p_0} $$

Moreover, $k$ is a coefficient. $p_0$ represents the original price of soft drinks (assume 1 $). In this formula, the form of square root is taken because the distance can measure the convenience of drinking water (area is the square form of the distance). It is obvious that citizens will use other ways to satisfy their demand of daily using water if they want to use drink water from water purification facilities after implementing the ban of bottled water.

With the time going on, citizens start to dislike drinking carbonate beverages. Through calculating the change rate of the number of purchasing of carbonated drinks in 2010-2018, people’s attention to health can be expressed as following equation:

$$ h(t) = e^{-d(t-t_0)} $$

Moreover, the government or some institution need to set some water purification facilities in order to satisfy citizens’ demand of drinking water after carrying out the ban of bottled water. For example, after implementing the ban of bottled water in the airport in San Francisco, more than one hundred free water dispenser or a water exchange zone are set in the airport, which will make visitors gain drink water more convenient. In this case, it is necessary for towns and cities to set more water dispensers and water exchange zones in order to satisfy the demand of using water after implementing the ban of bottled water. It is obvious that the cost of gaining pure water is proportion to the density of water purification facilities. The convenience of drinking water from water dispenser can be expressed as:
In this equation, \( n \) represents the number of water dispenser and \( S \) represents the area of towns, cities and airports. Citizens gain water from water purification facilities more conveniently; the density of water dispenser is larger. It is assumed that drinking water in airport of San Francisco most conveniently. There are more than one hundred water dispensers in this airport, which make visitors can gain water very conveniently. These conditions are set as standards. The outlet of the airport of San Francisco is developed from Google map. Analyzing the map and collected data lead to the result that the terminal cover 5.3% of the total area of the whole airport, as shown in Figure 4-4.

![Figure 4-4 Calculation of the area of San Francisco airport terminal](image)

The result of the density of water purification facilities in the San Francisco is shown in the following part:

\[
d_0 = \frac{n_0}{S_0} = \frac{100}{5207 \times 5.3\%} = 0.36
\]

The equation means that there are 0.36 water purification facilities per acre. In terms of the above equation, the new form can be expressed as:

\[
f = \sqrt{\frac{n}{0.36 \times S}} \cdot e^{0.02(t-t_0)} \cdot \frac{P}{P_0}
\]

After carrying out the ban of bottled water, in different density of water purification facilities and different attention to health. The prerequisite is that the number of water purification facilities is 100. The substitution effect of sparkling water and pure water, include bottled water, as shown in Figure 4-5:

![Figure 4-5 Substitution effects under different conditions](image)

Through observing the above figure, the rate of drinking tap water is higher when the density of water purification facilities is higher. Otherwise, the rate of drinking bottled water increases when the density of water purification facilities is lower. With the time goes on, citizens pay more attention to the health. In this case, the favor and demand of sparkling water will decrease.
4.3.2. Construction Cost. After implementing the ban of bottled water, cities need to set some water dispenser or a water exchange zone in order to satisfy the citizens’ demand of drinking water. Suppose that the cost of water dispenser is \( C \) and the maximum use year is \( T \) years. If using straight-line depreciation, the yearly cost of using water is shown in the following equation:

\[
AC = \frac{TC}{Q} = \frac{FC + VC}{Q} = n \cdot \frac{C}{T} + \frac{Q \cdot c_1}{Q}
\]

\( c_1 \) expresses the water cost of water dispenser production per unit, which is composed by some electricity cost, operation cost, etc. The unit water cost of water purification facilities after implementing the ban of bottled water is calculated from the above equation. Given the machine purchasing cost 2000\$, using year 10, variable cost 0.02 \$ per unit, the changes of average cost with the different consumption of tap water is calculated, as shown in Figure 4-6.

![Figure 4-6 Average cost within different quantities of water purifier facilities](image)

Additionally, the amounts of water purifier facilities based on the population approximately is produced. Considering the real application of a ban in San Francisco Airport, one water purifier facility could support the drinking demands of 205 persons, which provides 74000 liters every year.

4.3.3. Health cost. The health cost of the society is caused by the principle or substitution that led by the ban of PET bottled water. After the bottled water is substituted by soft drink to some extent, the toxic chemicals and high calories within those soft drinks may cause people a higher risk of gaining diseases like Heart Attack and Stroke[8]. Therefore, the health cost should be the amount of people that get sick for drinking the substitutions of bottled water times the cost for those people to have medical care:

\[
HC = Q_{sick} \times C_{med}
\]

\( Q_{sick} \) is the quantity of the group of people that gain diseases like Heart Attack and Stroke because of the soft drinks which are the substitutions of the PET bottled water. It can be calculated as the change of the quantity of drink sold times the increased rate after people have the substitutional soft drinks of bottled water:

\[
Q_{sick} = \Delta Q_{drink} \times r_{sick}
\]

\( r_{drink} \) is the rate of gaining sickness after drinking the substitutional drinks after the ban of the selling of PET bottled water. We calculate this rate as the original rate of getting those kinds of diseases times 100\% with extra rate caused by the soft drinks:

\[
r_{drink} = r_{natural} \times (1 + r_{affected})
\]

4.4. Data source and usage

There are some factors that are difficult to measure, including the disease associated with soft drinks, the PET bottles pollution cost. Medical institutions could record these diseases reasoned by cola, coffee, etc. The data of the cost for handling pollution are collected from the environment ministry. For more concrete analysis, more sources and types of data are needed, such as pollution costs, environmental costs, etc., to illustrate the impacts of a bottled water ban. All of these calculations are mainly based on the measurement of the amounts of bottles. Some impacts are correlated with the substitution effect.
Hence, in the following part, we focus on the amounts of bottled water and soft drinks, as well as inconvenience caused by a ban to people’s drinking.

4.5. Impacts in Towns and Cities

The effects of the ban of bottled water is different because the distribution and density of population is not the same. In small towns, the density of population is low. The cost for citizens to drink water will be higher than the one in the past because citizens have to go to farther places in order to get drinking pure water. Moreover, the benefits of setting water purification facilities are not high because the density of population is very low. In big cities, water purification facilitates can serve more population to make citizens get drinking water more conveniently because of the high density of population. The data of the population number, population density and the area of Concord, San Francisco and the surroundings of San Francisco Airport.

| Place          | San Francisco Airport | Concord | San Francisco |
|----------------|-----------------------|---------|---------------|
| Population     | 20502                 | 19000   | 885000        |
| Area (km²)     | 21.07*5.3%            | 67      | 600           |
| Population density | 18359                | 284     | 1475          |

Note: Supposing that each person stays in airport for 4 hours.

4.5.1. Application of Concord. Concord is a town with large area (over 67 km²) and fewer citizens (about 19000)[9]. The density of population is 284/km². Assuming each people drink 1.5 liter every day, the average costs of drinking tap water under different water purifier densities are calculated. According to section 3.2, after implementing the ban of bottled water, the situation of average cost of drinking water for citizens and the substitution effect of soft drinks is shown in Figure 4-8.

Through analyzing the above figure, citizens in Concord need to cost more time to go to the place that has water purification facilities in order to drink water after implementing the ban of bottled water because Concord is a big town with small city. Moreover, with the increasing of the water purification facilities, the average cost for citizens will increase because the settings of water purification facilities are not appropriate in a vast place with small population. However, the results of the second graph show that citizens drink sparkling water as substitution drink is a less situation when the government set more water purification facilities. Based on the fact that one water purifier facility can support 205 persons’ drinking, the essential purifier facilities needed is about 94. Due to the fact that Concord has a vast territory with a sparse population, the ban really causes some inconvenience to people’s drinking. And people will drink lots of soft drinks as a substitution effect, which, inevitably, weakens the positive impacts of a ban on the sale of bottled water.
4.5.2. Application of San Francisco

For San Francisco, the population density is 1475/km$^2$, which is relatively high compared to Concord. Similarly, using 1.5 liter of drinking water each day in San Francisco, under different water purifier facilities, the changes of average cost and soft drinks demands are shown as follows:

According to the figure above, the population density of San Francisco is relatively higher. Though it brings people inconvenience to some extent after the ban of selling bottled water, this influence is not very significant, compared to small towns. Moreover, with a high density of water purifiers, citizens have fewer soft drinks as the substitutions of bottled water, which, averagely, has the potential for reducing bottles pollution. Besides, some adjustments are made to the basic model given the distribution of population in San Francisco, shown in Figure 4-10.

![Figure 4-9 Changes of Average Cost and Soft Drinks – San Francisco](image)

From the figure shown above, it is clear that population in San Francisco is not equally distributed. Hence, the average cost about drinking may be small. Let $N$ represent the amounts of population in San Francisco, and $N_i$ represent the amounts of population in district $i$ of San Francisco. Then the average cost of drinking purified water from purifier facilities can be illustrated as follows:

$$AC = \sum_i \frac{N_i}{N} \cdot AC_i = \sum_i \frac{N_i}{N} \cdot \frac{n_i \cdot C_i}{Q_i} + \frac{Q_i \cdot c_i}{Q_i}$$

Obviously, when considering the population distribution, the average cost of drinking purified water as well as inconvenience will be reduced. In high population density area, they have much bigger weights for measuring convenience and average cost. Thus, the result is better than the situation without...
considering population distribution.

4.6. Impact on the Airport
As for the airport in San Francisco, it can be concluded that there are many purifier water facilities (bigger than 100 approximately). Hence, tourists or passengers are extremely convenient to drink water from these purifier water facilities without wasting lots of time. As the model shows above, the substitution effect between soft drinks and bottled water can be illustrated as follows:

$$\Delta x_2 = -(1 - f(d, h)) \cdot \Delta x_1$$

Due to the convenience of the purified water from water facilities, passengers have the trends to drink purified water instead of soft drinks after the ban on the bottled water. That means:

$$\Delta x_2 = 0, \Delta x_3 = -\Delta x_1$$

As the result shows, the bottled water ban in San Francisco airport is more efficient. As the population density is high, passengers can drink purified water conveniently without additional consumption on soft drinks.

5. Further Analysis

5.1. Multi-Objective Model
Many cities carry out the ban of bottled water in order to protect the environment better. However, the implementing of the ban causes many inconvenient things, such as difficult for citizens to drink enough water. As a result, a multi-objective programming model is built from protecting environment and reducing cost in order to analyze the most appropriate limitation of the ban of bottled water and the relevant number of water purification facilities under the optimal results of protecting environment and reducing the cost. In the passage, the situation of environment can be reflected by producing of bottled water and of carbon dioxide in the whole process. The carbon dioxide emission will be reduced after implementing the ban of bottled water. Instead of buying bottled water, the consumers will consume more coal, which means the substitution effect will cause the carbon dioxide emission increases. Therefore, the total effects need to except the effect in this situation. In this case, the purpose of protecting environment can be expressed as:

$$\max O_1 = E_1q_1 - E_2q_2$$

In this equation, $E_1$ represents the emission of carbon dioxide that is caused by a mineral water bottle; $q_1$ represents the number of mineral water bottles; $E_2$ represents the carbon dioxide emission that is caused by sparkling water. And due to the differences of the materials usage, the emissions of carbon dioxide may have some differences; $q_2$ represents the number of sparkling water bottles. The aim of reducing the cost of drinking water can be expressed as the following equation:

$$\min O_2 = c(d) \cdot q_1 \cdot f(d, h, p)$$

The equation needs to satisfy the following condition:

$$q_2 = f(d, h, p) \times q_1$$

$$d = k_2 \cdot \frac{n}{S}$$

$$E_1q_1 - E_2q_2 > 0$$

$$q_1 \geq 0, q_2 \geq 0, n > 0$$

The third constraint illustrates that the carbon dioxide emissions after the ban should be lower than the result before the ban. Hence, the constraint is added into our multi-objective model [10]. Based on the work above, the overall model is mentioned in the following part:
\[
\begin{align*}
\max O_1 &= E_1 q_1 - E_2 q_2 \\
\min O_2 &= c(d) \cdot q_1 \cdot f(d, h, p) \\
q_2 &= f(d, h, p) \times q_1 \\
d &= k_2 \cdot \frac{n}{S} \\
E_1 q_1 - E_2 q_2 &> 0 \\
q_1 &\geq 0, q_2 \geq 0, n > 0
\end{align*}
\]

5.2. **Optimization Result**

In evaluating this multi-objective model, the same weight is assigned to the two objectives. Surely, the weights of the two objectives can be changed according to the level of concerns. In this problem, the Concord is the analyzed object.

| City          | $w_1=0.5, w_2=0.5$ | $w_1=0.8, w_2=0.2$ |
|---------------|-------------------|-------------------|
| **Concord**   |                   |                   |
| $n$           | 5999              | 5999              |
| $Q_2$         |                   |                   |
| $O_1$         | 465069.4          | 465069.4          |
| $O_2$         | 112535            | 112535            |
| **San Francisco** |               |                   |
| $w_1=0.5, w_2=0.5$ | 53729       | 53729             |
| $w_1=0.8, w_2=0.2$ |             |                   |
| $Q_2$         | 2.16*10^7        | 2.16*10^7        |
| $O_1$         | 5232674          | 5232674          |
| $O_2$         |                   |                   |

From model estimation results of Concord, a reduction of the carbon dioxide emissions by 465069.4 kg can be reached when 5999 purifier water facilities are put in Concord, with a cost of 112535 per year.

For San Francisco, a reduction of carbon dioxide emissions by 2.16*10^7 kg can be achieved if the bottled water is banned, a policy that really enhances the environment.

5.3. **Sensitivity Analysis**

As the section 4.2 and section 4.3 show, the positive and negative impacts of a ban on the sale of bottled water will mainly reflect on the amounts of bottles. Hence, the reduced number of bottles can be estimated under a ban on the sale of bottled water.

5.3.1. **Changes of Health Concerns.** Setting the range of $\delta$ from 0.02 to 0.1 means that people are more concerned about their health. Correspondingly, the changes of the average cost and substitution effect of soft drinks are shown in Figure 5-1:

![Figure 5-1 Changes of average cost and soft drinks with different health concerns](image)

Figure 5-1 suggests that increasing health concerns can lower the average cost of drinking water from purifier facilities and weaken the impacts of substitution effects for soft drinks. Thus, raising people’s concerns for health will encourage more purified water drinking.
5.3.2. Changes of Price of Soft Drinks. Similarly, the results of average cost and substitution effect for soft drinks are stimulated by changing the price of soft drinks, as shown in Figure 5-2.

From the figure shows above, the substitution effect is sensitive to the changes of soft drinks’ price comparatively. Hence, increasing tax or the price on soft drinks help reaching a ban on bottled water.

6. Conclusions and Discussions

This research project reveals that the bottled water ban has both benefits and drawbacks. Firstly, the policy has advantages on environment and global climate while it does badly to the convenience of people’s drinking. Maybe the government should alter the ban a little bit considering the real conditions of cities then spread it to the whole U.S. Secondly, the usage of bottled water will increase sharply without a ban on the sale of bottled water. The AR(\(p\)) model indicates that bottled water will increase from 27.2 gallons in 2010 to 45.2 gallons in 2020, which will cause great challenges to the development of the environment. Hence, governments or organizations should take some actions to reduce the amounts of PET bottles. Thirdly, some methods like putting more purifier water facilities and enhancing the soft drinks’ price can help reduce the pollution of PET bottles.

In order to help the carry out of the water bottle ban and help to improve the health condition of people, some suggestions are made for the government. The following suggestions helps the improvement of the health condition on both sides: make less people drink soft drinks and ask them to drink purified water.

- The government should give subsidies to the companies that make the water purifiers and lower the price of the water purifiers. Then, it will be much easier for the tap water to substitute the PET bottled water with a lower cost of installing water purifier and popularize in public areas.
- The government should increase the tax on the soft drinks in order to lower the demand of the soft drinks. Thus, the number of people who drinks soft drinks will decrease and there will be more people drinking pure water. The increase of tax will be able to ensure the health of people.
- The government should make more announcement of the negative influence of soft drinks on people in order to make less people drink it. Thus, the health situation will be improved because the government let more people to drink pure water instead.
- The government should tell the public the benefit of drinking pure water in order to motivate the public to drink less drinks which harm to the people may do, so that the cost of health care can be reduced.

7. Strengths and Weaknesses

There are a few strengths of the analysis. First, the impacts of a ban on the sale of bottled water from the perspective of environment, energy, and substitutes are illustrated. The whole analysis process could be furthered used to measure other kinds of pollution, like water pollution, plastic pollution, etc. Second, the model is concerned about the actual conditions of towns, cities and airports. As the model shows,
their biggest difference is the population density. When the density is large, the negative effects could be easily reduced by putting more purifier water facilities, which is not economic for some remote areas. Third, the multi-objective model is attracting to some extent. It is obvious that some challenges will be faced when imposing a ban. Hence, the influences of a ban could be evaluated by maximizing positive impacts or minimizing negative impacts, which helps us understand the challenge thoroughly. The weakness is that due to the lack of authoritative data, some essential impacts are not measured by money. Surely, given the data, the whole procedure could be more attracting and give very concrete suggestions to the bottled water ban.

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