Resilient NdFeB magnet recycling under the impacts of COVID-19 pandemic: Stochastic programming and Benders decomposition

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NdFeB Magnet Industry

World: Applications for NdFeB permanent magnets (Source: Roskill)
Research Motivation

• Highly vulnerable to supply disruption

Figure: Global REE production, USGS (2019)

• Magnet-to-magnet recycling inside USA is a solution

World: NdFeB magnet production by region, 2005 to 2020 (kt)
Research Goals

• Designing a reverse logistics network for NdFeB recycling in USA

• Making the supply chain resilient to large-scale disruptions through inventory management
Methodology

• Modeling scenarios for large-scale disruption and uncertain recovery

• Developing a chance constraint two-stage stochastic (CTSP) model for optimal decision making
• Applying Benders decomposition method to solve the model
Case Study

- **Problem Size:**
  - 48 Collection centers
  - 6 candidate locations for dismantling
  - 5 potential locations for recycling
  - 6 sales points
  - Five years of planning horizon

- **CTSP vs Deterministic**

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<thead>
<tr>
<th></th>
<th>CTSP</th>
<th>Deterministic</th>
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<tbody>
<tr>
<td>Risk Tolerance</td>
<td>7%</td>
<td>100%</td>
</tr>
<tr>
<td>Profit</td>
<td>$165M</td>
<td>$168M</td>
</tr>
<tr>
<td>Shortage (%)</td>
<td>0.28</td>
<td>2.56</td>
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Key Insights

HIGH FACILITY SETUP COST (63% OF TOTAL COST)

LOW INVENTORY HOLDING COST (0.31% OF TOTAL COST)

HIGH RESILIENCY (0.28% SHORTAGE)
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