Modern Logistics & Supply Chain Management

ML & SCM

Introduction to Modelling

Dr. Wolfgang Garn
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"Management by objectives works if you first think through your objectives. Ninety percent of the time you haven't."
Peter Drucker

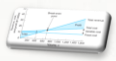
As gold which he cannot spend will make no man rich, so knowledge which he cannot apply will make no man wise.
Samuel Johnson: The Idler No. 84

Learning Objectives

- To apply the Supply Chain Analytics Process
- To construct simple models
- To do a break-even analysis
- To identify SCA techniques & applications

Contents

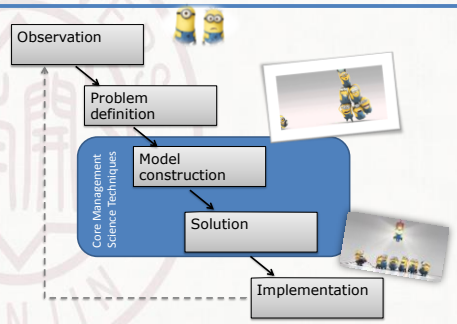
- SCA Process
  - Approach
  - Process
  - Example
- Break-Even Analysis
  - Model construction
- Techniques and Applications



Supply Chain Analytics Approach

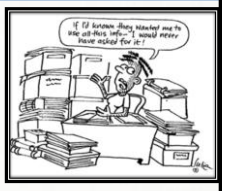
- Supply Chain Analytics uses a **scientific approach** to *solving* **management** problems.
- It is used in a *variety of organisations* to solve *many* different types of problems.
- It encompasses a *logical* **mathematical** approach to problem solving.
- Supply Chain Analytics is a part of Management Science
- Management science is also known as operations research, quantitative methods, decision science, etc.

Supply Chain Analytics Process



SCA Process

1. **Observation**
   Identification of a problem that exists (or may occur soon) in a system or organization.
2. **Definition of the Problem**
   problem must be clearly and consistently defined, showing its boundaries and interactions with the objectives of the organization.



SCA Process

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3. **Model Construction**
   Development of the functional mathematical relationships that describe the decision variables, objective function and constraints of the problem.
4. **Model Solution**
   Models solved using management science techniques.
5. **Model Implementation**
   Actual use of the model or its solution.

Example – observe & define (1 of 3)

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- Information
  - Business produces Basmati rice bags
  - Product costs £5 to produce
  - Product sells for £20
  - One bag requires 22 pounds of grain to make
  - Company has 1100 pounds of rice grain per day
- Business problem
  - Determine the number of units to produce to make the most profit, given the limited amount of rice grain available.

converter.eu

Example – Model Construction

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Variables: x = # units to produce (decision variable)

z = total profit (in £)

Model: z = £20x - £5x (objective function)

22x = 1100 lb of rice grain (resource constraint)

Parameters: £20, £5, 22 lb, 1100 lb (known values)

Formal Specification of Model:

$\max_x \{\mathbf{20}x - \mathbf{5}x : \mathbf{22}x = \mathbf{1100}\}$ or

maximise $\mathbf{20}x - \mathbf{5}x$
subject to: $\mathbf{22}x = \mathbf{1100}$

Example – Model Solution

Solve the constraint equation:

$22x = 1100$
$(22x)/22 = (1100)/22$
$x = 50$ units Solution

Substitute this value into the profit function:

$z = £20x - £5x$
$= (20)(50) - (5)(50)$
$= £750$ Solution value

(Produce 50 units, to yield a profit of £750)

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- Management Science Process
  - Approach
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  - Example
- **Break-Even Analysis**
  - **Model construction**
- Techniques and Applications



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Model Building: Break-Even Analysis (1 of 6)

- Used to determine the *number of units* of a product to sell or produce that will **equate total revenue with total cost**.
- The *volume* at which **total revenue equals total cost** is called the break-even point.
- Profit at break-even point is zero.

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Model Building: Break-Even Analysis (2 of 6)

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Model Components

- **Fixed Cost** (c_f) - costs that remain constant regardless of number of units produced.
- **Variable Cost** (c_v) - unit production cost of product.
- **Volume** (v) – the number of units produced or sold
- **Total variable cost** (vc_v) - function of volume (v) and unit variable cost.

Model Building: Break-Even Analysis (3 of 6)

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Model Components

- **Total Cost** (*TC*) - total fixed cost plus total variable cost.

$$TC = c_f + vc_v$$

- **Profit** (*Z*) - difference between total revenue vp (p = unit price) and total cost, i.e.

$$Z = vp - c_f - vc_v$$

Model Building: Break-Even Analysis (4 of 6)

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Computing the Break-Even Point

The volume when total revenue equals total cost is called *break-even point.*

$$vp = c_f + vc_v$$

$$vp - vc_v = c_f$$

$$v = \frac{c_f}{p - c_v}$$ … the break-even point

Note: when revenues are equal to costs, then the profit is zero.
Note 2: It is not a "point" with *x* and *y* coordinates

Model Building: Break-Even Analysis (5 of 6)

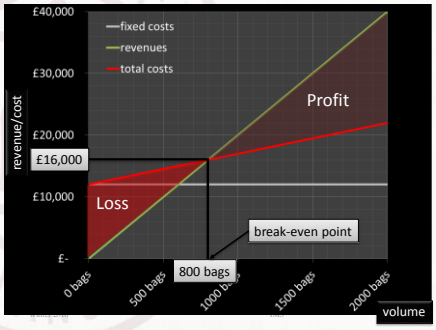
Example: Rice company

Fixed Costs: c_f = £12,000 per day
Variable Costs: c_v = £5 per bag
Price : p = £20 per bag

The Break-Even Point is:

$$v = \frac{12{,}000}{20-5} = 800 \text{ bags}$$

Model Building: Break-Even Analysis (6 of 6)



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SCA Techniques

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Mathematical Programming ⟺ **Network flows** **Probabilistic Techniques**

Mathematical Programming	Network flows	Probabilistic Techniques
Goal Programming Linear Programming (LP) Integer Programming (IP) Mixed IP (MIP) Nonlinear Programming	Shortest path Maximal flow Assignments Minimum cost flows Project Management	Statistics Waiting Line Systems Decision Analysis Simulation Forecasting

Transportation models
Transshipment
Assignments

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Characteristics of Modeling Techniques

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- **Linear Mathematical Programming**
  - clear objective; restrictions on resources and requirements; parameters known with certainty.
- **Probabilistic Techniques**
  - results contain uncertainty.
- **Network Flows**
  - model often formulated as graphs

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Business Use of Supply Chain Analytics

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- **Some application areas:**
  - Profitability of businesses
  - Business process optimisation
  - National "grids"
  - Inventory Analysis
  - Production Planning
  - Scheduling
- ***Interfaces*** - Applications journal published by Institute for Operations Research and Management Sciences (INFORMS)

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Recap – "the end is near"

- What is Supply Chain Analytics all about?
  - Solving business challenges analytically
- What's the underlying process?
  - Observe >> define >> model >> solve >> implement
- What's so "cool" about the Break-Even Analysis?
  - relates revenues & costs, zero profit and loss, …
- Are there useful MS applications & techniques?
  - Scheduling, inventory, planning, …
  - Math. programming (LP), decision science, network flows, …

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The End

- Any questions?

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Appendix
SCA Process - a bit more detail

- Existing issues, New challenge
  - Raised by top management, observed by OR
- Interview Subject Matter Experts
  - Need to know people who will validate and later implement the challenge
  - Get links to existing data, or ideas for data collection
- Specify challenge
  - Problem specification, scope definition
- Create model
  - A model that describes the essential factors ("usually data independent")
- Data analytics
  - Collect, analyse and prepare data
- Solution
  - Solve issues or provide solutions to new challenges
  - Usually this includes a set of experiment
  - Present solution to stack holders
- Implementation
  - Define responsibility, oversee, trouble-shoot ad-hock problems
  - Change management

1. Plan
2. Analysis
3. Design
4. Implement

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