

COVID-19 Resource Allocation

Given the shortage of materials in
the COVID-19 situation, we
wanted to focus on how to
allocate limited resources

motivation

description

formulation

demonstration

KEY QUESTION

How can we best allocate a limited number of ventilators to the 48 mainland states?

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CONSIDERATIONS

weekly cases

Weekly new cases recorded for the last 8 weeks : Feb 26 - April 26

production

5 factories produce a given number of ventilators per week: NJ, MS, NE, CA, OH

fairness

Each state needs to have X percent of their need met at any given time

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Decision Variables

X_{ij} – # ventilators to send from state i to state j
 y_k – # ventilators to produce from state (factory) k

Data

C_k – production capacity of factory k
 CO_k – cost of production per ventilator for factory k
 CT_{ij} – cost of transporting one ventilator from state i to j
 d_i – projected demand for ventilators in state i next week
 v_i – existing # of ventilators from previous week (base = 0)

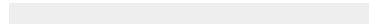
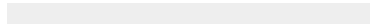
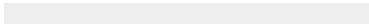
Pre-determined: f – fairness parameter (default: 0.5)

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FOR EACH WEEK:

$$\min \sum_{k=1}^5 \overbrace{CO_k}^{\text{Production Costs}} * y_k + \sum_{i \neq j} \overbrace{X_{ij} * CT_{ij}}^{\text{Transportation Costs}}$$

s.t.

Non-producing
States:

$$v_i - \sum_{\substack{j=1 \\ j \neq i}}^{48} X_{ij} + \sum_{\substack{j=1 \\ j \neq i}}^{48} X_{ji} \geq f * d_i \quad \forall i \notin k$$

States with
Factories:

$$v_i - \sum_{\substack{j=1 \\ j \neq i}}^{48} X_{ij} + \sum_{\substack{j=1 \\ j \neq i}}^{48} X_{ji} + y_i \geq f * d_i \quad \forall i \in k$$

Number of ventilators in
state i must at least be
meet a percentage of its
demand

Surplus: how
many ventilators
sent out of state i

Shortage: how
many ventilators
coming into state i

$$X_{ij}, y_k \geq 0 \quad \forall i, j, k$$

Update for Next Week:

$$v_{i, \text{next week}} = v_i - \sum_{\substack{j=1 \\ j \neq i}}^{48} X_{ij} + \sum_{\substack{i=1 \\ j \neq i}}^{48} X_{ij} + y_i$$

Only if state i has a factory

FINDINGS

Takeaways

- Keeping up with exponential growth is hard--requires informed policies
- Collecting/estimating accurate data for large-scale problems is challenging

Model Improvements

- Integer programming
- More robust production capacity model

Extensions

- Different political philosophy (federalist vs. decentralized)
- Different moral philosophies (fairness parameter)