CS302: Modeling And Simulation Lab2 Report

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1 Q1: Models of innovation diusion

1.1 CASE I - External Influence Model

In this part, we study the effect of external influence on the adoption of technology by the people. The external influence is the factor which does not depend on how many people already use that technology nor it depends on the total number of people.

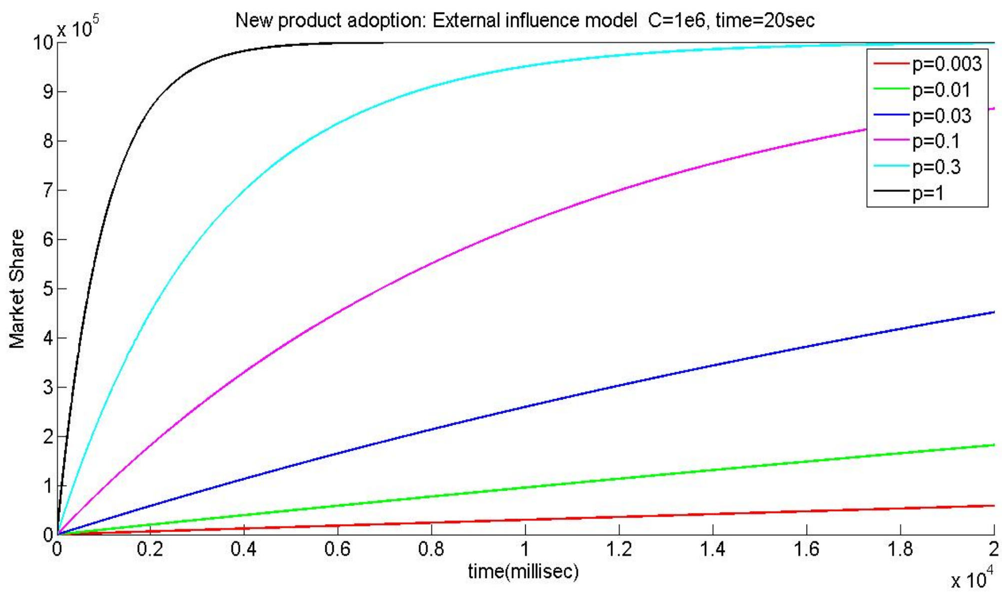

Figure 1: CASE I - Market Share

Observations:

- In the figure above, graph1 since the factor affecting the market share is constant p, the relationship is exponential.
- As p increases, the external influence on the population increases and the market share of the population that accepts the product, increases rapidly.
- For p = 1, the black line in the graph shows that the adoption rate is very high and the technology quickly reaches all the people.

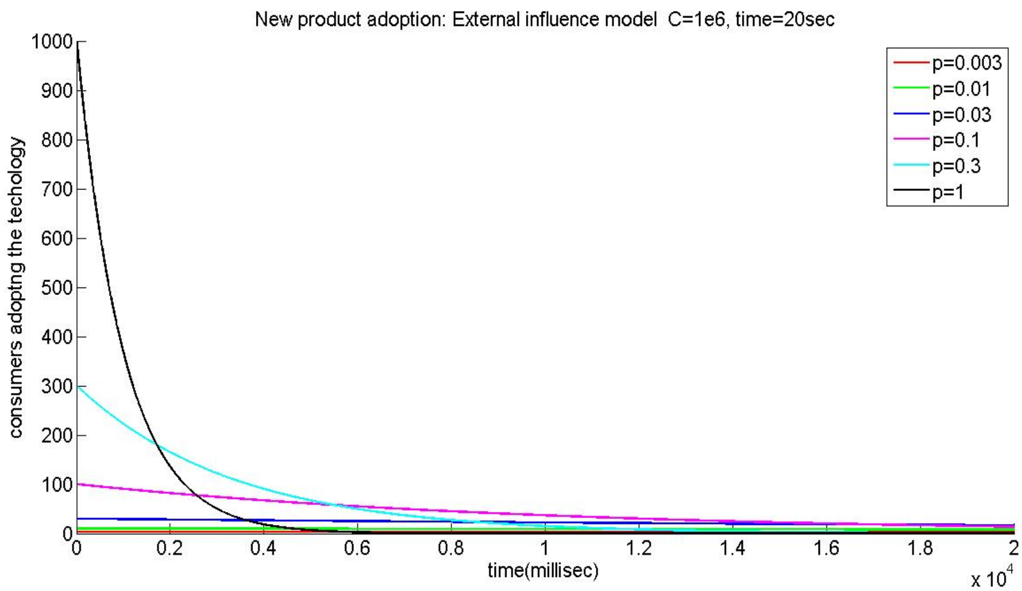

Figure 2: CASE I - Consumer Adoption

Observations:

- Since the factor affecting the market share is constant p, the adoption factor is inverse exponential and not a normal distribution as displayed in the problem statement.
- When p is large, the external influence on the population is high and hence the consumer adoption rate of the technology is initially large as can be seen by the black graph in the above graph fig:graph2
- Since the initial adoption rate is high, as the time progresses, the number of people adopting the technology decreases drastically since most of the people have already adopted the technology.
- This can be observed in the black (p=1), cyan (p = 0.3) and magenta (p = 0.1) graphs. The black graph is initially very high indicating large number of people adopting the technology early on, while it decreases rapidly than the other two in the later stages.

1.2 CASE II - Internal Influence Model

Here, the influencing factor are the other people who have adopted the technology. Hence, some people/innovators must use the technology beforehand (i.e. at time = 0 units) in order for the technology to be adopted by other people.

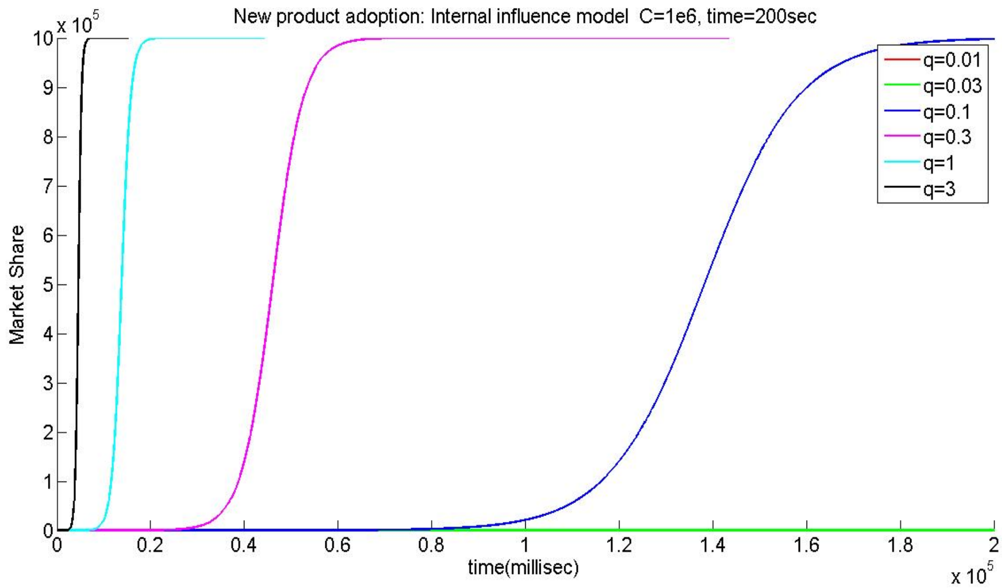

Figure 3: CASE II - Market Share

Observations:

- Here the influencing factor is the effect of other users (N(t)) who have adopted the technology. And q is the moderating factor.
- The graph is of sigmoidal nature and as q increases, there is more and more effect of the users on the non-users of technology and hence the steepness of the graph increases indicating the non-users are adopting the technology quickly. This is visible in the above figure. fig:graph3

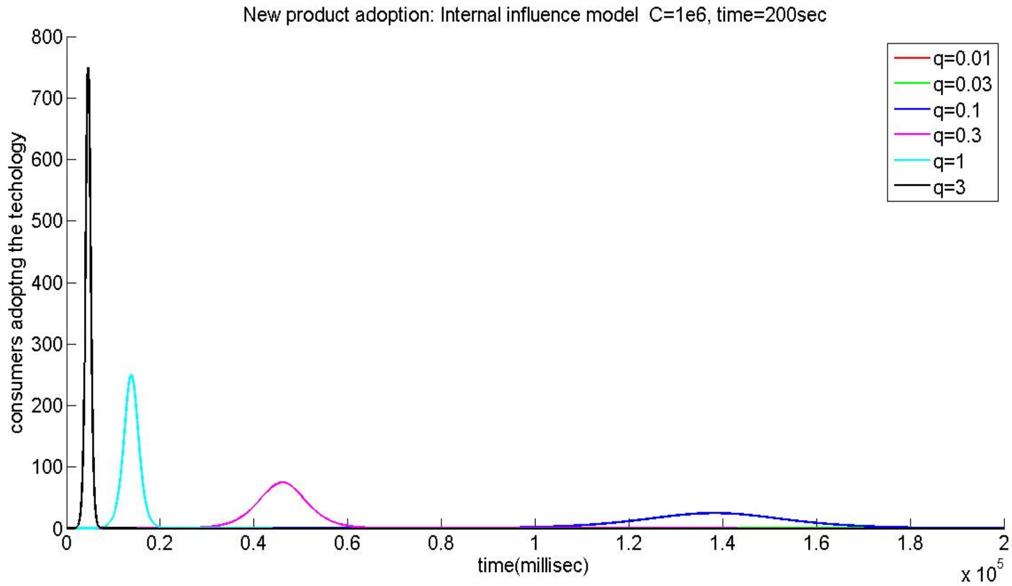

Figure 4: CASE II - Consumer Adoption

Observations:

- The above graph fig:graph4 shows the consumer adoption of the innovation.
- The graphs show normal distribution behaviour indicating that this case is closer to reality.
- Here as q increases, the peaks of the graphs rise higher and higher and shift leftward. This means that as q increases, more people adopt the technology and at earlier times.
- Also, as q increases, the spread of the graphs decreases, indicating that due to high internal influence, more number of people adopt the technology in a short span of time.

Can you comment on the aspect of the problem which the logistic equation can not capture?

1.3 CASE III - Mixed Influence Model

Here we have divided the problem in two parts to get a better understanding of the problem.

1.3.1 Keeping q constant and varying p

Here the internal influence factor is constant and we vary the external influence factor and observe the impact on the adoption rate and the market share of the technology.

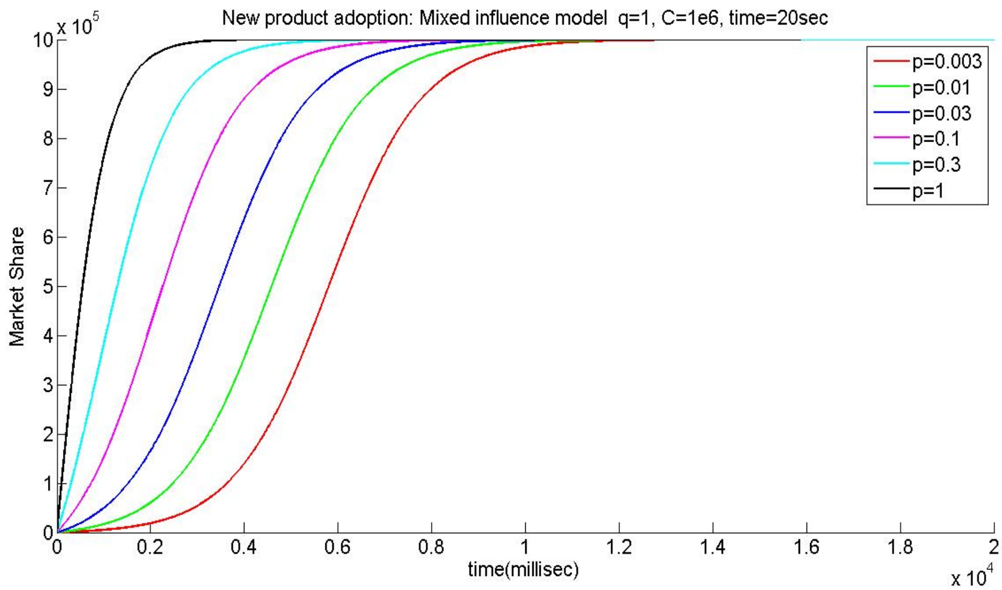

Figure 5: CASE III - Market Share with q constant and p varying

Observations:

- Observe here that as p increases, the sigmoidal nature of the graph decreases and the exponential nature of the graph increases. This means that the external influence factor dominates over the internal influence factor.
- For all the graphs, the whole population eventually adopts the technology but at varying times.
- For the blue (p=0.03), green (p=0.01) and red (p=0.003) graphs, the steepness of the graphs is almost the same. This shows the the effect of p is negligible here as compared to the effect of q.

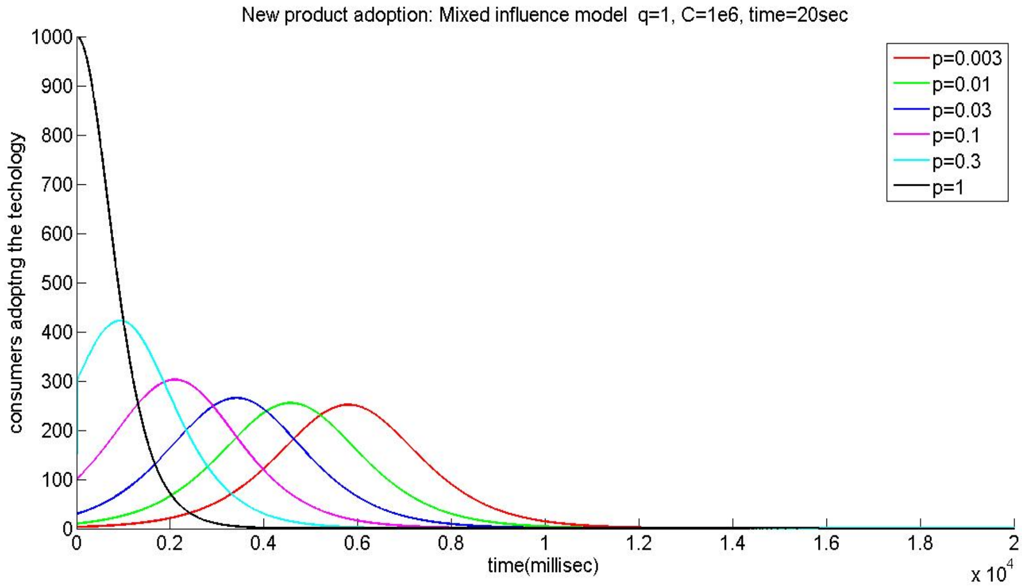

Figure 6: CASE III - Consumer Adoption with q constant and p varying

Observations:

- Here the black graph is almost the inverse exponential indicating that p dominated over q and the external influence on the adoption of technology is much higher.
- Rest of the graphs show the normal distribution behaviour.
- The blue, green and the red graphs are almost similar indicating that q dominates over p and the influence factor is almost the same. Only the position of the graphs is different which means the time of influence is different. This shows that variation in p has mild role to play in the adoption of technology over time.

1.3.2 Keeping p constant and varying q

Here the internal influence factor is varying while the external influence factor is constant. We observe the impact of these changing parameters on the adoption rate and the market share of the technology.

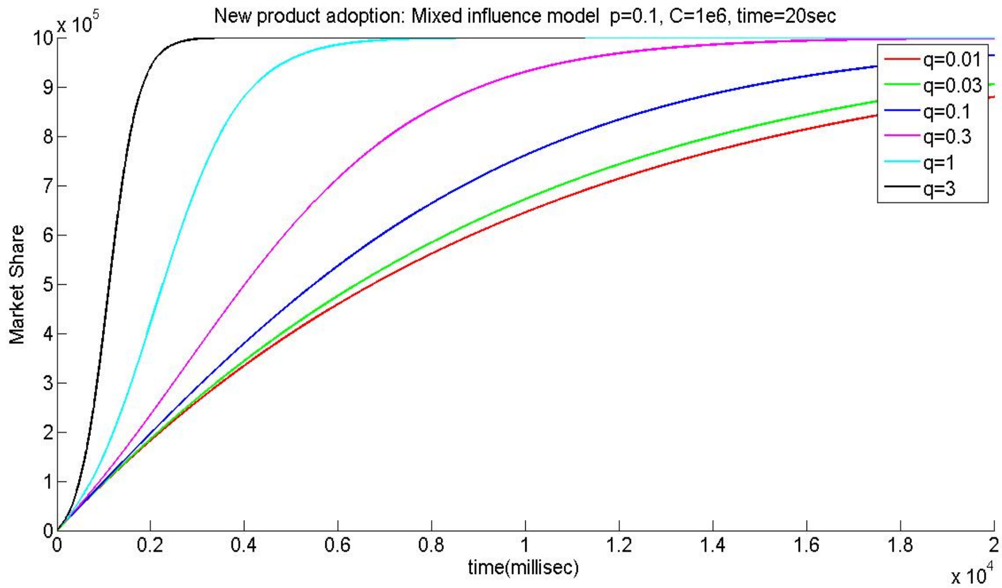

Figure 7: CASE III - Market Share with p constant and q varying

Observations:

- In the above graph fig:graph7, we have p - the factor of external influence as constant and we observe the effect of the variation in factor of internal influence.
- We can see that as q increases, the steepness of the graphs increases and the graphs become more sigmoidal in nature. This indicates that the internal influence causes sudden rise in the market share of the technology.

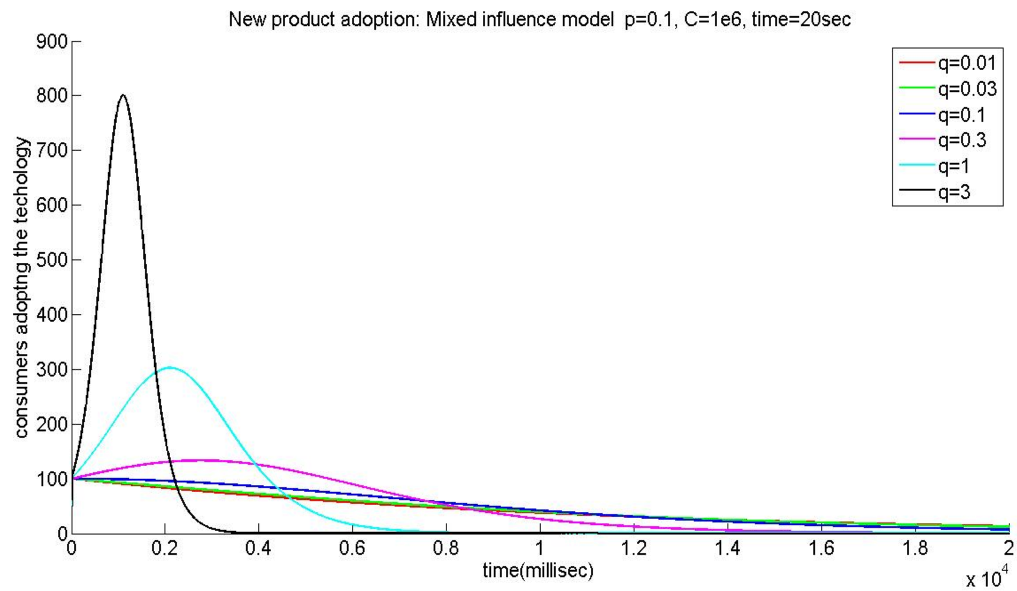

Figure 8: CASE III - Consumer Adoption with p constant and q varying

Observations:

- In this graph, the starting point of all the curves is 100. This shows the effect of the constant p factor of external influence.
- The increase in q contributes to higher peaks, smaller spreads and leftward position of the graphs.
- The higher peaks and smaller spreads indicate that there is huge effect of the influence which results in adoption of technology by more people in a short span of time.
- The leftward shift of the graphs shows that due to higher influence, the technology is adopted at an earlier time.

Can you identify how the missing aspect in CASE II that is already accounted for in the mixed model?

In CASE II, the adoption of technology by the people completely depends on how many people or innovators have adopted that technology at t = 0. If no one has adopted the technology, then the effect of internal influence i.e. of the users is zero since there are no users. Hence the technology won't be adopted at all.

In CASE III, the mixed influence model ensures that even if there are no adopters of the technology initially, the constant external influence factor will always work and hence the technology will be adopted irrespective of how many people have adopted it at t = 0. Only the total adoption rate would be different based on the constants p and q.

What processes according to you would be captured by the constants p and q?

The constant p captures the effect of an external influence like an advertisement or Television or Internet on the user irrespective of how many users are persuaded to adopt that technology. While, the constant q captures the effect of the current users of the technology in persuading the non-users of technology.

Both the factors affect the user adoption of the technology but their medium and hence extent of effect is different.

2 Q2: Modeling Population using logistic equation

2.1 Model the dynamics of the carrying capacity

Explain the parameters used.

From the figure for carrying capacity vs time provided, we see that for some time, the the carrying capacity does not increase. After some time it increases in a sigmoidal manner and finally saturates to a maximum.

Thus, the capacity must start from a value, increase very slowly for some time, then show logistic behaviour and terminate to some final value.

The usual logistic equation is as follows:

$$K' = \alpha K(1 - K/K2) \tag{1}$$

Where, K2 is the maximum value attainable and alpha is the factor which decides the steepness of the logistic increase.

In the given behaviour, notice that initially, for a long time, the derivative is almost 0. To capture this behaviour we introduce a difference term in our equation. Thus the equation now becomes:

$$K' = \alpha(K - K1)(1 - \frac{K - K1}{K2}) \tag{2}$$

We have introduced a difference term in the equation. If we set the initial value of K close to K1. Then initially K will grow at a very small rate (close to zero). Eventually, it will start to show logistic behaviour and saturate at a terminal value of K1+ K2. This is precisely what we need. Even here, α represents the steepness of the logistic curve.

2.2 Which of the parameter(s) you have used in your expression when changed would change the time the carrying capacity spends at the lower value K1.

In (2), α not only decides the steepness of the logistic portion, but it also determines the time the carrying capacity spends close to the minimum value. This is because to start displaying the sigmoid behaviour, the difference term needs to be significant enough. This depends on how fast K increases. Thus for larger values of α, as K will increase faster, the difference term will grow faster, hence the time spent at the lower value will therefore decrease.

Now attempt to produce a gure similar to Fig. 2. What is the initial condition and why?

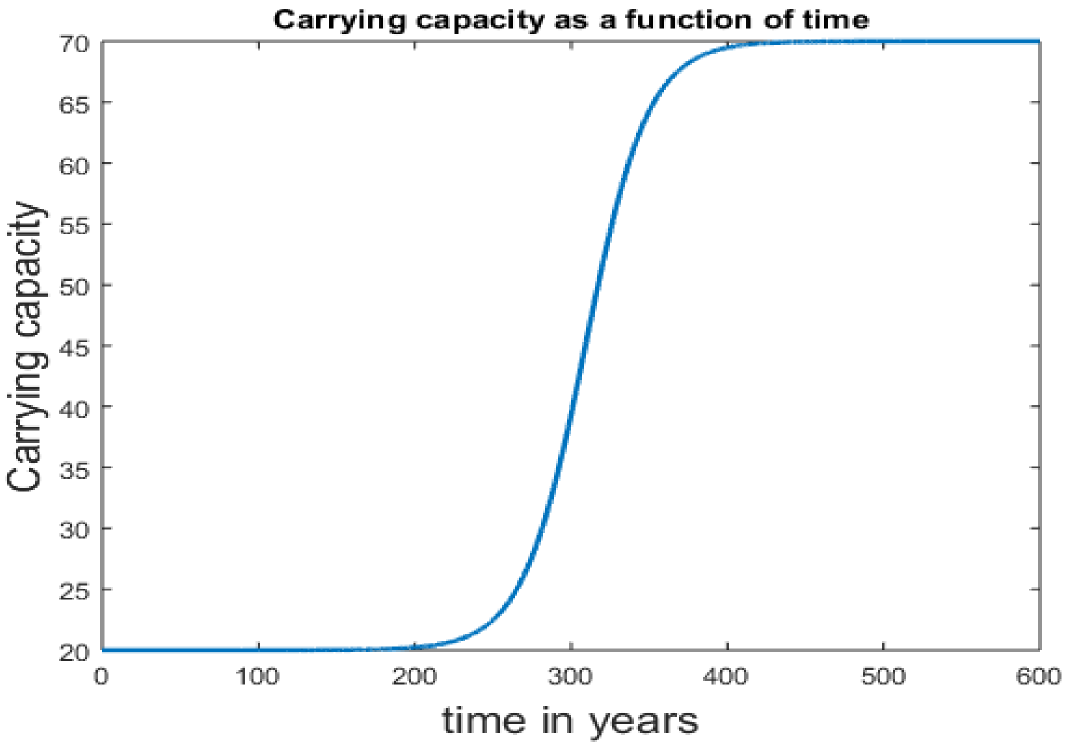

Figure 9: Dynamic carrying capacity vs time

We want the carrying capacity to be close to the initial value for some time. To achieve this, keep the initial carrying capacity very close to K1=20. So for a long time, the difference of K(t)-K1 will be small and hence K' will be close to zero during this time period. Once, the difference attains a sizeable value then the sigmoid behaviour is observed.

2.3 Now solve using reasonable values from part 2.2 above

what according to you should be a reasonable value of α.

If you think that α can take any positive value then taking a range of values comment on the dierent behaviors observed.

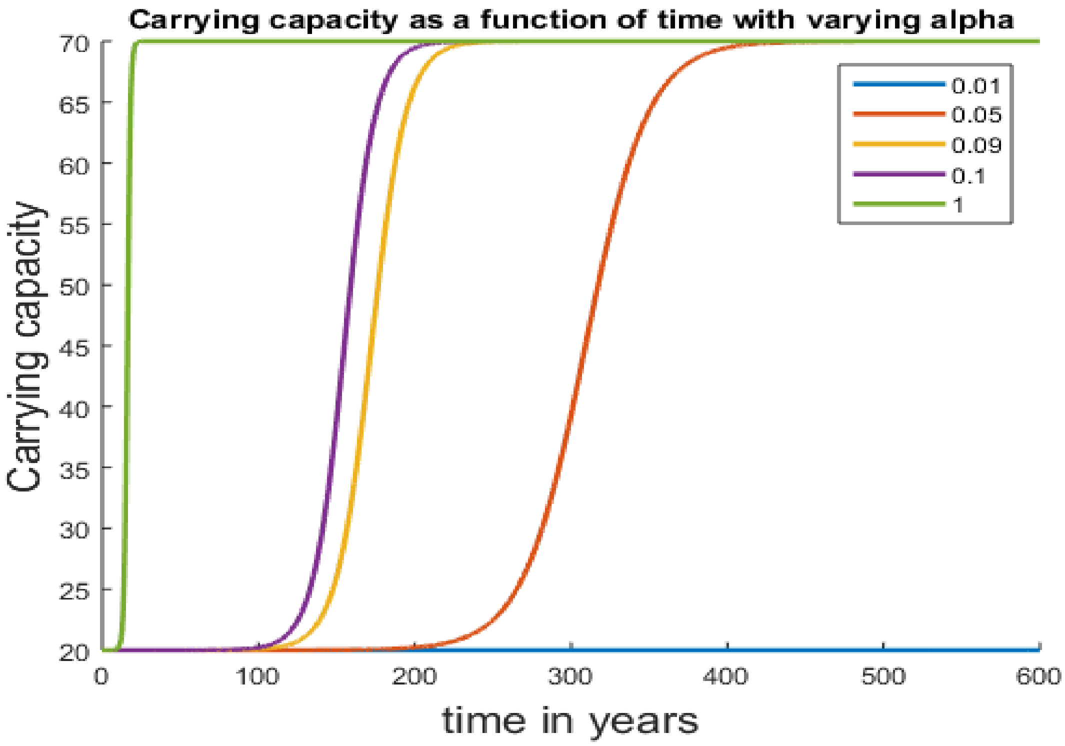

Figure 10: Dynamic carrying capacity vs time

Carrying capacity of a population should increase gradually at a reasonable pace. From the plot, we clearly see that for larger values of α the time spent at the initial condition is less and the steepness of the sigmoid increases.

Here values 0.01 and 1 are quite extreme. For 0.01, the increase in carrying capacity is too small while it is too drastic in case of α equal to 1. Hence, values between 0 and 1 seem reasonable depending on how fast the technology spread happens.

2.4 Compare and contrast the current case with the situation in which the carrying capacity is a constant.

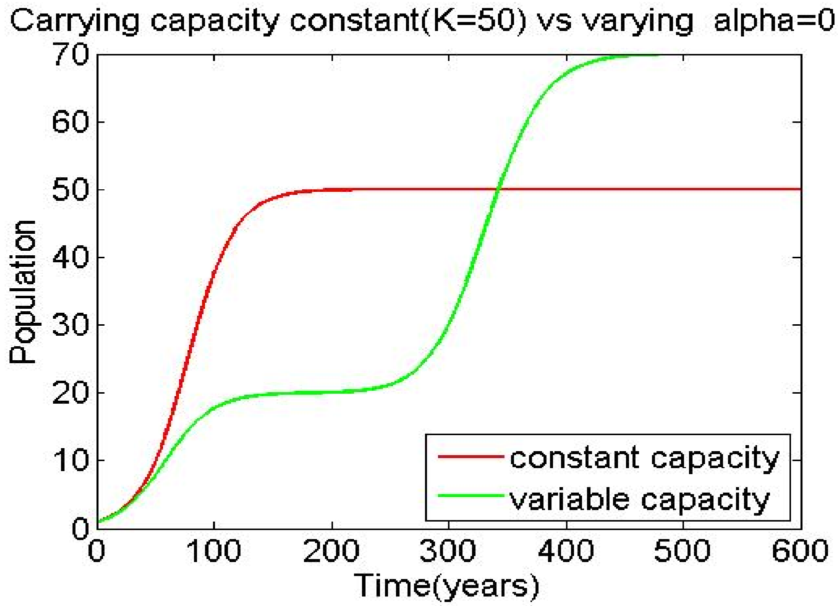

Figure 11: Carrying Capacity - Constant vs Varying

In the above graph, we have compared the case of constant carrying capacity with the case of variable carrying capacity (Ref. Figure 9).

The red graph shows the change in population when the carrying capacity is constant at K = 50. Initially the population is very small and it eventually saturates to 50.

In the green graph, we can see that the population changes based on the changes in the carrying capacity. Initially, the population saturates to K1=20 which is the carrying capacity in the earlier stages. But when the carrying capacity starts increasing, say due to technological advancement, the actual population also starts increasing since the environment can support that much population. The population finally saturates at the new carrying capacity which is K1+K2=70.