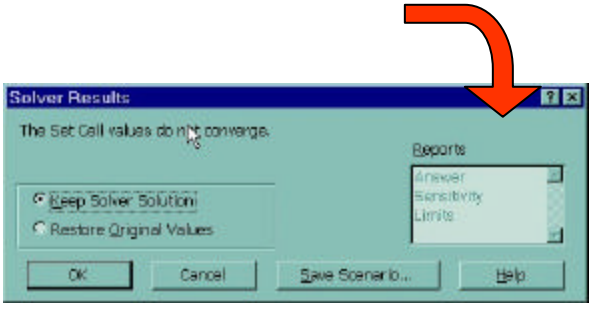
Sensitivity Analysis

- **What if…**
  - **An objective function coefficients changes?**
  - **A right-hand-side value changes?**
  - **A constraint coefficient changes?**
  - **Several things change at once?**
- **Two approaches:**
  - **Direct approach (re-solve with changes)**
  - **Analytical approach (can handle one change at a time---uses Sensitivity Report information)**

Getting the Sensitivity Report

- **Click on these options**



- Each of these will generate a new, separate worksheet inside your spreadsheet

Limitations of Sensitivity Report

- **Results only apply to the immediate neighborhood of the solution (big changes mean that you must resolve)**
- **Only describes effects on the objective function value**
- **Gives no information regarding changes in the technical coefficients of the model (the a_{ij}'s)**
- **Can only deal with changing one thing at a time**

Changes in objective function coefficients

- ***Allowable Increase/Decrease*** **indicates range in which solution stays the same---outside of range, must re-solve**
- **Variable values stay the same; objective function value changes accordingly**
- **If objective function coefficient at end of range (zero allowable increase or decrease)---*alternate optimal solutions***
  - **Find alternate solutions by either a) adding constraint to keep objective function value the same, max/min decision variable, or b) move objective function coefficient just out of range, i.e., by .01---then re-solve (may take some trial-and-error)**

Changes in RHS values

- **Binding constraints: *Shadow price* indicates amount by which objective function value changes if RHS is increased by one unit**
- ***Allowable Increase/Decrease* indicates range in which shadow price is relevant---outside range, re-solve**
- ***Important*: variable values will change to produce new objective function value---need to re-solve to find exact values**
- ***Also*: shadow price indicates additional price above and beyond normal (sunk) cost**

Analytical Approach, cont.

- **Changes in constraint coefficients**
  - **Can use shadow prices to calculate whether or not a change will make a difference in optimal solution, but…**
  - **Must re-solve to determine actual new solution, so…**
  - ***Use direct approach (re-solve with new information) for these kinds of changes***
- **Several things change at once**
  - **Limited ability to analyze through Sensitivity Report information, so…**
  - ***Use direct approach (re-solve with new information) for these kinds of changes***

More Sensitivity Analysis Stuff

- **New variable**
  - **New product may be considered**
  - **Can determine if new variable will be in optimal solution or if current solution still optimal**
    - **Use shadow prices of constraints times coefficient for new product in each constraint to evaluate marginal value of new product (relative to current solution)**
    - **Objective function contribution must be at least as great as total marginal value of resources**
  - **Must re-solve to get new solution if variable enters solution**

Even More Sensitivity Analysis Stuff

- **New constraint**
  - **New resource may be considered**
  - **Can determine whether new resource will change optimal solution**
    - **Check feasibility of current solution in new constraint**
      - **If current solution satisfies constraint---still optimal**
      - **If current solution infeasible in new constraint---must re-solve to get new solution**

Degeneracy

- **Essentially, fewer variables are positive in solution than should be mathematically**
- **Can cause interpretation problems of sensitivity information since value of some variable is zero** and **reduced cost is zero**
- **Tip-off in Sensitivity Report: some constraint has an allowable increase/decrease of zero**
- **Bottom line: check degeneracy before analyzing any alternate optimal solutions (objective function with allowable increase/decrease of zero)**
  - **When in doubt, re-solve with new information**

Stuff to Remember

- Shadow Price = **change in optimal objective function value per unit increase in** RHS coefficient
- Reduced Cost = **change in optimal objective function value per unit increase of a** variable **currently at a value of zero (nonbasic variable)**