Suez canal obstruction causing Supply chain issue in Europe demonstration using SIR model

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Abstract

We come across numerous complicated systems in daily life where people are interacting with one another, such as the stock market or rush hour traffic. We may be able to better comprehend these complex systems' dynamics and mimic their behaviour under varying settings by developing suitable models for them. Using agent-based models, which explicitly simulate people and their interactions rather than assuming the dynamics of the system as a whole, is one method for modelling complex systems.
In this report, we'll attempt to apply the SIR model to scenarios involving interconnected systems and things that spread like epidemics.

1. Introduction to the problem

Suez Canal is one of the world's most important trading route. Everyday approximately 50 ships travels through the canal, which consist of about 15% of total global trade. On 23 March 2021, vessel(ship) named **"Ever Given"** stuck in canal causing around 300 ships to stuck (50 ships x 6 days) around the canal.
For each day canal was closed; vessels were not delivering food, fuel and manufactured goods to Europe and goods are not being exported from Europe to the Far East. This resulted in delayed shipping around the world, rise in prices of everyday items.

1.1. Motivation

We sought to apply the SIR model to the issue and determine when the Suez canal will experience its peak congestion as well as the effects it will have on the European supply chain.
Economic Impact – Rises in prices:

- Incident resulted in shipping delays of everyday items for customers around the world.
- Value of goods delayed each hour was US$400 millions.
- To clear the obstruction; it would require another US$9 billions worth of goods.

Knock-on-delays:

- There were delays of delivery of the items causing shortages(like semiconductor shortages); this also caused some of the industries to close their businesses.

Livestock's:

- Lot of sheep's and other livestock's was stuck and due to not providing enough food; there were fatalities.

1.2. State of current literature

As there was no study that could be obtained online, we chose to focus on the interconnected systems problem that contains events like the Suez canal obstruction which mimics like epidemics.

2. Methodology

We applied SIR model for 2 things in this problem:

1. SIR model to implement vessel movement across the Suez canal.
   - (S) Susceptible – vessels which many result in non-movement
   - (I) Infected – vessels not traveling
   - (R) Recovered – vessels traveling again
2. SIR model to showcase stock (of everyday items) impacted and prices impacted due to this event.
   - (S) Susceptible – stock of items may impact
   - (I) Infected – stocks impacted
   - (R) Recovered – stocks are back in normal state

2.1. Model

We created two distinct models and linked them based on a few criteria that reflect how they interact in real life.

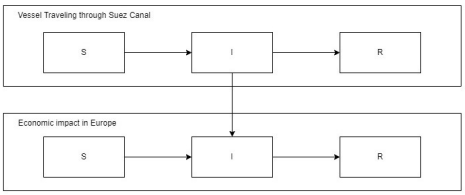

Figure 1. Interconnected systems

2.2. Algorithm

1. There are 2 sub SIR models. 1 for vessel movement and 1 for health of stock of everyday items.

2. As and when disruption occurs in 1 driving model(which manages movement of vessels across the Suez canal) causing effect like epidemic event triggers which causes disruption in other model.

3. Other model then have epidemic like behaviour unless there is another trigger that clears impact.

2.3. Equations

$$\frac{\partial S}{\partial t} = -\beta SI$$

$$\frac{\partial I}{\partial t} = \beta SI - \gamma I$$

$$\frac{\partial R}{\partial t} = \gamma I$$

where,

S = Susceptible population
I = Infected population
R = Recovered population
β = Rate of Infection
γ = Rate of Recovery

3. Results and discussion

Vessels typically travel 9 days to reach locations in Europe from Suez Canal. Additionally, a boat travels around the canal in about 10 to 12 hours. Considering both conditions, we linked up the models.

3.1. Results without constraints

If use the model without any additional constraints we found below results:
In Figure 2 (Below), we can see that vessels stopped moving(recovered stage) after certain period of 1 vessel stuck in the canal. Although there is no movement within canal; there were lot of vessels reaching to the both ends of the canal and queuing for the pass through.

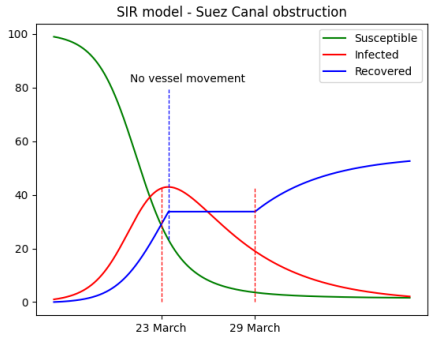

Figure 2. Vessel movement

In Figure 3 (Below), we can see that stocks started to get impacted from 1st April as it takes around 9 days from the Suez canal to the ports.

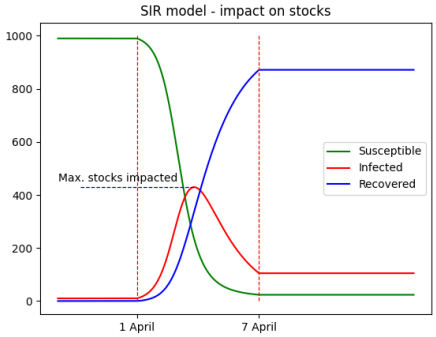

Figure 3. Impact on stock

3.2. Results with constraints

In this section, we considered additional constraints of queued vessels causing delay in pass through the canal, which will last additionally for the days canal was closed. Considering canal was closed for 6 days, there will be delay of additional 6 days to clear traffic congestion around the canal.
In Figure 4 (Below), we can see that vessels stopped moving(recovered stage) after certain period of 1 vessel stuck in the canal. Although there is no movement within canal;

there were lot of vessels reaching to the both ends of the canal and queuing for the pass through. As there is both way traffic and no passage through canal, rate of infection will double also as there will be no recovery in that period. Rate of recovery will be halved for next period until congestion is over.

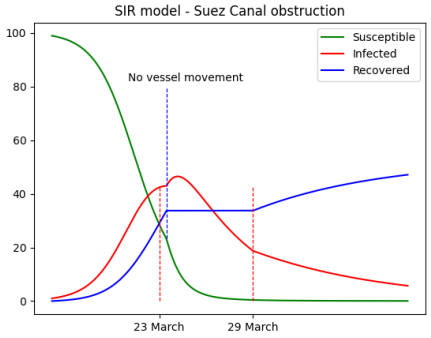

Figure 4. Vessel movement

In Figure 5 (Below), we can see that stocks started to get impacted from 1st April as it takes around 9 days from the Suez canal to the ports.
Also, once around 7 April, when everything is back to normal, there wont be any susceptible stocks anymore and rate of recovery will still be impacted by the fact that there is traffic congestion at the canal.

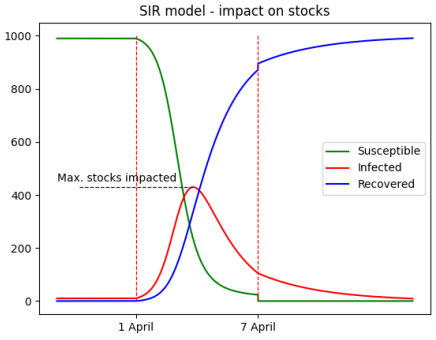

Figure 5. Impact on stock

4. Conclusion

Although not a real epidemic, which has a greater impact on daily life, these little incidents can have a significant economic impact that lasts for a longer time.
We never would have imagined that an occurrence of this magnitude might result in problems with billions of dollars on the line.
Being a transportation system, the canal is constantly being used by vessels. Traffic jams at the Suez Canal have a big influence on the economy since it saves a lot of fuel and time for travel from Asia to Europe and the Americas. It is well known that billions of dollars would be lost if the canal were to be closed. Better mechanical mechanisms ought to be in place to prevent such incidents in the future. In these scenarios, the SIR model may or may not be able to forecast future events. But if these issues are fixed, it may be used to forecast how the economy will perform over the following several days and to prevent inflation.
Even if we treated all of Europe as a single society, the effects of such catastrophes would vary greatly throughout the continent. Different supplies are kept in each nation for such situations.

References

- 2021 Suez Canal obstruction
- Suez Canal blockage is delaying an estimated $400 million an hour in goods