Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
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BU7150 — Business Decision Optimization

Integer Programming
Simulation

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Mathematical Programming Lecture Practice

DHL Supply Chain

https://hbsp.harvard.edu/tu/07e87d3b

1) What is the business function and context of application? What is the role of the decision maker?

2) What is the 'best' we are trying to achieve? What are our limitations? What do we need to decide on?

3) How can we express these descriptions in stage 2 mathematically so that we can enter them into an optimization software and solve our problem?

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1) What is the business function and context of application? What is the role of the decision maker?

DHL logistics company is aiming to decrease carbon emissions from its activities such that its customers will be experiencing these decreases in their activities over their supply chains. The decision maker is Yee Hwai, a member of the solutions team at DHL Supply Chain, and Hwai is looking into the production and transportation decisions for two products of a consumer electronics company.

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2) What is the ‘best’ we are trying to achieve? What are our limitations? What do we need to decide on?

The ultimate aim is to reach 30% decrease in carbon emissions globally. Overall, Hwai is helping a customer coordinate its supply chain where a budget has been determined for production of two products (TV sets) at Original Design Manufacturers (ODMs) and transportation of these TV sets from ODMs to distribution center in China. The current ‘best’ aimed is to stay within the budget and coordinate production and coordination to minimize carbon emissions from these activities. We also have other limitations on order amounts (min and max) as well as shipment mode volumes.

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3) How can we express these descriptions in stage 2 mathematically so that we can enter them into an optimization software and solve our problem?

Decision variables:

$x_{ijk} = amount\ of\ product\ i\ to\ be\ produced\ at\ ODM\ j\ and\ shipped\ via\ mode\ k$

$i = LCD42, LCD32 \quad j = ODM1, ODM2, ODM3, ODM4, ODM5, ODM6, ODM7$

$k = Regular\ Air, Air\ Express, Road, Road\ LTL, Road - Network, Rail, Water$

$$y_{ij} = \begin{cases} 1\ if\ ODMj\ was\ contracted\ at\ all\ for\ product\ i \\ 0\ otherwise \end{cases}$$

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3) How can we express these descriptions in stage 2 mathematically so that we can enter them into an optimization software and solve our problem?

Objective Function:

Minimize Total Carbon Emissions:
Sum_over {i,j,k}
(# product i produced and shipped from ODM j via shipment mode k (x_{ijk})* Weight of product i in metric ton * Distance from ODM j to Distribution Center (Km)* CO2 emission in Kg per Ton-Km shipped via mode k)

Sum_over {i,j,k}
$\text{Units} * \frac{Ton}{Units} * Km * \frac{Kg}{Ton{-}Km}$, the final expression is in Kg of CO2

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3) How can we express these descriptions in stage 2 mathematically so that we can enter them into an optimization software and solve our problem?

Constraints:

1) Minimum and Maximum Production Amount Constraints (Logical Relationships between the constraints):

If I choose Not to work with an ODM for a particular product, then all production and shipment amounts of that product from that ODM should be zero

$$\sum_{k=1}^{7} x_{ijk} \leq 600{,}000 * y_j \text{ for all i}$$

If I choose to work with an ODM for a particular product, then all production and shipment amounts of that product from that ODM should be at least 200,000

$$\sum_{k=1}^{7} x_{ijk} \geq 200{,}000 * y_j \text{ for all i}$$

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3) How can we express these descriptions in stage 2 mathematically so that we can enter them into an optimization software and solve our problem?

Constraints:

2) Minimum Shipping Amount Constraints (One example is provided here)

Minimum LCD 42 by Regular Air or Air Express 46,000: Sum_over(j,k=1,2) $x_{1jk} \geq 46{,}000$

3) Budget Constraint:

Sum_over {i,j,k}
[# product i produced and shipped from ODM j via shipment mode k* (Unit production cost + Weight of product i in metric ton * Shipping Cost per Ton-Km shipped via mode k)] ≤ 3.10^9

4) Total Production of a particular product (LCD 42, LCD 32) should be at least as much as the contractual amount (920,000; 530,000), since we are minimizing, the model will make it as small as possible

5) Impossible selections for shipment modes needs to be assigned the value of 0

Simulation

Introduction

Mimic the complexity of the system and test alternative scenarios

Does not guarantee optimal solution

Easiness in analysing the effects of uncertainty

System: Entities and sub entities that interact to transform input to output

State of a System: Input, processing, and output variables necessary to describe the system

Discrete versus Continuous Models: Events that change the state of the system happen in discrete points in time versus they continually keep happening

Static versus Dynamic Simulation Models: Estimate the system at a given time point versus behaviour over a series of time points or intervals

Deterministic versus Stochastic: No random variables versus random variables

Simulation

Simulation Methodology

Purpose and Scope of the Simulation Model

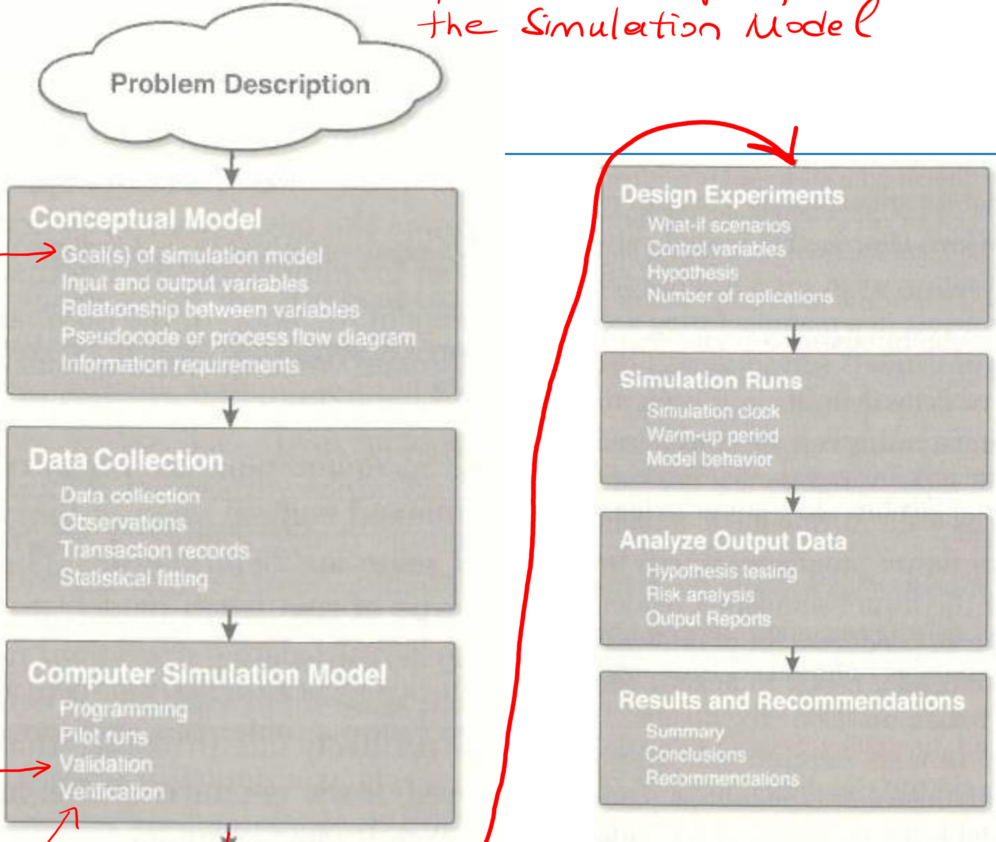

Figure 10-1 Simulation methodology

Performance Criteria

Validation: what is modeled answers the problem description well

Verification: How the system modeled works to obtain the desired observation

Simulation

Example – Blood Bank Agency

Weekly timeline of events

1. **Decision: Units of blood collected and converted to blood platelets (conversion cost: $150 per unit to platelet)**

2. **Random Input: Weekly demand, $400 per platelet charged to hospitals**

3. **System Closed: Unused platelets disposed, $20 per platelet**

Need to simulate the system to determine a policy for weekly collection amount

Data collected about the demand

Table 10-1 Distribution of Weekly Demand for Platelets

Weekly Demand for Platelets	Probability
300	.10
500	.25
800	.35
1000	.30

Simulation

Example – Blood Bank Agency

(Made the decision on the # units to collect)

Collect the blood units

↓ (Incurred the $150 per unit)

Convert them into platelets

↓

Demand occurs

Collected Amount ≥ Demand

Revenue (Sales) = min(CA, D)

= $400 * Demand

Disposal cost

= $20 * [Collected A. − Demand]

Collected Amount < Demand

Revenue (Sales)

= $400 * Collected Amount

Disposal cost (Resort to 'If' Excel Function)

= $20 * 0

Net Revenue

= Revenue (Sales) − Conversion/Processing Cost − Disposal cost

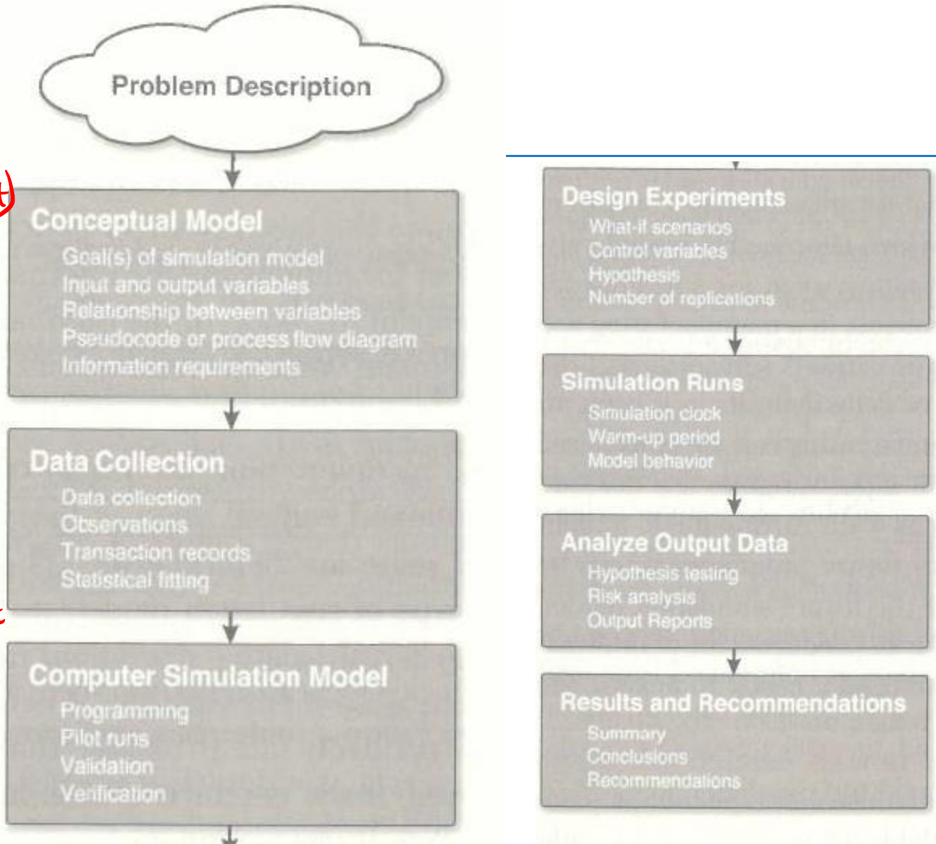

Figure 10-1 Simulation methodology