Analysis of Supply Chain Resilience with ABM

Ethan Guo
Northwestern University, Evanston, IL, USA

Abstract

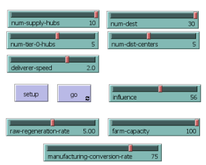
Analyzing resilience and determining points of efficiency regarding resilience and costs is vital for businesses to determine optimal logistics configurations. This study aims to analyze a wide range of system configurations, testing each across simulated environmental stresses with NetLogo Multi-Agent Modeling. Calculated results suggest a correlation of moderate strength between the number of network nodes in a given system and resiliency values adjusted for system output, with a corresponding p-value of 2.845e-10 for linear regression slope, suggesting a statistically significant difference between the slope and 0. However, it should be noted that the data suggest there is no linear correlation between number of network nodes and raw resiliency.

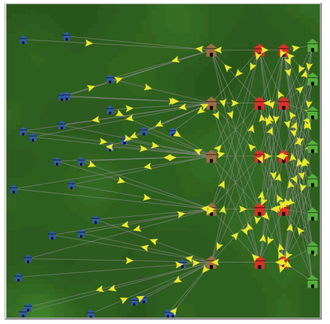
Model & Rules

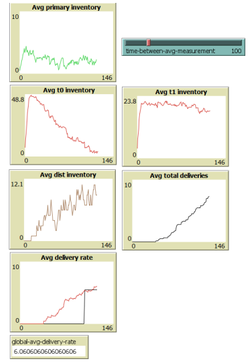
Agents utilized in this model consist of primary producers, manufacturing centers, distribution centers, destinations, and deliverers. Each contributes one tier to the overall supply chain structure, creating a simulated, simplified view of a real world supply chain model. To simulate external influence, traversability values are assigned to each patch and diffused according to Gaussian Diffusion. At each time step, deliverers travel and manufacturers process products according to the traversability on the patch they are on.

$$\text{Processing Efficiency} = (1 - \frac{\textbf{influence}}{100})^2 * \frac{\textbf{manufacturing-rate} * \textbf{traversability}}{1.5}$$

$$\text{Speed} = \frac{\textbf{deliverer-speed} * \textbf{traversability}}{1.5}$$





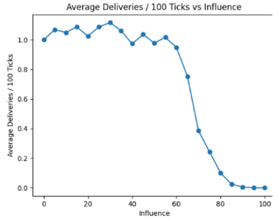


Configuration Scoring Methodology

The primary 2 metrics used consist of an unweighted (A(f(x)), and weighted (W(f(x)) resilience score calculated given the delivery graphs generated from BehaviorSpace.

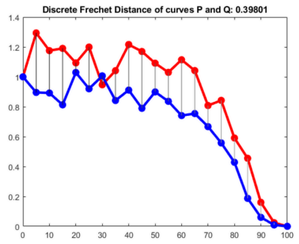
$$A(f(x)) = \int_0^{100} f(x)dx \approx \sum_{k=1}^{21} \frac{f(x_{k-1}) + f(x_k)}{2} * 5$$

$$W(f(x)) = \sum_{k=1}^{21} \frac{f(x_{k-1}) + f(x_k)}{2} * 5 + 25 * \ln(x_1)_0$$



The metric used to compare two different graphs is Fréchet Distance, given by F(A,B) below.

$$F(A, B) = \inf_{\alpha,\beta} \max_{t\in[0,1]} \{d(A(\alpha(t)), B(\beta(t)))\}$$



Results

Results were tabulated into a scatterplot for 50 system configurations pared down from the 450 possible, and conducting linear and polynomial regression analysis.