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EAS 550/STRATEGY 566: Systems Thinking for Sustainable Development and Enterprise

Individual Homework 3: Phone sales

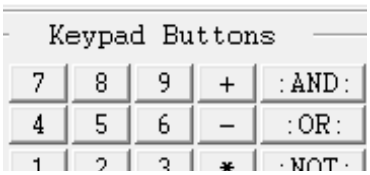
Introduction: The electronics store in town is about to start the sale of a newly released phone. Because of the sales records of previous generations of this phone brand on launch, the owner is concerned about the initial stock of phones in their store. The planned initial stock is 500 units.

Demand: Theoretically the daily sales would be limited by the stock in store because obviously it can't sell more than what it has in stock, but the electronics store will take orders and people will wait for their phones even if they don't have enough stock that particular day. The projected daily demand is determined by the number of days since launch, meaning the initial demand would be 100/day and gradually lowered to 45/day in 900 days.

Time (days)	demand (units/day)
0	100
15	100
20	80
30	65
40	55
50	50
60	48
100	45
900	45

Supply: The store will receive supply from the factory on a daily basis. For the first 15 days, the shipment from the factory is fixed at 40 units/day. Later the supply will be calculated based on the following conditions:

1. When the stock is lower than 300 units, the daily order from the factory will be 1.2 times the daily demand.
2. When the stock is between 300 and 500 units, the daily order from the factory will be 1.1 times the daily demand.
    a. **Tip:** When creating an IF THEN ELSE statement, if a variable should fall between two values, you should write: VALUE 1 <= VARIABLE *:AND:* VARIABLE >= VALUE 2
    b. :AND: can be found under "Keypad Buttons" in the equation editor for any variable



3. When the stock is higher than 500 units, the daily order from the factory will be 0.95 times of the daily demand

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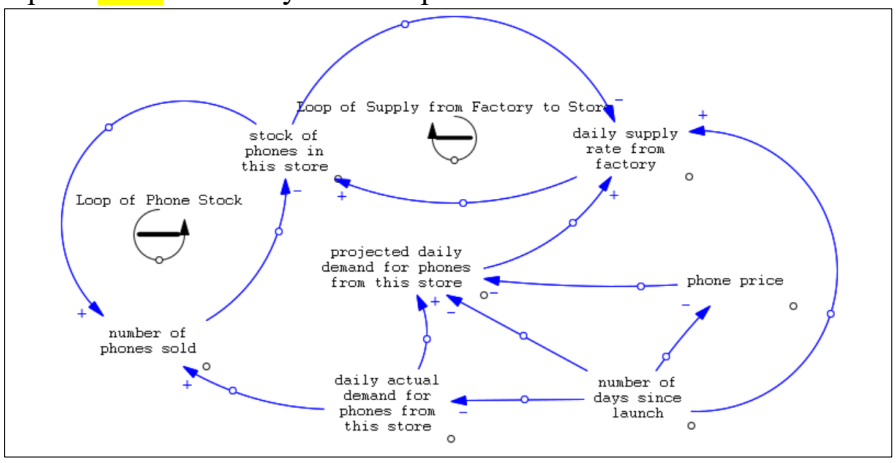
Questions:

1) State the specific problem being addressed by modeling this scenario.
By modeling this scenario, we are able to confirm the sufficient number of initial stock that will not result in shortage, even though customers are able to wait for a few days to get their new phones.

2) Formulate a dynamic hypothesis. What is your theory for the behavior of this system?
Without further information about the phone's brand, features, marketing strategies, store location, selling venues, etc., I try to build a model as simple as possible so that further steps are allowed.
When the phone is newly launched, its demand will reach its peak because people are thrilled to be cool/show off with the new phone as their accessory. While time goes on, the number of days since the phone is launched increases, and both the estimated demand and the actual demand decrease. Phone price is also a critical factor to the projected daily demand for phones. I define this phone as a "necessity" instead of a "luxury," although it may be unnecessarily expensive because of the additional economic values added to it, because modern people live on phones. As the price of the phone enhances, less demand is seen, according to the law of supply and demand.
The store's staff members estimate daily demand for the phone and communicate with the factory about the number of daily supply they require. The factory is committed to provide the exact number of phones requested by the store; thus, as the projected daily demand increases, the daily supply rate from the factory to the store will also increase. The staff cohort is willing to make accurate estimation on daily demand of the phone to maximize their benefits. So they record the actual daily demand for the phone, and adjust their estimation day by day using different estimation models. This generates the positive relationship from the actual demand to the projected demand.
The actual numbers of demand and supply compose the number of phones sold at this store. When the demand goes higher, the number sold increases. When there are more phones stocked at the store, the ability of the store to sell phones also increases. However, more phones being sold indicate less stock in the storage.

3) Sketch a quick CLD for this system and paste below.



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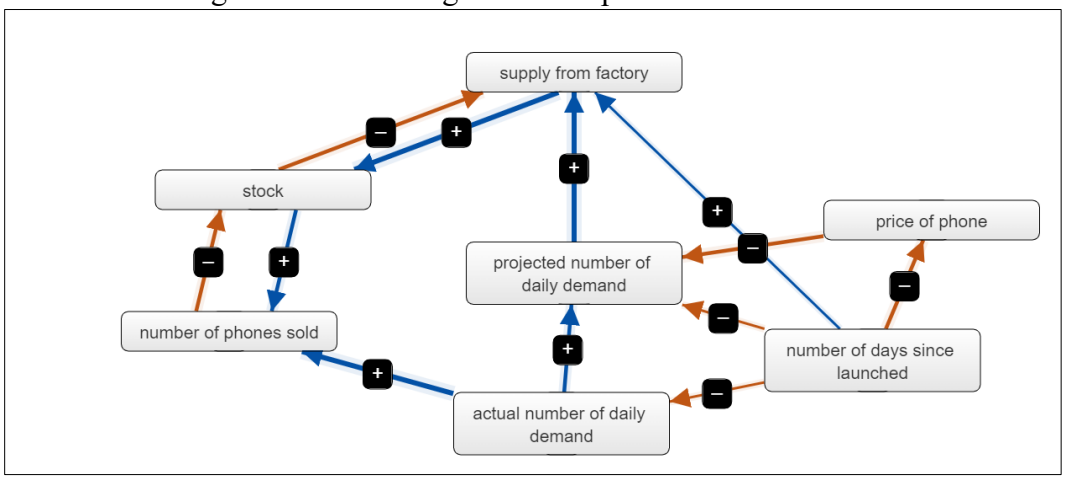
The causal loop diagram is drafted as the image above. There are two loops in this CLD: 1) a loop of phone stock in this store; and 2) a loop of supply between the factory and this store.

4) Made a fuzzy cognitive map of the system, using your CLD as the basis for the concepts and connections. Use your intuition and understanding of the system to estimate connection strengths. Paste an image of the map below.



I utilized four values for the strengths: 0.25 for the weakest, 0.5 for medium relationship, 0.75 for stronger connections, and 0.9 for the strongest.
Number of days since the phone is launched has the weakest connections to both projected number of daily demand and actual number of daily demand because I assume the phone is a necessity to customers. This also causes the medium connection from the price to the projected number of daily demand. The weak, positive connection between number of days since the phone is launched and supply quantity from factory is according to the prompts, where $40 < 45 * 0.95$.
However, number of days of launch has a medium, negative relationship with the price because as the demand goes down, the price of the product decreases. This goes align with what is related to Economics. Number of stock at store also has a medium, positive relationship with number of phones sold because it can boost strategies of sales to be applied more than ever, but is not the most decisive factor in terms of increasing purchasing.
On the contrary, number of phones sold effects number of stock greatly, and thus they share a stronger, negative relationship. Number of stock then effects the quantity factory supplies for the store, and they have a medium, negative relationship. Estimations come with bias or error sometimes, so the relationship between the actual number of daily demand and the projected number is mediumly positive.
As stated, the factory is committed to provide the exact amount of what the store requests; thus, the relationship between them is the strongest and is positive.
Quantity supplied from the factory is decisive of the number of stocked phones at store, so they share strongest, positive connection, and so does number of the actual daily demand to the phone.

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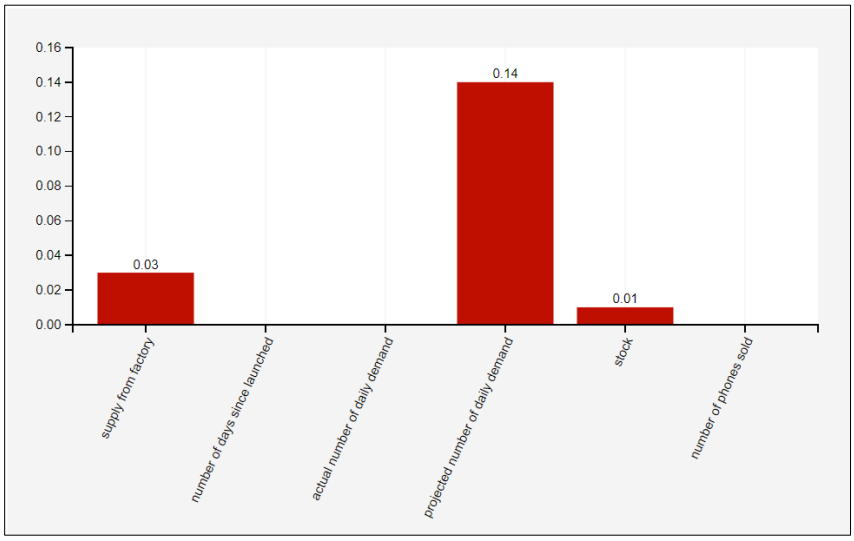
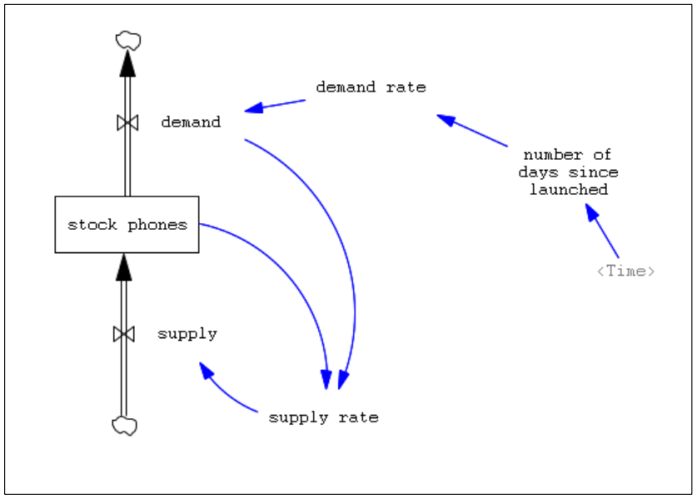
5) Run a scenario where you "push" sales (or an equivalent concept in your map). Paste an image of the graph below and discuss the outcomes – was it similar to your dynamic hypothesis? Why or why not?

Under my model, pushing sales can be equivalent to reducing the price of the phone. Since "hyperbolic tangent" has constantly stopped working on my device, I've turned to utilize "sigmoid" per Carissa's suggestion.



The outcomes are similar to my dynamic hypothesis—when the price of the phone decreases, the projected number of daily demand will increase. The store will then request for more supply from the factory and thus the number supplied will also increase. Lastly, the stock will increase according to the increase of supply. One slight difference between the output and my assumption is that the actual number of daily demand and number of phones sold should also increase, but they remain unchanged in the result above. This may be due to the delay that exists in this dynamic supply and demand system. If the FCM is able to present time sequence, the results may go align with my assumption.

6) Next, translate your CLD into a stock and flow diagram and paste in an image of the diagram.



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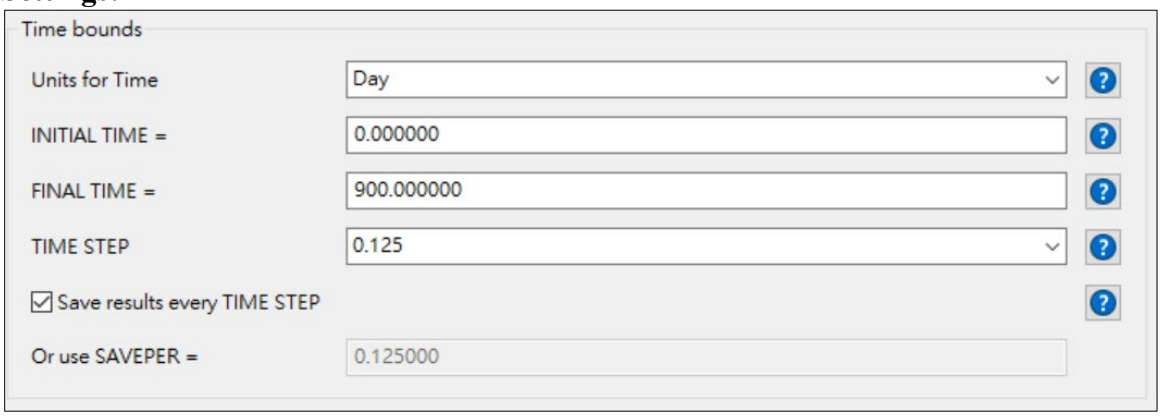
7) Can the supply meet the demand? **Justify your answer by providing relevant model simulation results below (provide the *equations* for everything in your model, *necessary graphs*, and *written words that answer this question*)**. (Tips: To include the current time of simulation in your model, establish a "<time>" variable by clicking "Shadow Variable" → "Time".) The simulation should be for 900 days, with a time step of 0.125.

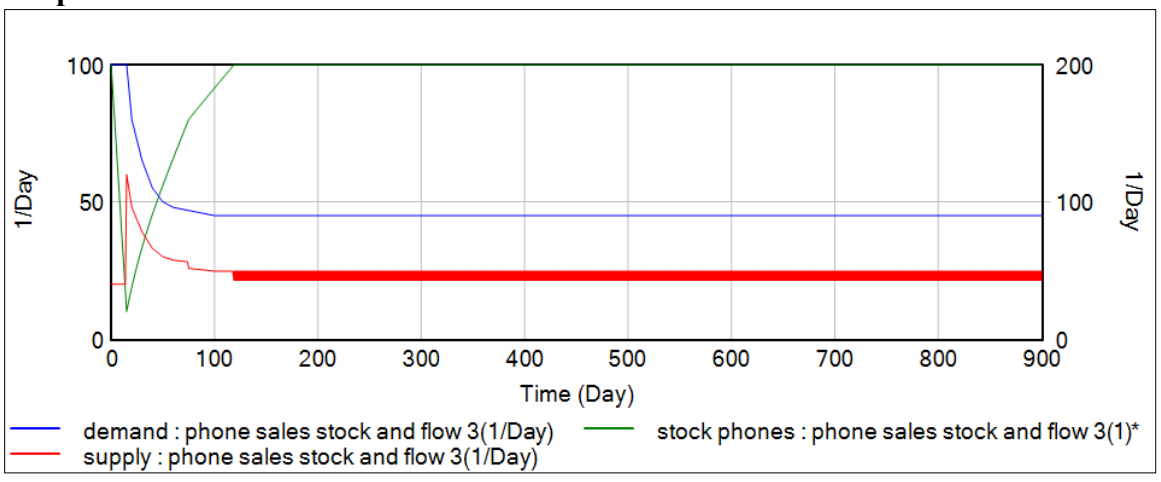
Settings:



Equations:

- **Time: shadow variable**
- **Number of days since launched: Time (unit: Day)**
- **Demand rate: number of days since launched with LOOKUP([(0,0)-(10,10)],(0,100),(15,100),(20,80),(30,65),(40,55),(50,50),(60,48),(100,45),(900,45)) (unit: 1/Day)**
- **Demand: demand rate (unit: 1/Day)**
- **Supply rate: 40*PULSE(0, 15)+IF THEN ELSE(stock phones < 300, 1.2*demand, IF THEN ELSE(500 >= stock phones :AND: 300 <= stock phones, 1.1*demand, 0.95*demand))*PULSE(15, 900-15+1) (unit: 1/Day)**
- **Supply: supply rate (unit: 1/Day)**
- **Stock phones: supply-demand with INITIAL VALUE at 500 (unit: 1)**

Graphs:



The supply was not able to meet the demand for the first 15 days, where the gap between the demand and the supply was constant at $40 - 100 = -60$. Thus, the stock phones kept decreasing and the greatest shortage was -400 on the 15th day.

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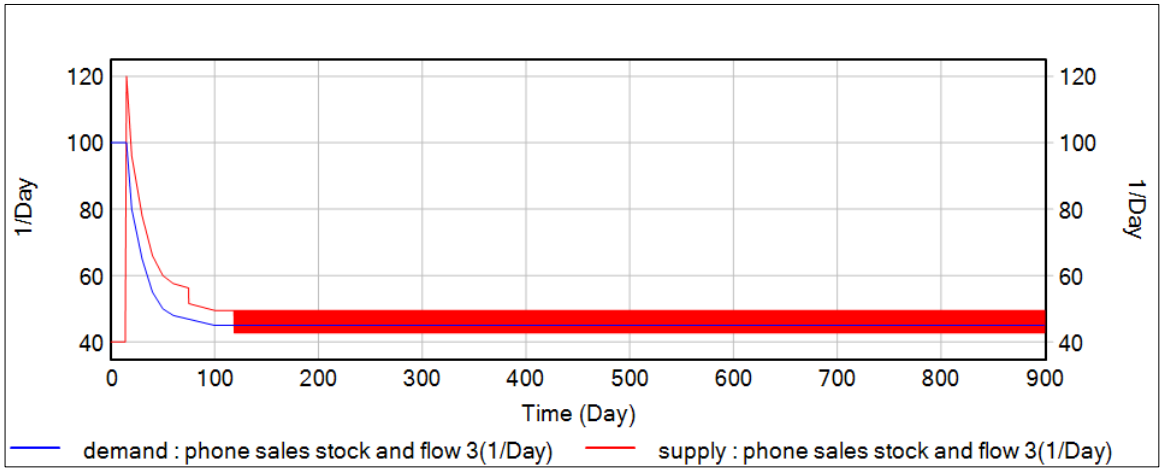
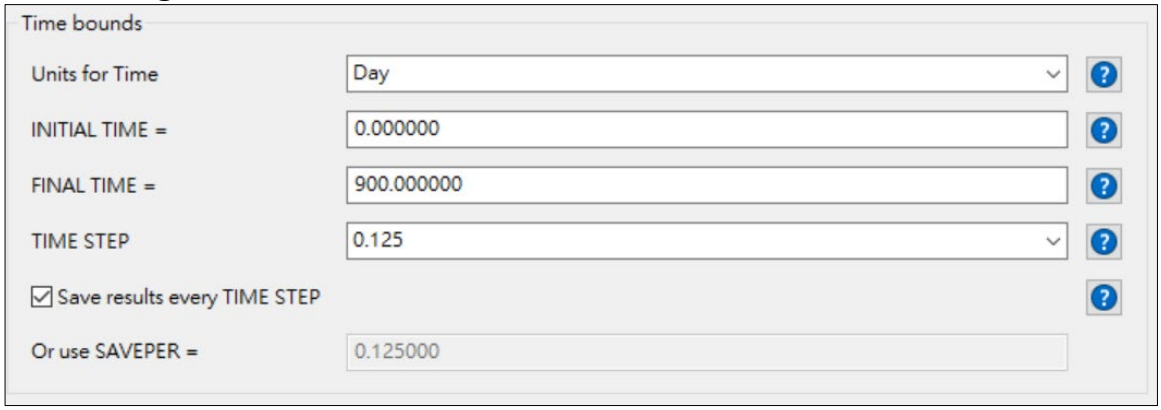


I adjusted the scales of both demand and supply to be the same to read more easily. Starting from the 15th day, the supply grew greatly and exceeded the demand. The stock increased accordingly and ever since the 118.75th day, the stock has remained constant with slight vibrant between 499.926 and 500.207. The supply has also remained constant with slight vibrant between 42.75 and 49.5 since the same day. It was sometimes lower than the demand when the stock was greater than 500, but was able to provide sufficient number of products to satisfy the demand.

8) What can the owner do to relieve the shortage in the first few days? You may have more than one theory, back each one up using their respective sensitivity analysis. **State your theory (or theories) and provide proof that each one is valid (any model equations that were altered, and subsequent graphs).**
To relieve the shortage in the first 15 days, I have 3 plans that the owner can take while settings remain all the same as:

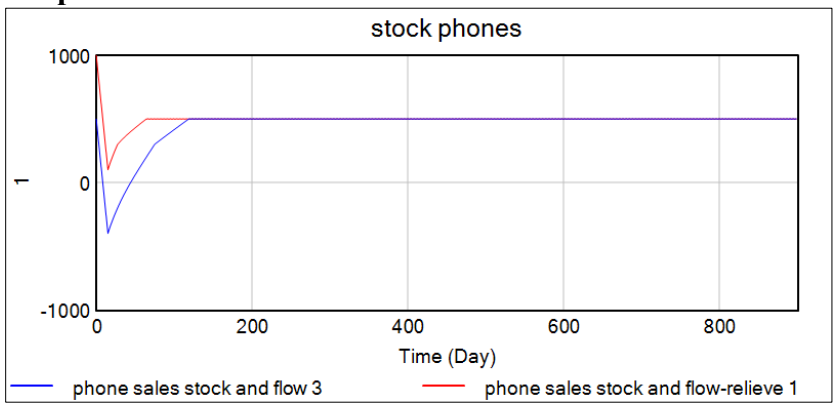


Solutions:

a. **Double the initial value of stock phones to 1,000.**
Since the shortage happened on the 8.375th day, which is approximately half way through the first 15 days, I assume that doubling the initial number of stocks helps.
Equations:
- **Time: shadow variable**
- **Number of days since launched: Time (unit: Day)**

- **Demand rate: number of days since launched with LOOKUP([(0,0)-(10,10)],(0,100),(15,100),(20,80),(30,65),(40,55),(50,50),(60,48),(100,45),(900,45)) (unit: 1/Day)**
- **Demand: demand rate (unit: 1/Day)**
- **Supply rate: 40*PULSE(0, 15)+IF THEN ELSE(stock phones < 300, 1.2*demand, IF THEN ELSE(500 >= stock phones :AND: 300 <= stock phones, 1.1*demand, 0.95*demand))*PULSE(15, 900-15+1) (unit: 1/Day)**
- **Supply: supply rate (unit: 1/Day)**
- **Stock phones: supply-demand with INITIAL VALUE at 1,000 (unit: 1)**

Graph:

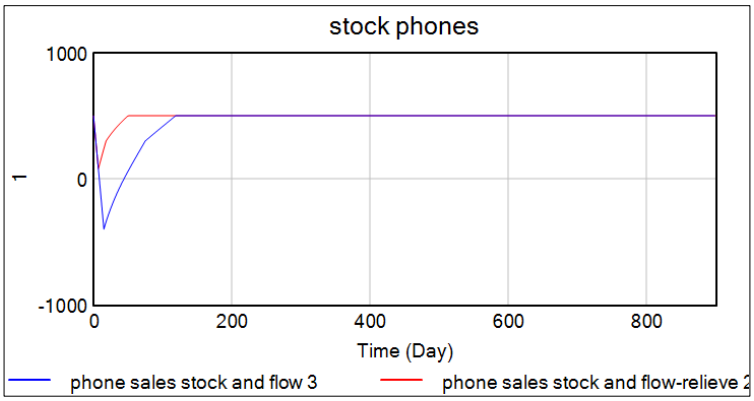


The sensitivity analysis proves that by doubling the initial value of stock phones, there will be no shortage.

b. Shorten the fixed supply days by half.
Since the shortage happened on the 8.375th day, which is approximately half way through the first 15 days, I assume that shortening the fixed supply days by half helps.
Equations:

- **Time: shadow variable**
- **Number of days since launched: Time (unit: Day)**
- **Demand rate: number of days since launched with LOOKUP([(0,0)-(10,10)],(0,100),(15,100),(20,80),(30,65),(40,55),(50,50),(60,48),(100,45),(900,45)) (unit: 1/Day)**
- **Demand: demand rate (unit: 1/Day)**
- **Supply rate: 40*PULSE(0, 7)+IF THEN ELSE(stock phones < 300, 1.2*demand, IF THEN ELSE(500 >= stock phones :AND: 300 <= stock phones, 1.1*demand, 0.95*demand))*PULSE(7, 900-7+1) (unit: 1/Day)**
- **Supply: supply rate (unit: 1/Day)**
- **Stock phones: supply-demand with INITIAL VALUE at 500 (unit: 1)**

Graph:

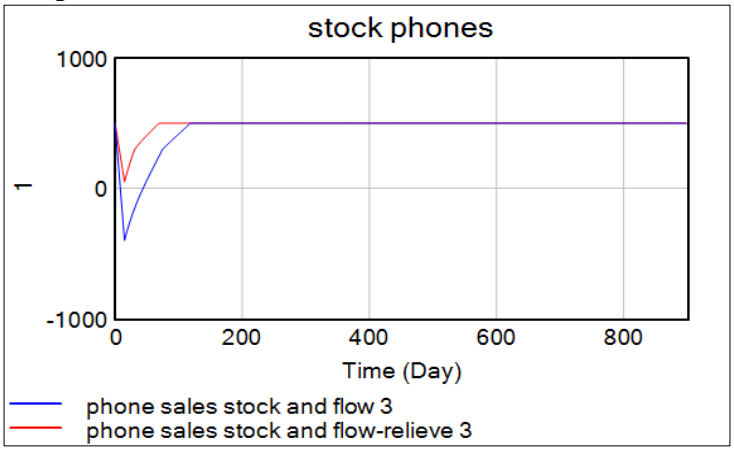


The sensitivity analysis proves that by shortening the fixed supply days by half, there will be no shortage.

c. **Multiply the fixed supply quantity by 1.75.**
Since the shortage happened approximately half way through the first 15 days, indicating that the accumulative gaps between the supply and the demand is overwhelming, I assume that increasing the fixed supply quantity helps.
Equations:

- **Time: shadow variable**
- **Number of days since launched: Time (unit: Day)**
- **Demand rate: number of days since launched with LOOKUP([(0,0)-(10,10)],(0,100),(15,100),(20,80),(30,65),(40,55),(50,50),(60,48),(100,45),(900,45)) (unit: 1/Day)**
- **Demand: demand rate (unit: 1/Day)**
- **Supply rate: 70*PULSE(0, 15)+IF THEN ELSE(stock phones < 300, 1.2*demand, IF THEN ELSE(500 >= stock phones :AND: 300 <= stock phones, 1.1*demand, 0.95*demand))*PULSE(15, 900-15+1) (unit: 1/Day)**
- **Supply: supply rate (unit: 1/Day)**
- **Stock phones: supply-demand with INITIAL VALUE at 500 (unit: 1)**

Graph:



The sensitivity analysis proves that by multiplying the fixed supply quantity by 1.75, there will be no shortage.