CUSTOMER-STORES CHOICE MODEL

A PREPRINT

Sachin Yadav
IIT Gandhinagar
sachin.yadav@iitgn.ac.in

ABSTRACT

There are various factors based on which customers choose which visit among the available stores. In this model we explore the factors of travelling time and waiting time for the decision. Using the two factors, we propose an objective value as "unhappiness value" and the customers make decisions to minimize the value. We then explore the effects of different parameters such as location of the customers and stores, the inventory replenishing rate at the store, current demand of the customers and many more on the average unhappiness value and the customers distribution over the stores as the time progresses. Using the results, we propose different concepts and cases to explain the emergence patterns in the model.

1 Introduction

When a customer has to decide which store to visit, given a set of options there are various factors at play. Such as a customer may prefer the store which is nearby to his/her home location, also the store which is less crowded and the customer does not have to wait for long, some stores may provide discounts, some may give better customer service and the customer may also have personal preferences such as taste in case of restaurants. In this model we explore the two factors of travelling time to the store and the waiting time at the store.

By using the two factors, we define "unhappiness value" which depicts lower customer satisfaction based on travelling time to the store and average waiting time at the store in past visits by the customer. It is a taken a linear combination of the two factors, for simplicity, the unhappiness value is defined as:

$$unhappiness\,value = Travelling\,time\,to\,store + Average\,waiting\,at\,store\,in\,past\,visits$$

As per our model, the customer chooses the store which gives the minimum unhappiness value for the customer from the available choices of stores. So a customer may choose a store farther from home, if the near shops are the crowded ones.

Our model comprises of mainly two entities: the stores and the customers. The stores must keep track of the current inventory and every store is assumed to have a maximum inventory capacity. The inventory stock gets replenished over the time steps by a certain rate, we call it as "supply-rate" for the store.

The most fundamental actions performed by the customers in this case will be visiting the store at some time intervals from its home with a certain required demand. On reaching the store, if the available stock is sufficient to fulfill the request, then the customer finishes the transaction and immediately heads back to home location. Otherwise when the quantity at store is less than the required demand, the customer will have to wait at the store for a time of:

$$Wait\,Time = \frac{Demand - Quantity\,at\,store}{supply\,rate}$$

A customer needs to keep track of his/her past experiences of the stores while making choice as to which store to visit as the stores associated with good past experiences are most likely to give similar high customer satisfaction in the future visits. In case the customer have not visited the given store yet, we can take the waiting time for that store to be zero in that case for calculating unhappiness value.

2 Methods

2.1 Agent Behaviours

2.1.1 Customers

A customer is assumed to be at one of the four states ["at home", "travelling to store", "at store", "travelling to home"]. The customer at home, will wait at the home for a specific rest time period. When leaving the home to buy stuff, the customer must make a choice for the store to visit. The decision in the model is based on the store that gives the least calculated unhappiness for the customer over the set of available stores. When customer reaches the desired store, the quantity of the store is updated as per the required demand.

$$Quantity\,of\,Store = Quantity\,of\,Store - Demand\,of\,customer$$

In the Introduction section, we mentioned about the wait time calculation in case the quantity at the store is less than the required demand.

2.1.2 Stores

At every time interval, the quantity of the store increases by the supply rate.

$$Quantity\,of\,Store = Quantity\,of\,Store + supply\,rate$$

If the quantity exceeds store capacity, the quantity becomes equal to store capacity.

2.2 Average Unhappiness value of the Population

The average unhappiness of the population is the mean value of the unhapppiness values of the population. We first observe how the average unhappiness varies over as the simulation progress; and thereafter in next set of results we focus on the unhappiness value of the system when it has reached a steady state.

2.3 Variation of the Customer Distribution over stores

The other main analysis point is how the customers are distributed at the stores and how the customer distribution is as the time progresses. For the variation, in some of the results we have used the standard deviation of the number of customers associated with each store. First we analyse, how it changes over the time and then what is the value in the steady state in case of long run.

3 Results

3.1 Trends in Average Unhappiness and Customer Distribution over time

The figure 1 shows how the customer distribution and the average unhappiness varies over the time.

3.1.1 Setup

The first image in 1 shows the initial setup of the grid with three stores and 260 customers. The other parameters are mentioned in the image.

3.1.2 Initial Phase

In the initial phase, as none of the customers have experienced any of the stores. So the unhappiness values simply depend on the distance between the stores and the home location of the customers. As the store 1 is nearer to the most of the customers, therefore we see a increasing crowd at the store 1 and also the number of waiting customers at the store 1 is the highest. As the store 0 and 2 are located near to almost same number of customers, are there in the these two stores. As most of the customers are experiencing crowd at the store 1, hence the average unhappiness value is seeing an upward trend.

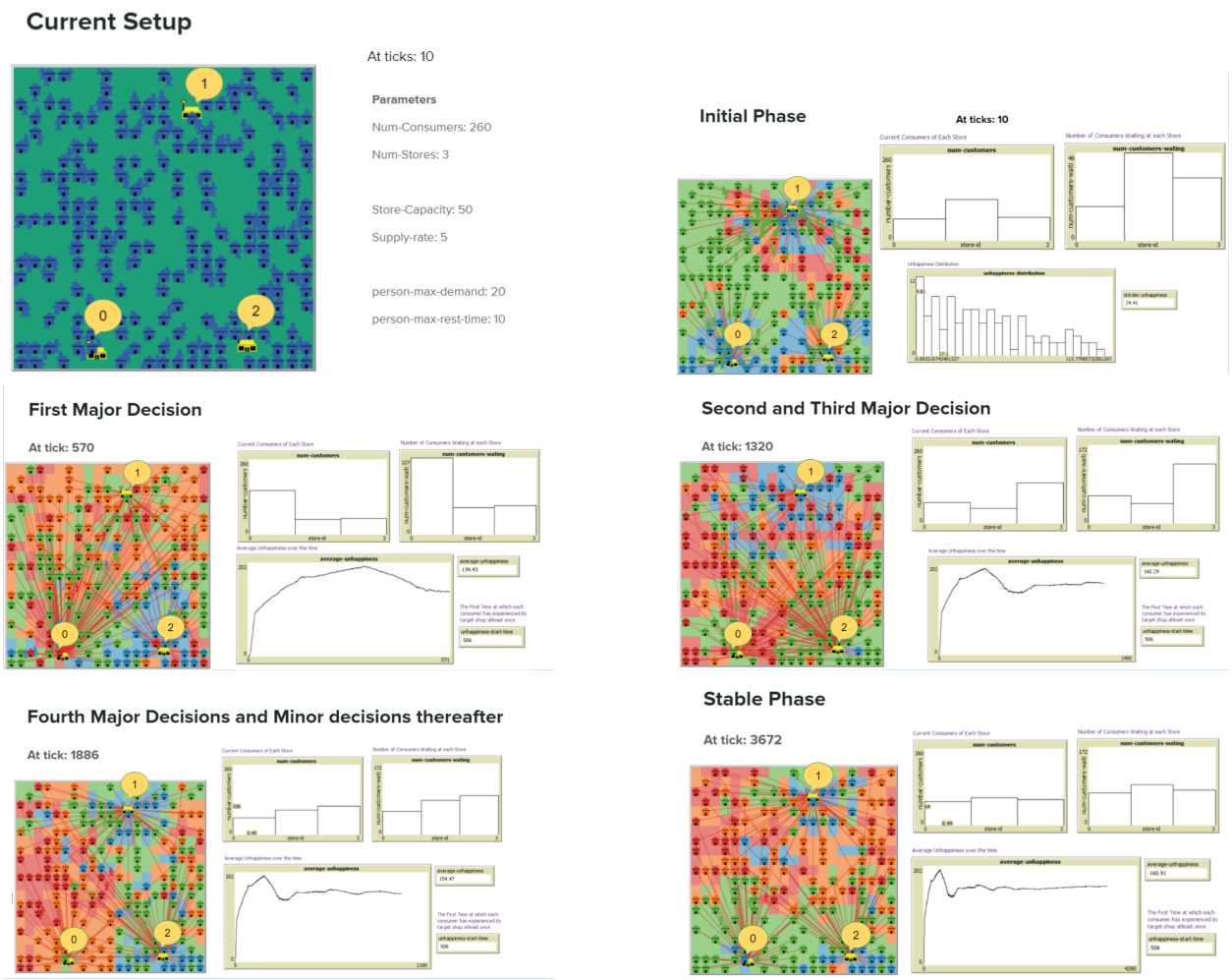

Figure 1: The changes over the time in a single simulation

3.1.3 First Major Decision

As the store 1 was getting crowded, so many of the customers returned unhappy. So they look for the other options of store 0 and store 2. As the store 0 is somewhat nearer to the customers of store 1, therefore the store 0 seems to getting crowded now as most of the earlier customers at store 1 has now moved to store 0 and store 2, but more on the store 0 side. This was the first major decision taken by a large crowd (mainly by customers of store 1), that is to leave the store 1 and switch to other stores of 0 and 2. Now as many of customers of store 1 are shifting to store 0, the customers of store 0 from the start are getting unhappier as the waiting time at store 0 is increasing.

3.1.4 Second and Third Major Decision

In the initial phase, the customers that arrived early at the store 1 were able to avoid the long waiting time as opposed to most of the other customers. Thus this small group of customers have remained loyal to store 1. As most of the customers of store 1 had switched to other stores, therefore the current remaining customers of the store 1 are experiencing a happy phase. While some of the unhappy customers of store 0 which were facing increasing crowd that switched from store 1 after initial phase, have now switched to store 2 for an alternative. Thus most of the customers are now the customers of store 0 and 2, thus the customers of these stores are experiencing an unhappy phase. While the customers of store 1 are the happiest ones.

3.1.5 Fourth Major Decision and minor decisions thereafter

Many of the customers that left store 1, were captured by shop 0. But then some of them shifted to store 2 for further alternative. However now they have to travel a long distance to reach the store of 0 and 2. It is evident from the figure that this group is now the one of the unhappiest customers.

3.1.6 Stable Phase

The phase of constant ups and downs in the average unhappiness value has now ended. The customer distribution over the stores and the average unhappiness value has now stabilished with minute variations over the time. In this particular run, we observe a somewhat equal distribution of the customers over stores, but in later results we notice that this distribution depends mainly on some of the parameters such as supply rate, ratio of stores and customers, etc.

3.2 Inferring the ups and downs in Average Unhappiness Value

As we noticed in the previous section, that the phases in the model can be very broadly divided into three main phases: the initial phase, decision phase and the stable phase. In initial phase the model just starts execution and most of the customers have not experienced any store and simply choose based on location. The majority of activities happen in the decision phase when the customers continuously try out the alternatives seeking better unhappiness values. In stable phase, after a long time and many switches back and forth, the customers have reached a final choice of the stores. The average unhappiness value thus stabilises here with minor fluctuations.

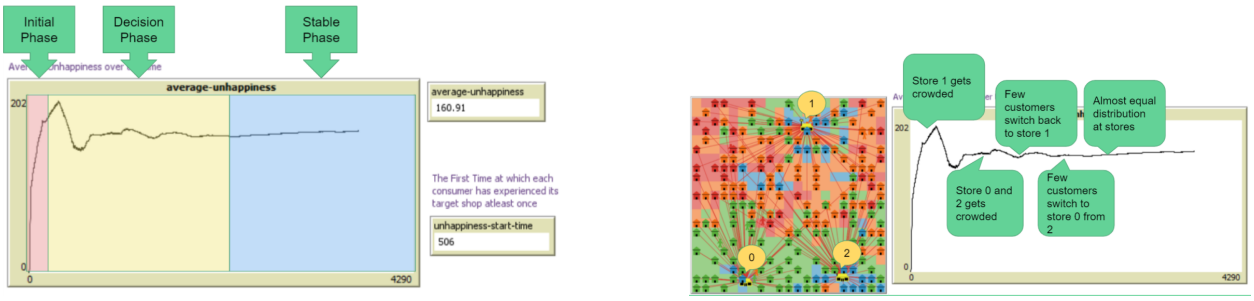

Figure 2: Inferring the average unhappiness trend

As seen in the second image of figure 2, that we can describe the various ups and downs in the average unhappiness value from the observed major events of the shifting of the customers from one store to alternative stores.

3.3 Effect of Number of Stores and Supply rate

As seen in the output graph in figure 3, that the Average Unhappiness value decreases as we increase the number of store or the supply rate at the existing stores or both.

One of the **potential use** of this information can be to make decision on whether it would be more beneficial to increase the existing capacity of the stores or addition of more stores to the chain. There are always cost factors associated with both things and we can use the information to know which decision would lead to more benefit in less cost.

In the customer distribution we see that in less number of store 2 or 3, the standard deviation first increases and then decreases as we increase the supply rate. In all other cases, the standard deviation of customer distribution decreases as we increase number of stores or supply rate. This can be due to the uneven distribution in case of highly crowded less number of stores with small supply rate where customers are stuck at the store waiting for a very long time.

3.4 Effect of Demand and Rest time

As seen in the figure 4, the demand parameter has more profound effect on the average unhappiness and the distribution of customers across stars. The number of stores for the data was kept at 3.

As we increase the max demand of each customer, the average unhappiness increases as the waiting time of the customers will increase due the increased consumption and as the supply rate is still same.

In the second image, the customer distribution standard deviation is high at the low values of demand by the customer and at the high values of demand by the customer. In case of low value of demand, the customer distribution depends

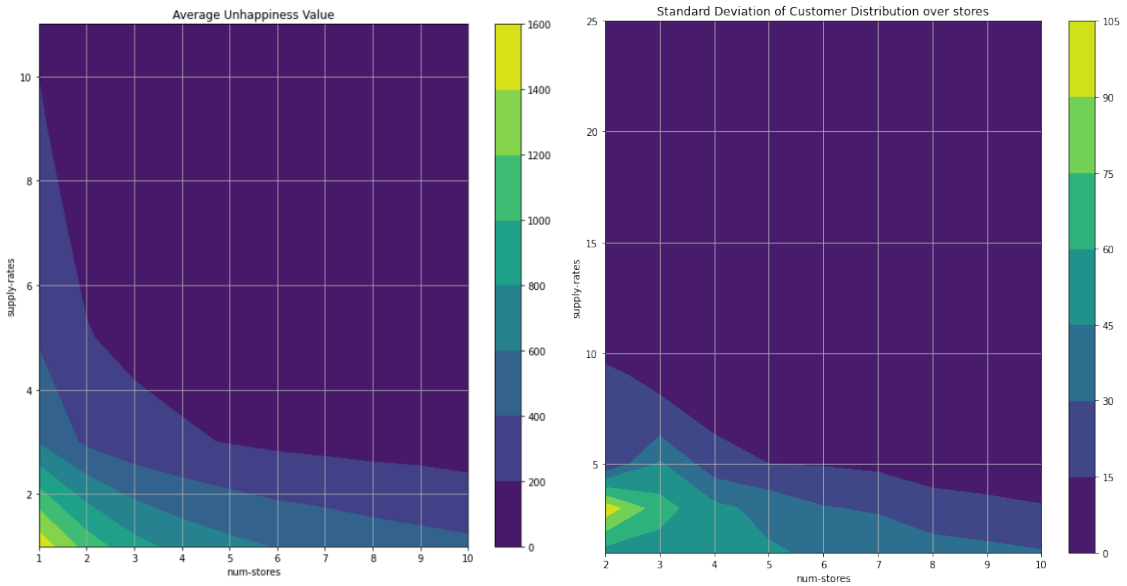

Figure 3: 1) Average Unhappiness 2) Standard Deviation of Customer Distribution vs Number of stores and Supply Rate

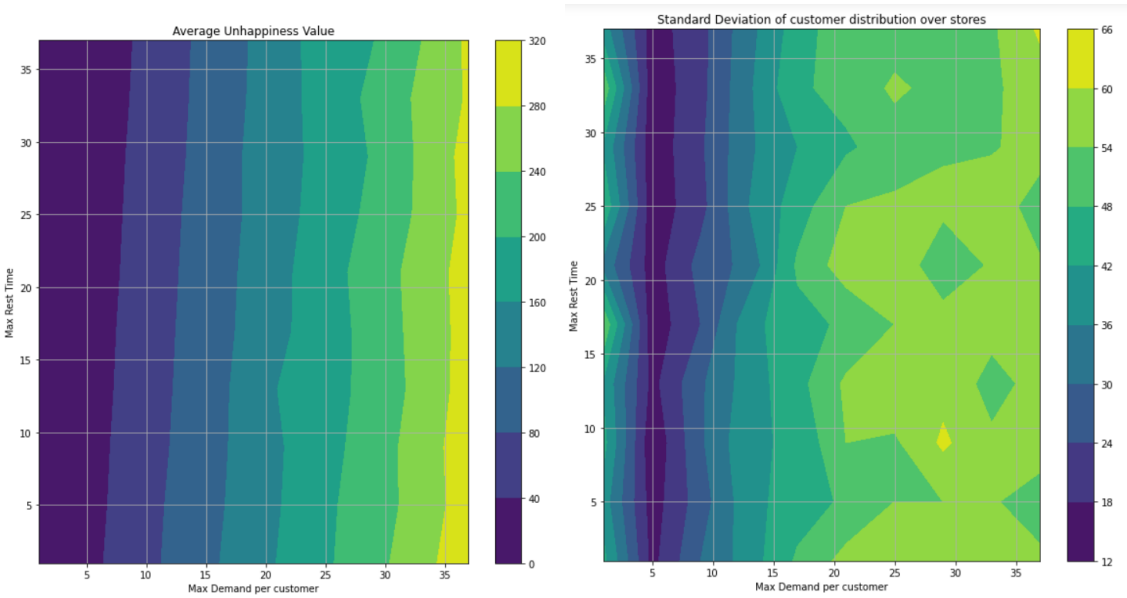

Figure 4: 1) Average Unhappiness 2) Standard Deviation of Customer Distribution vs Max Demand and Max Rest Time

mostly on the location preference and hence the location preference creates the variation in the customer distribution. We observer there is an optimal demand value which results in the most equal customer distribution. The value in the above case comes to be at 5.

3.4.1 Effect of Demand and Supply rate

As shown in the figure 5, the condition of high demand and low supply creates a very unhappy situation for the customers.

In last section we saw that there was a particular range of value of demand, when we kept the supply rate fixed which leads to the most even distribution of customers. The second figure shows a region of even distribution in the demand supply parameters being varied. The ratio of the supply rate and demand in this case seems to be the deciding factor

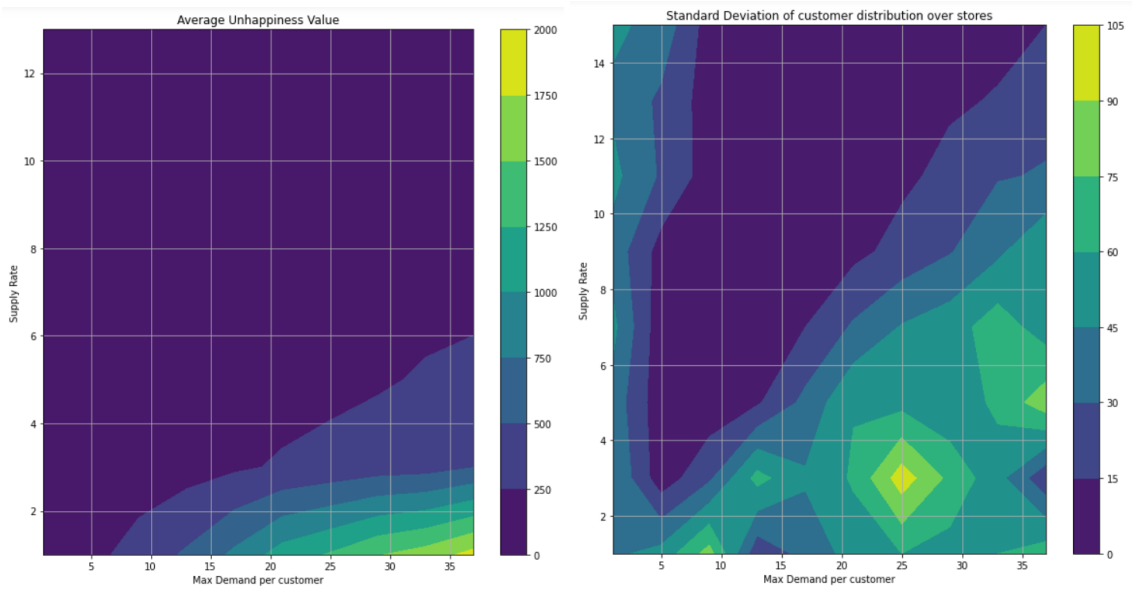

Figure 5: 1) Average Unhappiness 2) Standard Deviation of Customer Distribution vs Max Demand and Supply rate

for the customer distribution variation. **Potential use** If the demand of the customers is increasing, what should be the adequate increase in the supply rate such that the even distribution of customers across stores is maintained and vice versa.

4 Discussion

To explain some of the results, we have come up with following interesting concepts:

4.1 Case of First "Bad" Experience

In the initial phase, when no customer has visited any store. The customers that visit the crowded store will experience the first impression as a bad experience. Due to this the given customer is likely to choose alternate store only even when it has to travel a long distance. It may happen that the store in next visit can give better experience, but the customer then also will choose the other stores.

4.2 Uneven distribution of Unhappiness over terrain

In various model runs, we observed that in many cases some happy customers were located in the majority regions of the unhappiest ones and vice versa. This happens due the difference of past experience and choices made by the agents as waiting time is also taken into consideration in calculation of unhappiness values.

4.3 Ratio of Supply rate and Customer Demand

From the 5, about the variation of the customer distribution; the ratio of the supply rate and demand seems to be one of the most important deciding parameter. We can observe the regions of even and uneven distribution in the standard variation plots and using it, we can roughly predict about where the distribution will be more towards equality or variation.

4.4 Optimal Location of the Stores

Placing the stores such that we achieve an optimal unhappiness value was explored for the model. The first attempt was to place the stores to the mean coordinate of their current customers. The second attempt, was to place the store to the unhappiness value weighted mean coordinated of the current customer. We were expecting to see better results in every iteration of changing the store location, however in few cases the value didn't decrease significantly. One part of the

reason can be that we reset the past experience of the customers on every iteration, in case the past experiences of the customers are maintained in the iteration, we hope to observe better results in most cases.

5 Conclusion

With this model, using the objective function of "unhappiness value" we explored the combined effect of parameters such as number of stores, supply rate at the store, demand of the customers, rest time on the mean unhappiness value and the distribution of customers over the stores. We explored the emerging trends in the decision and initial phase of the model and inferred the decision making process of the group of customer based on the crowd at each store and the unhappiness distribution over the grid terrain. Using the results and some other interesting cases, we proposed concepts to explain the behaviour of the model.

5.1 Possible Future Work

- In the model, each store is assumed to sell only one type of commodity. We can include the case in which there are more than one type of commodities and stores keeps track of the quantity of these all commodities. On starting a visit, the customer set a demand and as well as the type of the commodity required.
- We have assumed that each store has the same supply rate. It may happen the supply rate is higher at certain stores than the typical stores.
- There can be customers influencing each other. Such as a customer may influence the decision of the customers who reside near to his/her home location.