A step towards optimal wood supply chain: A case study on optimal tree bucking in Central Finland

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Tree bucking control

Two main questions to be solved:
- What kind of wood assortments (products) from which stand
- What kind of log (length, diameter, quality) within each wood assortment
Tree bucking control

Three main levels:
- Stem level - optimize cutting of one stem
- Stand level – optimize cutting of all stems in a stand
- Forest level – optimize bucking of all trees of several stands
Aim of the study

- How large net profit can be achieved provided that a forest-level tree bucking can be achieved?
  - A Case study: search for the maximum net profit and minimum net profit (assuming all restrictions are fulfilled)
  - Potential gain: $(\text{Maximum} - \text{Minimum})/2$
Case study: Mills/assortments

**Supply**
- 15 study stands >= 5080 m³

**Demand**
- All mills = 4830 m³

**SAWMILL1**
- Sawlogs 3420 m³

**SAWMILL2**
- Sawlogs 450 m³
- Small sawlogs 150 m³

**LOGGING FACTORY**
- Special dimensions
  - Sawlogs 170 m³

**PULPMILL**
- Pulpwood 470 m³

**JOINERY FACTORY**
- Good quality
  - Butt logs 170 m³

**Own Mills**
- Delivery mills
Calculation of costs and revenues

**Own mills**

- **Costs**
  - Stumpage price
  - Cutting costs
  - Forwarding costs
  - Timber trucking costs
  - Capital costs of wood
  - Wood supply chain management cost
  - Processing costs

- **Revenues**
  - final products (lumber, pulp, etc)

**Delivery mills**

- **Costs**
  - Stumpage price
  - Cutting costs
  - Forwarding costs
  - Timber trucking costs
  - Capital costs of wood
  - Wood supply chain management cost

- **Revenues**
  - log products (sawlogs, pulpwood, etc)
GA-optimization

Stem data stand 1 → Stem data stand 2 → ... → Stem data stand n

General price matrices - log product k

Demand matrix string 1 → Demand matrix string 2 → ... → Demand matrix string m

BUCKING PROCEDURE

Apply mutation → Apply crossover → Apply selection

Calculate the fitness (returns – costs) of each demand matrix string

Has the maximum iteration number been reached? Yes → End

No →

Model for forwarding cost

Log product 1

Model for trucking cost

Revenues & stumpage prices - Log product 1

Production cost at mill - Log product 1

Volume constraints - Log product 1

Transport distances - Stand 1 – Mill 1

Log product 2

Log product k
Activity based costing

- A cost management system developed for harvesting and timber trucking

  - The more time certain product requires resources the more cost must be allocated to it

Time consumption analysis of the mechanized CTL harvesting system

- Time study carried out in the Middle-Finland in 2004
- 9 final cutting stands, 5 thinning stands
- 8 harvesters, 10 operators
- 8 forwarders, 9 drivers

Productivity of long-distance wood transportation

Time study carried out in the Middle-Finland in August 2005

- 368 loads, 17 900 m³, 9 mills
- 62% from one storage, 38% collecting from several (2 – 8 storages)
- 13 drivers, 8 vehicles

Costing Method for sawmilling

A virtual "greenfield" sawmill

The model calculates the realistic cost for each log size

Outputs:
• A model running on excel –sheet

Costing Method for kraft pulp mill

A virtual "greenfield" pulp mill

The model calculates the realistic cost for each log size

Outputs:
• A model running on excel –sheet

Revenues of sawmilling

- Revenues for each log
  - Quality differences between stands
    - Pre-harvest measurement (Uusitalo 1997)
  - Yields and proportions of quality grades by diameter and log type
  - Amount of by-products (chips, bark, sawdust)
  - Price level 2010
Revenues of pulp milling

– Revenues for each log
  – Amount of bark
  – Pulp yield
    • pulp yield increases with increasing basic density

– Yield and markets prices of by-products (Bark, Oil, Turpentine, Black liquor)
Results
## Results: Allocation of wood assortments

<table>
<thead>
<tr>
<th>Log products</th>
<th>Stand</th>
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</table>

A = Best feasible solution    B = Worst feasible solution
### Results: Net profit

<table>
<thead>
<tr>
<th>Allocation</th>
<th>Net Profit</th>
<th>Allocated volume</th>
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<tbody>
<tr>
<td>A (best feasible solution)</td>
<td>24181</td>
<td>5083</td>
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<td>B (worst feasible solution)</td>
<td>8380</td>
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<td>Difference</td>
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</table>

- Increase of net profit by 50-100%
- In our Case study area (demand of pine 300 000m³) €500,000 - €1,000,000 annually
Conclusions

• It is theoretically possible to compare the profitability of various logistic chains (value chains) and search for (close) optimal solutions.

• It can be only strategic or tactic tool – no operative.

• Competition on energy resources and desire to develop new processes (bio-refinery) calls for tools that can compare production chains.
Thank you