HYBRID OPTIMIZATION/SIMULATION APPROACH FOR FLEXIBLE SUPPLY CHAIN MANAGEMENT

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Supervisors: Jorge Pinho de Sousa / Samuel de Oliveira Moniz

LIST OF CONTENTS

- 1 - Introduction
- 2 - Case Study
- 3 - Methodology
- 4 - Models
- 5 - Implementation
- 6 - Results
- 7 - Conclusion
1 - INTRODUCTION

1. INTRODUCTION

CONTEXT

• Market competitiveness [1]
• Importance of supply chain design [2]
• Good stock management [3]
• Use of additive manufacturing [1]

1. MOTIVATION

- Evaluate new supply chain configurations
- Develop a decision support tool for supply chain management

1. OBJECTIVES

- Develop optimization/simulation model
- Consider the use of 3D printers
- Evaluate new supply chain configurations
2 - CASE STUDY

Inserted in the European project FASTEN
A company intends to use 3D printers and evaluate the impact of its use

Supply chain

External suppliers  Remote stations  Final clients
2 CASE STUDY

Inserted in the European project FASTEN
A company intends to use 3D printers and evaluate the impact of it's use

Supply chain

External suppliers
Remote stations
Final clients

Don't belong to the company
Supply parts

Where 3D printers will be installed
Distribution Centers
2. CASE STUDY

Inserido no projeto europeu FASTEN
Empresa pretende utilizar impressão 3D e avaliar o impacto do seu uso

Supply chain
- External suppliers
- Remotes stations
- Final clients
Where elevators are installed

2. CASE STUDY

CURRENT SUPPLY CHAIN

[Diagram showing the current supply chain with external suppliers, remote stations, and final clients connected by trucks and elevators installed in buildings.]
2. CASE STUDY
SUPPLY CHAIN TO BE IMPLEMENTED

3 - METHODOLOGY
3 METHODOLOGY

Conceptualization → Modelation → Validation and verification → Run optimization → Run simulation → Results analysis → Implementation

Define simulation model requirements and integration with optimization
3 METHODOLOGY

Conceptualization  Modelation  Validation and verification  Run optimization  Run simulation  Results analysis  Implementation

Build the simulation model

Test the simulation model na the integration with the optimization
### 3 METHODOLOGY

**Conceptualization** → **Modelation** → **Validation and verification** → **Run optimization** → **Run simulation** → **Results analysis** → **Implementation**

- Running the optimization model for the case study

**Conceptualization** → **Modelation** → **Validation and verification** → **Run optimization** → **Run simulation** → **Results analysis** → **Implementation**

- Evaluate the performance of the supply chain
3 METHODOLOGY

Conceptualization → Modelation → Validation and verification → Run optimization → Run simulation → Results analysis → Implementation

Analysis and comparison of the results of both models

3D printers, stock levels, capacities
4 - MODELS

OPTIMIZATION

Decision variables
- Suppliers
- Number of 3D printers
- Parts produced
- Stock levels
- Supplying parameters
4. MODELS

OPTIMIZATION

Constraints

• Number of 3D printers $\geq 0$
• A remote station can only provide parts that produce
• A remote station can only produce for its own consumption and/or supply
• A station can’t produce above its capacity
• For a part type, a station can only be supplied by a supplier or remote station

Objective function

Costs

4. MODELS

SIMULATION

Optimization

- Suppliers
- Number of 3D printers
- Parts produced
- Stock levels
- Supplying parameters

Simulation

- Simulation
- Monitorization
- Dashboards and tables
4. MODELS

SIMULATION MODEL

Configuration 1
- 3 Part types (A, B & C)
- 3 Remote stations (A, B & C)
- 1 External supplier (1)

4. MODELS

SIMULATION MODEL

Configuration 2
- 5 Part types (A, B, C, D & E)
- 3 Remote stations (A, B & C)
- 3 External supplier (1, 2 & 3)
4. MODELS

COSTS DASHBOARD
4. MODELS

INVENTORY/PRODUCTION DASHBOARD

5 - IMPLEMENTATION OF THE METHODOLOGY
5 IMPLEMENTATION DA METHODOLOGY

Inputs → IBM CPLEX → Supply chain → Simio → Results

Inputs (costs, demand, times, etc.) given by Excel
5 IMPLEMENTATION DA METHODOLOGY

Inputs → IBM CPLEX → Supply chain → Simulation model → Results

Running the optimization models with the inputs

Suppliers, number of 3D printers, stock levels, capacities, etc. saved on Excel
5 IMPLEMENTATION DA METHODOLOGY

- Inputs
- Optimization model
- Supply chain
- Simulation model
- Results

Simulation model executed with the optimization results

5 IMPLEMENTATION DA METHODOLOGY

- Inputs
- Optimization model
- Supply chain
- Simulation model
- Results

Results visualization
### 6. RESULTS

#### TEST SCENARIOS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>3D printers type</th>
<th>Configuration</th>
<th>Localization</th>
</tr>
</thead>
</table>

02/08/2018
### Results

#### Test Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>3D printers type</th>
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<th>Localization</th>
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<tbody>
<tr>
<td>1</td>
<td>Actual</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>Advanced*</td>
<td>1</td>
<td>A e C</td>
</tr>
</tbody>
</table>

*2x faster and half of the cost*
### TEST SCENARIOS

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<tr>
<td>3</td>
<td>Actual</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>Advanced*</td>
<td>2</td>
<td>A</td>
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</tbody>
</table>

*2x faster and half of the cost*
6. RESULTS

RESULTS DO CASE STUDY

### Lead time

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>5.1h</td>
<td>4.7h</td>
<td>4.8h</td>
<td>4.8h</td>
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</table>

### Service level

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>96%</td>
<td>97%</td>
<td>98%</td>
<td>98%</td>
</tr>
</tbody>
</table>
6. RESULTS

RESULTS DO CASE STUDY

Inventory status

Scenario 1:
Inventory of part B in remote B

6. RESULTS

RESULTS DO CASE STUDY

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Optimization</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>€ 225 430</td>
<td>€ 237 514</td>
</tr>
<tr>
<td>2</td>
<td>€ 192 242</td>
<td>€ 200 849</td>
</tr>
<tr>
<td>3</td>
<td>€ 346 291</td>
<td>€ 348 844</td>
</tr>
<tr>
<td>4</td>
<td>€ 288 111</td>
<td>€ 297 303</td>
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</table>
### 6. RESULTS

**RESULTS DO CASE STUDY**

#### Scenario 1 costs

<table>
<thead>
<tr>
<th>Costs</th>
<th>Optimization</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>€ 66 000</td>
<td>€ 66 000</td>
</tr>
<tr>
<td>Orders</td>
<td>€ 159 135</td>
<td>€ 162 594</td>
</tr>
<tr>
<td>Inventory</td>
<td>€ 295</td>
<td>€ 440</td>
</tr>
<tr>
<td>Stockout</td>
<td>€ 0</td>
<td>€ 8 480</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>€ 225 430</strong></td>
<td><strong>€ 237 514</strong></td>
</tr>
</tbody>
</table>

### 7 - CONCLUSION
CONCLUSIONS

• The tool developed (which integrates optimization and simulation) helps design supply chains
• The obtained results allowed to verify that well located 3D printing improves the lead time and the service level

FUTURE DEVELOPMENTS

• More detailed transports simulation
• Consideration of maintenance teams
THANK YOU

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