**What Have We Learned Up to Now?**

1. What is Management Science? (A structured approach to problem solving)

- Problem Understanding, Problem Formulation, Search for a Solution, What-if Analysis.

- Modeling? (Reflection before Action)

- Thinking as a Mental Modeling Process

- Analytical Modeling is At the Heart of OR/MS

- Analytical Decision Making Process

- Why Analytical Modeling?

2. What is a Mathematical Model? Deterministic vs. Stochastic (probabilistic)

3. What is Linear Programming? What are LP Applications? LP, ILP, MILP

4. Equation of a Line: ax + by = c

5. Resource Constraint: (Add Slack Var.) Note 1: Increase RHS, Increase O.V. by

Shadow price and vice-versa

6. Production Constraint: (Sub. Surp.) Note 2: Increase RH, Decrease O.V. by

Shadow price & vice-versa

Notes 1 and 2 are true only if the RH side is non-negative and it's a Max problem!

Solution Methodologies:

7. Graph Method:

- Pretend all constraints are in equality form

- Graph lines

- Define feasible region

- Plug points into objective function to determine optimum value

- This procedure works for bounded feasible regions, if unbounded, or having many constraints use ISO - value obj. function

Advantage: Disadvantage:

- Can visually eliminate some vertex

Points at the start, so don't have to It can only use for 2 dimensional problems

Evaluate the objective function for them

- Helps to understand the software solution e.g., it is the fact that Optimal Solution (if exists)

Is always one of the vertices!

8. Dual Problem (Formulation, and its managerial meanings):

Primal Dual\_\_\_\_\_\_\_

Max 5x1+3x2 Min 40u1 + 50u2

ST 2x1+x2 ≤40 St 2u1+u2 ≥ 5

x1+2x2 ≤ 50 u1+2u2 ≥ 3

x1, x2 ≥ 0 u1, u2 ≥ 0

Optimal Solution Optimal Solution

x1 = 10 x2 = 20 s1 = 0 s2 = 0 u1 = $7/3 u2 = $1/3 s1 = 0 s2 = 0

Notice that, The Optimal Value of Primal = The Optimal Value of Dual (Not optimal solution!). This property is called “**Economical Equilibrium**”.

Consider Constraint # 2

x1 + 2x2 ≤ 50, Increase RH of resource 2 by one unit, the O.V. will increase proportionately by the shadow price.

Shadow price u2 = 1/3 is the max you would be willing to pay for each additional unit of this resource, **while the change is within the shadow price range**.

9. Sensitivity and the What-if Analysis: **Surprise is not an element of a roust decision**

A. RHS and Cost Coffs. Sensitivity Range

**Meaning of the RHS range:** How far can we increase or decrease RHS (i), for fixed i while maintaining the current shadow price of the RHS (i)?

**Meaning of the Cost Coefficient range:** How far can we increase or decrease each cost coefficient c (j), of variable Xj, such that the current optimal solution (i.e. extreme point) remains optimal?

B. Adding a New Constraint

- Substitute optimal solution into new constraint

- If constraint is not violated, does not affect current solution

- If constraint is violated, problem must be re-done since solution will change

C. Deleting a Constraint

- Determine if the constraint is binding constraint

(**Is Si = 0, or is the constraint an equality when the O.S. is plugged into it**)

- If binding, deletion may change the solution, re-do problem (will not change if degenerate)

- If not binding, deletion will not affect solution

D. Introduction of New Product

- Find out how much it cost to produce one unit of the new product, using the shadow price(s).

- If the cost of producing one unit the new product is less or equal to the net-profit of the new

product, then do not produce Otherwise produce. To know how many you have to solve a

10. The Dark-side of LP

Unbounded, Infeasible, Multiple Solutions cases: **Their Causes and Remedies**

11. Problem Formulation and other LP Applications, such as Integer LP

12. How to Solve a Linear System of Equations by LP Solvers?

13. Goal‑Seeking (i.e. Satisfying) Problem

14. Computer Assisted Learning: Managerial Interpretation Generated Report

15. **Learning-to-learn**