Accenture - MIT Capstone Project

Empowering Supply Chain through AI Driven Supplier Indexing and Recommendation
Motivation: the Empty Shelf Problem
Behind the Empty Shelf: A Vulnerable Supply Chain

Our project focuses on tackling the first two problems, and the 3rd problem will continue to be explored by Accenture in the future.

1. Limited understanding of the industry supply chain
   
   Solution: An indexing method for measuring the relative importance of each supplier in a supply chain

2. Suboptimal supplier selection
   
   Solution: A recommendation algorithm for recommending the optimal suppliers based on the client company’s specific needs

3. Lack of end-to-end visibility
   
   Solution: A simulation model that simulates how the supply chain may evolve in the future
**Dataset Overview**

- **FactSet Supply Chain Relationships Dataset**
  - Contains pairwise supplier-customer relationships info

- **FactSet Relevance Rank Dataset**
  - Contains the grade and ranking that FactSet assigns to the supplier/customer in each customer-supplier relationship

- **Arabesque Dataset**
  - Contains company-level sustainability info covering aspects like emission, diversity, and human rights

<table>
<thead>
<tr>
<th><strong>Pilot Industry: Mining and Mineral</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers to</td>
</tr>
<tr>
<td>Companies in Mining and Mineral</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Companies in Metals and Mining</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>4065</strong>*</td>
</tr>
<tr>
<td>Reported Relationships</td>
</tr>
<tr>
<td><strong>538</strong></td>
</tr>
<tr>
<td>Unique Companies</td>
</tr>
<tr>
<td><strong>2052</strong></td>
</tr>
<tr>
<td>Unique Suppliers</td>
</tr>
<tr>
<td><strong>74</strong></td>
</tr>
<tr>
<td>Unique Countries</td>
</tr>
</tbody>
</table>

* Numbers displayed are from the cleaned dataset used to train the RecSys in Phase 2. The numbers may differ for the indexing creation stage as we used slightly different filtering requirements.
**Phase 1: Supplier Indexing**

**Objective:** Obtain a relative importance score for each supplier in the entire industry's supply chain.

1. **Uniqueness**
2. **Ranking**
3. **Centrality Measures**

- **Obtain Raw Metrics**
- **Metric Normalization:** Normalize each metric to a scale of 0 to 100 so that no single metric can dominate the overall score.
- **Node-level Aggregation:** Obtain a single indexing score from weighted average of all metrics.
- **Non-linear Transformation:** Emphasize or de-emphasize the variation in node-level indexing scores if necessary.
- **Index Normalization:** Normalize the node-level scores to a scale of 0 to 100 for better interpretability.
Supplier Indexing Results

Below are the suppliers with the TOP 10 highest overall importance scores in Mining and Mineral:

1. Franco- Nevada Corp (100)
2. Pennar Industries Ltd. (98)
3. Sand-Storm Gold Ltd. (92)
4. KCP Ltd. (76)
5. Assa Albloy AB (85)
6. ArcelorMittal SA (84)
7. POSCO. (74)
8. Prism Johnson (73)
9. ALROSA PJSC (63)
10. TOCALO CO., Ltd. (84)
Phase 2: Supplier Recommendation

**Objective:** Recommend high-quality suppliers for the client company based on industry patterns and client-specific needs

- **Inspiration: Movie recommendation**
  - Recommend movies to users based on users’ rating history
  - Ex. “People like you have also watched…”

- **Main Challenge: No Explicit Ratings**
  - Need to create an index that is representative of a company’s rating for a particular partnership

<table>
<thead>
<tr>
<th></th>
<th>$\text{Supplier}_1$</th>
<th>$\text{Supplier}_2$</th>
<th>$\text{Supplier}_3$</th>
<th>$\text{Supplier}_4$</th>
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</thead>
<tbody>
<tr>
<td>$\text{Comp}_1$</td>
<td>3</td>
<td>?</td>
<td>9</td>
<td>?</td>
</tr>
<tr>
<td>$\text{Comp}_2$</td>
<td>7</td>
<td>8</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>$\text{Comp}_3$</td>
<td>?(^\uparrow)</td>
<td>9(^\downarrow)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>$\text{Comp}_4$</td>
<td>?</td>
<td>?</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

It’s very likely that company 3 will give high rating for supplier 1 and low rating to supplier 3 given its similarity with company 2.
Phase 2: Supplier Recommendation (Cont’d)

Company Segmentation
We want to understand the strategic behavior across companies and identify those sharing common behaviors.
- Macro-level info
- Supply chain network
- Company-specific partnerships

Rating Construction
Company-supplier rating can be computed for each cluster using the following data.
- Supplier-specific info
- Trust in partnership
- Strategic behaviors

Recommendation Algorithm
We use the ratings constructed in step 2 to train a recommendation model via SVD++.

For each company of interest, we can identify the best supplier(s). End-users can customize their recommendation results on a Web-App.
Company Segmentation Results for the Mining and Mineral Industry

- Mostly located in Europe
- High GDP per capita
- Lots of suppliers

- Mostly located in Oceania/South America
- Medium GDP per capita
- Lots of suppliers

- Mostly located in Asia
- Low GDP per capita
- Few suppliers

- Mostly located in North America
- High GDP per capita
- Not so many suppliers
Supplier Recommendation Results

• The recommendation algorithm recommends the best set of potential suppliers
• In addition, the client can customize the recommendation results to better reflect their needs via our Web Interface

I want to identify the TOP 5 suppliers that are in Mining and Mineral and have sustainability scores above 50 in Canada

<table>
<thead>
<tr>
<th>supplier_id</th>
<th>supplier_name</th>
<th>supplier_country</th>
<th>supplier_industry</th>
<th>supplier_sustainability</th>
<th>rating</th>
<th>rounded_rating</th>
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<tbody>
<tr>
<td>06LBVF-E</td>
<td>Lundin Mining Corp.</td>
<td>Canada</td>
<td>Mining and Mineral Products</td>
<td>61.45</td>
<td>6.08</td>
<td>6</td>
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<tr>
<td>06LTWP-E</td>
<td>First Majestic Silver Corp.</td>
<td>Canada</td>
<td>Mining and Mineral Products</td>
<td>73.98</td>
<td>5.57</td>
<td>6</td>
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<tr>
<td>001Y5Z-E</td>
<td>Pan American Silver Corp.</td>
<td>Canada</td>
<td>Mining and Mineral Products</td>
<td>64.67</td>
<td>5.33</td>
<td>5</td>
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<tr>
<td>003P6F-E</td>
<td>Yamana Gold, Inc.</td>
<td>Canada</td>
<td>Mining and Mineral Products</td>
<td>70.37</td>
<td>4.98</td>
<td>5</td>
</tr>
<tr>
<td>05DZGZ-E</td>
<td>Barrick Gold Corp.</td>
<td>Canada</td>
<td>Mining and Mineral Products</td>
<td>65.62</td>
<td>4.95</td>
<td>5</td>
</tr>
</tbody>
</table>

Screenshot of the Web Interface output of the query on the left
Business Impact

21.4% improvement in RMSE compared to the baseline

Expected to save over 21,000 work hours if applied to all companies in Mining and Mineral

Customizable recommendation results from Web Interface

Our pipeline is highly adaptable because the same pipeline can be easily adapted to other industries

Why is this important?

Client Company

- Reduced costs in supplier selection
- Improved supplier quality

General Consumers

- Improved supply chain reliability
- Fewer empty shelf problems
Potential Directions for Future Work

**Short Term:**
- Expand drivers in previous analysis
  - Examples of additional data sources: financial metrics, news articles, alternative sustainability measures (S&P ESG)
- Refine interactive user interface
  - More filtering options, real-time computation

**Long Term:**
- Explore simulation techniques
  - Potential techniques: Monte Carlo, Agent-Based, Digital Twin
Thank you