Impact of standardization on integrated supply chain design in a relocation context

Bertrand Baud-Lavigne$^{1,2}$
Bruno Agard$^2$
Bernard Penz$^1$

$^1$Laboratoire G-SCOP, Grenoble-INP

$^2$Ecole Polytechnique de Montréal

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Outline

1. Description of the issues and modelling with Integer Programming

2. Analysis of the standardization impact

3. Conclusions and perspectives
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3. Conclusions and perspectives
Context of the study

Several production units
Issues and Modelling
Analysis of the standardization impact
Conclusions and perspectives

Context of the study

Suppliers → Plants → Customers

- Several production units
- Manufactured products with multi level bill-of-materials (BOM)

- sub-assemblies can be transported
- (optional) family product can share sub-assemblies

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(in this presentation) Relocation issues
Context of the study

- Several production units
- Manufactured products with multi level bill-of-materials (BOM)
  - sub-assemblies can be transported
  - (optional) family product can share sub-assemblies
- (in this presentation) Relocation issues
- Looking for the lower global production cost (production + transportation costs between units)
State of the art in product - supply chain design

Supply chain design with BOM consideration

- Technology decisions [Paquet et al., 2004]
- Transportation mode decisions [Cordeau et al., 2006]
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Product design with supply chain consideration
- Design for Logistics [Dowlatshahi, 1996]
State of the art in product - supply chain design

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Joint product and supply chain design
- Generic BOM [Lamothe et al., 2006]
- Modular conception [El Hadj Khalaf et al., 2009]
- Scenarios [ElMaraghy and Mahmoudi, 2009]
Issues that are investigated

Production localisation
For each sub-assembly, which production unit is the best?
Issues that are investigated

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Standardization choices (not in this presentation)
Only two scenarios with different BOM are investigated
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Aim of this presentation

1. Justify the joint product and supply chain optimisation problem
2. Show the mutual impact of standardization and supply chain design
Modelling with Integer Programming

Based on the model presented in [Paquet et al., 2004]

- Integer Programming
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- Integer Programming
- Decision variables:
  - quantity of product (or sub-assembly) p produced on unit i
  - quantity of p transported from i to j
  - implantation of production unit

Variable and fixed costs:
- Transportation cost depends on physical volume
- Production cost depends on time processing

Flow constraint:

\[ F_p_{ji} = \sum G_{qp} X_{qi} - \sum X_{pi} - d_{pi} \]
Modelling with Integer Programming

Based on the model presented in [Paquet et al., 2004]

- **Integer Programming**
- **Decision variables**:
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  - transportation cost depends on physical volume
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\[
\begin{align*}
F_{pji} & \quad G_{qp} X_{qi} \\
X_{pi} & \quad d_{pi}
\end{align*}
\]
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Case study

- Bill-of-materials:

```
Specific BOM
P1
  A  B
    F  D  E
P2
  B'  C
    E  G
```

```
Standardized BOM
P1
  A  B
    F  D  E
P2
  C
    G
```
Case study

- Bill-of-materials:

  ![Specific BOM](image1.png)  ![Standardized BOM](image2.png)

- Supply chain:

  ![Supply chain diagram](image3.png)

  - Variable costs are higher on local unit
  - Fixed costs are higher on distant unit

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Experiment description

Parameter variations

- Demand of each product varies between 100 and 5000 units (step of 100)
- Resolution with Cplex 9.0
- Solution: product location and gain of the optimisation compared to production on local unit
- Specific BOM optimization

![Specific BOM optimization graph]

- Standardized BOM optimization

![Standardized BOM optimization graph]
Specific Vs Standardized BOM optimization
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Main results

- Standardization possibilities impact on optimal supply chain decision (the opposite has been also verified)
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- Complexity of the model
  ⇒ behaviour
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There is high interest in joint product and supply chain optimisation
Current and future researches

Supply chain design

- Further analysis on relocation and general context
- Application to a real case study from Reyes Constructions company
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Supply chain design
- Further analysis on relocation and general context
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Joint product and supply chain design
- Linear modelling
- Exact and approximated resolution methods
- Study on diversity in a family product
- Application to sustainable development
An integrated model for logistics network design.

The role of logistics in concurrent engineering.

An experimental study for the selection of modules and facilities in a mass customization context.

Concurrent design of product modules structure and global supply chain configurations.

An optimization model for selecting a product family and designing its supply chain.

Including technology selection decisions in manufacturing network design models.
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Bertrand Baud-Lavigne\textsuperscript{12}  
Bruno Agard\textsuperscript{2}  
Bernard Penz\textsuperscript{1}

\textsuperscript{1}Laboratoire G-SCOP, Grenoble-INP  
\textsuperscript{2}Ecole Polytechnique de Montréal

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