The RBC (Royal Bank of Canada) uses online banking to market two new banking products. The first product is a home risk insurance that allows buyers to default for up to 6 months on their mortgage payments. The second is a guaranteed mortgage fund that buyers may purchase to leverage funds without increasing their debt loads.

The RBC expects to make profit contributions of \$20 per unit on the home risk insurance instrument, and \$8 per unit on the guaranteed mortgage fund. The bank has a policy that no more than 50% of total sales of the two products are home risk insurance instruments. The bank is now determining sales quotas for its online offerings to maximize total expected contribution to profits based on the product resource requirements, as follows:

Resource Requirements per Product Offering (Hours per Unit)

Bank Department	*Home Risk Insurance (HRI)*	*Guaranteed Mortgage (GM)*	*Resource Availability (Hours)*
Legal	6	4	4,800
Data Management	1	2	2,000
Policy Claims	3	0	1,800

A correct formulation for this problem is provided below:

Let *HRI* and *GM* denote the number of units of Home Risk Insurance instruments and Guaranteed Mortgage units to sell online, respectively.

MAX $z = 20\,HRI + 8\,GM$ (\$)

subject to,

1) Legal Hours $6\,HRI + 4\,GM \le 4{,}800$ hrs
2) Data Mgt Hours $1\,HRI + 2\,GM \le 2{,}000$ hrs
3) Policy Claims $3\,HRI \le 1{,}800$ hrs
4) Ratio Policy Limits $-0.5\,HRI + 0.5\,GM \ge 0$
5) Non-negativity $HRI, GM \ge 0$

RBC Problem Solution

Microsoft Excel 12.0 Answer Report

Target Cell (Max)

Cell	Name	Original Value	Final Value
\$F\$8	Variables Profits	0	A 13440

Adjustable Cells

Cell	Name	Original Value	Final Value
\$C\$8	Variables HRI	0	480
\$D\$8	Variables GM	0	480

opti-value

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
\$E\$11	Legal Hours LHS	4800	\$E\$11<=\$G\$11	Binding	0
\$E\$12	Data Mgmt LHS	B 1440	\$E\$12<=\$G\$12	Not Binding	560
\$E\$13	Policy Claims LHS	1440	\$E\$13<=\$G\$13	Not Binding	C 360
\$E\$14	Ratio Policy Limits LHS	0	\$E\$14<=\$G\$14	Binding	0

same

change by

Microsoft Excel 12.0 Sensitivity Report

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
\$C\$8	Variables HRI	480	0	D	1E+30	8
\$D\$8	Variables GM	E	0	8	5.333333333	28

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
\$E\$11	Legal Hours LHS	4800	2.8	4800	1200	4800
\$E\$12	Data Mgmt LHS	B	0	2000	H	560
\$E\$13	Policy Claims LHS	1440	F	1800	I	J
\$E\$14	Ratio Policy Limits LHS	0	6.4	G	150	350

Increase # × 2.8, added to Max Z (Final value)?

ANSWER REPORT

Target Cell - Final Value - Gives the maximized profit or minimized cost at the optimal solution. Sub Final values of adjustible cells into the Max/Min Function.

Adjustible Cells - Final Value - Gives the values for the decision variable at the optimal solution.

Cell Value - Shows how much of each constraint is being used up at the optimal solution. For a binding constraint this will be equal to the RHS. For a non-binding constraint the formula is RHS-Slack.

Status - Tells whether a constraint is binding or not. A binding constraint is one that has all of its resources used up. A non-binding constraint's resources are not all being used.

Slack - Shows how much excess resources we have for each constraint. A binding constraint will have slack of "0". Slack = RHS - Resources Used

SENSITIVITY REPORT

Adjustible Cells - Final Value - Same as above.

Reduced Cost - For any adjustible cell that has a final value that is NOT "0", the reduced cost will be "0". Otherwise Reduced Cost is equal to -(A. Increase).

Objective Coefficient - The coefficient attached to each variable in the optimization function.

Allowable Increase/Decrease - Shows the range in which the shadow price and opt. solution remain valid for the coefficients in the optimization function and the RHS of a constraint. For a non-binding constraint the allowable increase is infinity and the allowable decrease is equal to the slack.

Constraint - Final Value - Tells us how much of each constraint is being used up at the optimal solution.

Shadow Price - shows a how a 1 unit increase or decrease will affect the maximized profit or minimized cost. The shadow price for a non-binding constraint is "0".

SOLUTIONS

A) MAX z = 20HRI + 8GM
= 20 (480) + 8 (480)
= \$13440

B) Cell Value = RHS - Slack
= 2000 - 560 = 1440

C) Slack = RHS - Cell Value
= 1800 - 1440 = 360

D) Objective Coefficient = 20
From MAX formula.

E) Final Value = 480
From Answer Report.

F) Shadow Price = 0
Non-Binding Constraint

G) RHS = 0 See 4th Constraint

H) A. Increase = Infinity
Non - Binding Constraint

I) A. Increase = Infinity
Non - Binding Constraint

J) A. Decrease = Slack = 360

Linear Programming

ADM2302 - BDM Cheat Sheet

i) Assumptions

1. Conditions of certainty exist.
2. Proportionality in objective function and constraints (1 unit – 3 hours, 3 units 9 hours).
3. Additivity (total of all activities equals sum of individual activities).
4. Divisibility assumption that solutions need not necessarily be in whole numbers (integers).
5. Non-negativity

ii) Components

1. Decision Variables - the unknown values (ie. - how much of each to produce)
2. Objective Function - minimize cost or maximize profit, the cost/profit associated with each decision variable
3. Model Constraints - the restrictions that must be met, put limits on the values of decision variables
4. Model Parameters - coefficients for contraints and objective function.

To validate a constraint, plug in number that you think would meet the requirements of the constraints and see if the contraint holds true. Then plug in numbers that do not meet the constraint and see if the constraint fails.

A Few Tricky Constraints:

1)% of total production -> x1/(x1 + x2 + x3) >=0.5
2)"x" must be equal to 2/3 of "y" -> x - 2/3*y = 0
3)Units produced of "x" must be more then 5 times "y" -> x - 5y >=0
4)Transhiptment Problem, constraint for distribution center "a" -> x_1a + x_2a - x_a10 - x_a11 = 0
5)Inventory Constraint -> beginning Inv + production - demand - ending inventory = 0

Graphical Method

Step 1 - Assign 1 variable to each axis. (Usually 'x' on horizontal axis and 'y' on vertical axis)
Step 2 - Plot each of the contraints:
1) To get x intercept, set y=0 and solve for x
2) To get y intercept, set x=0 and solve for y
3) Plot the 2 points and connect them

Step 3 - Determine the feasible region and shade it in. For >= shade above the constraint line, for <= shade below the constraint line. Do this for each constraint.
Step 4 - Solve to minimize cost or maximize profit

Option 1 - Plot the Maximisation or Minimisation function. For Max slide this line diagonally from pt (0,0) until you reach the furthest possible feasible point. For Min do the same, exept we are looking for the first point this line touched when sliding it out from pt (0,0) **You need to plot the slope of the line. To do this you can set the optimization function equal to any number and solve.
Option 2 - Calculate the x and y values at all intersecting lines (when 2 constraints intersect or when 1 constraint intersects with an axis).
To do this you must set the constraints equal to one another
Plug each of these combination points in to the Max (Min) function to see which yeilds the highest (lowest) value.

What if Analysis

Reports: -Answer Report

Target Cell -> Minimized cost or Maximized Profit
Adjustible Cells - >Optimal Solution
Contraints - > Binding or Not Binding and amount of Slack

-Sensitivity Report

Adjustble Cells -> You are given the optimal solution as well as the objective coefficient, allowable inc. and allowable dec., and reduced cost.
Contraints - > You are given the final value as well as the shadow price, allowable increase and allowable decrease
Slack - Extra resources available at optimal solution
Shadow Price - The max price you are willing to pay for an additional 1 unit or resources

Range of Feasibility of Shadow Price = Top end (final value + allowable increase), Low end (final value - allowable decrease)
100% Rule for objective function co-efficients - The optimal solution (or shadow price) will not change if SUM(change/allowable change)*100 is <= to 100
=SUM(100* (|new value - current value|)/alloable change)

Hints -

1) A Non Binding Constraint is one where not all resources are being used up. This will have a slack > 0 and a shadow price =0. For this contraint, the allowable decrease = slack, and the allowable increase will be unlimited.
2) A Binding constraint is one where all resources are being used up (RHS = LHS). This will have a slack=0 and the shadow price will not be "0" (usually).
3) If a variable in the optimal solution had a value other that "0" the reduced cost will be "0" for this variable.
4) If a variable in the optimal solution is equal to "0", the reduced cost will NOT be "0". For a maximization function, the reduced cost will be a negative number (ie -5), the allowable increase for the coefficient for this variable will then be 5, and the allowable decrease in infinity. For a minimization problem, the reduced cost will be a positive number (ie 3), the allowable increase for the coefficient for this variable will then infinite, and the allowable decrease will be equal to the reduced cost (3).

Transportation Models

Decision Variables: The amount of goods or item to be transported from a numbers of origins to a number of destinations
The number of decision variables = number of arcs in the network representation diagram

Objective Function Minimize total transportation cost for all shipments
The sum of the individual shipping costs from each supplier to each demand destination

Constraints Supply
Demands
The number of constraints = number of nodes in the network representation diagram
Balanced model -> supply = demand — Constraints are equalities (=)
Unbalanced Model -> supply <> demand — One set of constraits is (<=)

Optimal Solution How much supply moved to each destination, Total shipping cost