International Production Planning

David Cheung and Ross Pieper
Advisors: Tim Russell & Jarrod Goentzel
Outline

Company Background
Problem Introduction
Math Model
Results
Additional Uses
Conclusion
Sponsor Company

- Multinational chemical producer
- Subsidiaries and joint ventures in more than 80 countries
- Supplies chemicals to over 190 countries
- Six integrated production sites and 390 other production sites
Agriculture Business Unit

- Produces herbicides, insecticides, fungicides, seed solutions and other specialty solutions
- Project focused on two plants
  - Brazil (Mercosur)
  - Puerto Rico (NAFTA)
  - Plants service customers from 20 countries
How do import customs duties and credits impact global production planning and network design?
Duties

• A form of tax typically on goods imported into a country. Used to promote purchase of goods manufactured within the country.
Duty Credits

A form of duty relief where countries remove or credit back duty charges on goods that meet specific criteria.

- **Drawback**
  - A product is imported transformed then re-exported

- **Subassembly**
  - A product is imported then transformed as part of a subassembly and re-exported

- **Re-import**
  - A product is exported transformed and re-imported
Production Planning

- The high level planning of finished good production and the raw materials needed to make that production.
  - Often uses optimization
  - Subject to capacity constraints
  - Sales forecast is the input that the production plan meets
Sponsor Company Production Plan

- Manually planned
- Simulation used to compare scenarios
- Production, purchasing, duty, and ocean transit costs included
Math Model

• Minimizes total costs
• Incorporates duties and the duty drawback form of duty credits
• Built in excel because the demand data was aggregated by country
• Biggest challenge: building the duty credit constraint
Math Model Objective Function

\[ z = \sum_{i} \sum_{j} \sum_{g} C_{ij} X_{ijg} + \sum_{z} \sum_{n} \sum_{j} E_{znj} Y_{znj} + \]

\[ \sum_{n} \sum_{j} d_{nj} + \sum_{j} \sum_{g} f_{jg} + \]

\[ \sum_{i} \sum_{j} \sum_{g} l_{ijg} X_{ijg} + \sum_{z} \sum_{n} \sum_{j} w_{znj} Y_{znj} - \]

\[ \sum_{z} \sum_{i} \sum_{n} \sum_{j} \sum_{g} c_{zijnjg} \]

Duties

Duty Credits
Math Model Constraints

Effective Duties on Raw Materials Constraint

\[ d_{nj} \geq \sum_z B_{znj} d_{znj} Y_{znj} \quad \forall \ n, j \]
\[ d_{nj} \leq M(1 - T_{nj}) \quad \forall \ n, j \]

Effective Duties on Finished Products Constraint

\[ f_{jg} \geq \sum_i V_{ijg} f_{ijg} X_{ijg} \quad \forall \ j, g \]
\[ f_{jg} \leq M(1 - S_{jg}) \quad \forall \ j, g \]

Effective Duty Credits Constraint

\[ c_{zijnjg} \leq B_{znj} d_{znj} \frac{X_{ijg}}{R_{zij}} \quad \forall \ z, i, n, j, g \]
\[ c_{zijnjg} \leq M(1 - T_{nj}) \quad \forall \ z, i, n, j, g \]
\[ c_{zijnjg} \leq M(1 - S_{jg}) \quad \forall \ z, i, n, j, g \]
Current Production Plan Results

- Puerto Rico volume = 1,182,193 kgs
- Brazil volume = 1,107,331 kgs
- Total Cost = € 200.6 MM
- Duty Costs = € 2.4 MM
- Duty Credits = € 350k
Math Model Results

• Puerto Rico volume = 1,536,923 kgs
• Brazil volume = 752,601 kgs
• Total Cost = € 199 MM
• Duty Costs = € 1.8 MM
• Duty Credits = € 104k
High Duty Cost Scenario (15% Raw Material Duties)

Math Model
- Puerto Rico volume = 2,119,765 kgs
- Brazil volume = 169,759 kgs
- Total Cost = € 206.9 MM
- Duty Costs = € 18.7 MM
- Duty Credits = € 10.6 MM

Original Plan
- Puerto Rico volume = 1,182,193 kgs
- Brazil volume = 1,107,331 kgs
- Total Cost = € 214.5 MM
- Duty Costs = € 20.9 MM
- Duty Credits = € 4.6 MM
Volume Comparison

![Graph showing volume comparison between different scenarios. The original plan and the math model show a lower volume compared to the scenario where all RM Import Duties are 15%.](image)
Financial Comparison

- All RMs Have 15% Import Duties: $206,904,544
- Math Model: $198,958,379
- Original plan: $200,584,159
- Original Plan with 15% RM Duties: $214,481,488
# Duty Comparison

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Original Plan with 15% RM Duties</th>
<th>All RM Have 15% Import Duties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original plan</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duty Costs</td>
<td>2M</td>
<td>Duty Costs</td>
</tr>
<tr>
<td>Duty Credits</td>
<td>0M</td>
<td>Duty Credits</td>
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<tr>
<td>Total Duty</td>
<td>2M</td>
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<tr>
<td><strong>Scenario</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duty Costs</td>
<td>20M</td>
<td>Duty Costs</td>
</tr>
<tr>
<td>Duty Credits</td>
<td>18M</td>
<td>Duty Credits</td>
</tr>
<tr>
<td>Total Duty</td>
<td>18M</td>
<td>Total Duty</td>
</tr>
</tbody>
</table>

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**Value**

- **0M**
- **2M**
- **4M**
- **6M**
- **8M**
- **10M**
- **12M**
- **14M**
- **16M**
- **18M**
- **20M**
Additions

- Use by other business units
- Include distribution costs
- Include other forms of duty credits
- Monthly time buckets
- Add in taxes
Conclusion

Duties and duty credits should be included in production planning, especially when the suppliers and customers are in different trading blocs than the manufacturing plants.
Questions?
Appendix
## Additional Results

<table>
<thead>
<tr>
<th></th>
<th>Brazil Volume</th>
<th>Puerto Rico Volume</th>
<th>Total Cost</th>
<th>Duty Costs</th>
<th>Duty Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Model</strong></td>
<td>752,601</td>
<td>1,536,923</td>
<td>€ 198,958,379</td>
<td>€ 1,705,162</td>
<td>€ 104,997</td>
</tr>
<tr>
<td><strong>No Duty Credits</strong></td>
<td>743,680</td>
<td>1,545,845</td>
<td>€ 199,035,264</td>
<td>€ 1,785,667</td>
<td>€ -</td>
</tr>
<tr>
<td><strong>No Duties or Duty Credits</strong></td>
<td>655,612</td>
<td>1,633,913</td>
<td>€ 196,998,383</td>
<td>€ -</td>
<td>€ -</td>
</tr>
<tr>
<td><strong>Original plan</strong></td>
<td>1,107,331</td>
<td>1,182,193</td>
<td>€ 200,584,159</td>
<td>€ 2,421,389</td>
<td>€ 353,832</td>
</tr>
<tr>
<td><strong>Only J200</strong></td>
<td>1,493,666</td>
<td>795,858</td>
<td>€ 201,877,418</td>
<td>€ 3,302,192</td>
<td>€ 463,128</td>
</tr>
<tr>
<td><strong>Only Manati</strong></td>
<td>0</td>
<td>2,289,524</td>
<td>€ 201,075,519</td>
<td>€ 2,406,530</td>
<td>€ 3,203</td>
</tr>
<tr>
<td><strong>All RM Have 15% Import Duties</strong></td>
<td>169,759</td>
<td>2,119,765</td>
<td>€ 206,904,544</td>
<td>€ 18,691,604</td>
<td>€ 10,552,410</td>
</tr>
<tr>
<td><strong>FGs and RM Have 25% Import Duties</strong></td>
<td>163,029</td>
<td>2,126,495</td>
<td>€ 266,363,538</td>
<td>€ 85,355,314</td>
<td>€ 17,713,812</td>
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<tr>
<td><strong>15% RM Duties Plant 1</strong></td>
<td>66,352</td>
<td>2,223,172</td>
<td>€ 200,718,504</td>
<td>€ 3,052,042</td>
<td>€ 730,408</td>
</tr>
<tr>
<td><strong>15% RM Duties Plant 2</strong></td>
<td>906,215</td>
<td>1,383,309</td>
<td>€ 204,311,113</td>
<td>€ 9,805,831</td>
<td>€ 3,407,998</td>
</tr>
<tr>
<td><strong>Actual Plan with 15% RM Duties</strong></td>
<td>1,107,331</td>
<td>1,182,193</td>
<td>€ 214,481,488</td>
<td>€ 20,919,802</td>
<td>€ 4,601,084</td>
</tr>
</tbody>
</table>