

GAMS



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Transportation Model

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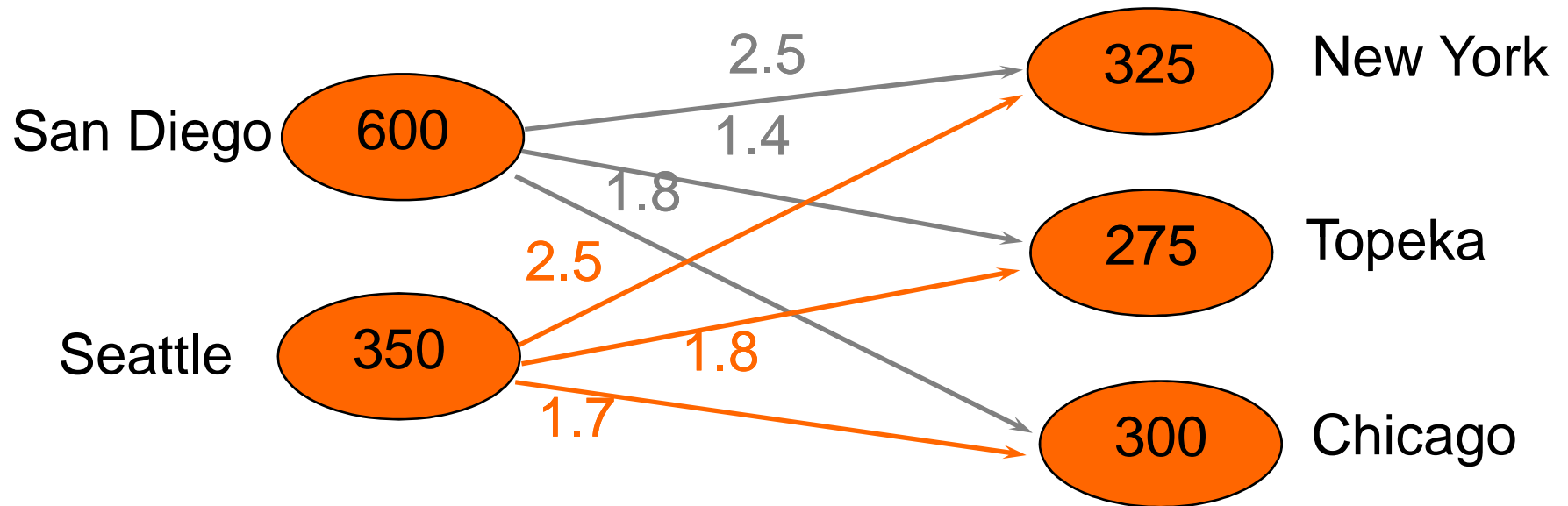
What is a Model?

- Mathematical Programming (MP) Model
 - List of Equations

- Collection of several intertwined MP Models
 - Data Preparation
 - Data Calibration
 - “Solution” Module (e.g. sequential, parallel, loop)
 - Report Module



A Transportation Model



Minimize Transportation cost
subject to Demand satisfaction at markets
 Supply constraints



Mathematical Algebra

$$\sum_{\substack{c,p: \\ (c,p) \in \mathcal{N}}} tcost \cdot dist(c,p) \cdot x_p^c \rightarrow \min$$

$$\sum_{\substack{c,p: \\ (c,p) \in \mathcal{N}}} x_p^c \leq sup(c) \quad \forall c$$

$$\sum_{\substack{c,p: \\ (c,p) \in \mathcal{N}}} x_p^c \geq dem(p) \quad \forall p$$

$$x_p^c \geq 0 \quad \forall c, p : (c, p) \in \mathcal{N}$$



GAMS Algebra

```
IDE gamside: C:\Documents and Settings\bussieck\My Documents\gamsdir\project.gpr - [c:\documents an...
IDE File Edit Search Windows Utilities Help
call {a}
transport.gms

Variables
    x(i,j)  shipment quantities in cases
    z       total transportation costs in thousands of dollars ;

Positive Variable x ;

Equations
    cost          define objective function
    supply(i)     observe supply limit at plant i
    demand(j)     satisfy demand at market j ;

cost ..          z =e= sum((i,j), c(i,j)*x(i,j)) ;

supply(i) ..     sum(j, x(i,j)) =l= a(i) ;

demand(j) ..     sum(i, x(i,j)) =g= b(j) ;

Model transport /all/ ;
```




A few Word about GAMS Syntax

- Symbols:

- Sets
- Parameters
- Variables
- Equations
- Models
- ASCII Output Files

```

Sets          i          canning plants / seattle, san-diego /;
Parameters   a(i)       capacity of plant i in cases
                /         seattle  350
                /         san-diego 600 /;
Variables    x(i,j)     shipment quantities in cases;
Equations    supply(i)  observe supply limit at plant i;
Model        transport /all/ ;
File         fx         some file / 'c:\t\text.txt' /
  
```

- Statements

- Declarations
- Data Assignments
- Equation Definition
- Programming Flow Control
- Option statement

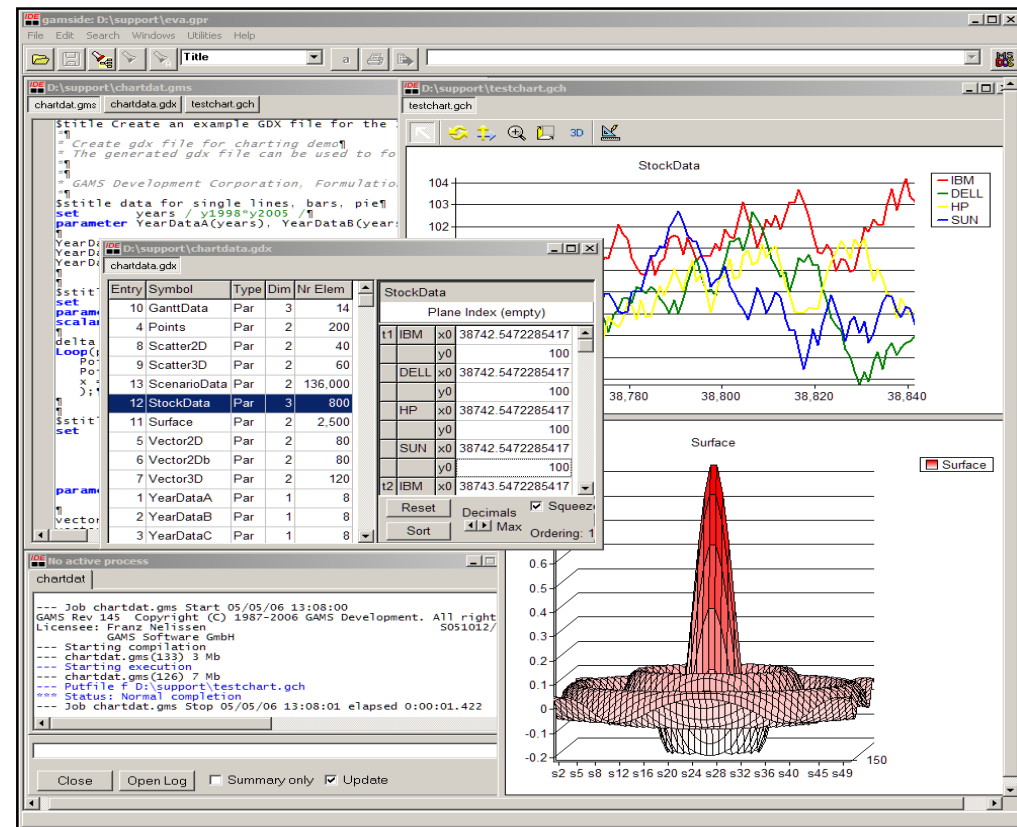
```

Parameter c(i,j);
c(i,j) = f * d(i,j) / 1000 ;
supply(i) .. sum(j, x(i,j)) =l= a(i);
loop(i, put fx i.t1);
option reslim=10;
  
```



Using the GAMS IDE to build a model

- IDE Project Management
- Documentation
 - User's Guide
 - McCarl User's Guide
 - Solver Manuals
- Model Library
- Solver Selection
- Option Editor
- Listing file
 - Tree view
 - Error navigation
- Spell checking





Hands-on! Transportation Model

The screenshot displays the GAMS IDE interface with several windows open:

- File Menu:** Shows options like New, Open, Save, and Run. The 'Model Library' option is selected, opening the GAMS Model Library window.
- GAMS Model Library Version 27.0:** A table listing various models. The first row is highlighted:

Seq#	Name	Application Area	Type	Contributor	Description
001	TRANSPORT	Management Science and OR	LP	Dantzig, G B	A Transportation Problem
002	BLEND	Management Science and OR	LP	Dantzig, G B	Blending Problem I
003	PRODMIX	Management Science and OR	LP	Dantzig, G B	A Production Mix Problem
004	WHHOUSE	Management Science and OR	LP	Dantzig, G B	Simple Warehouse Problem
005	JOBT	Management Science and OR	LP	Dantzig, G B	On-the-Job Training
006	SROUTE	Management Science and OR	LP	Dantzig, G B	The Shortest Route Problem
007	DIET	Micro Economics	LP	Dantzig, G B	Sigler's Nutrition Model
008	AIRCRAFT	Management Science and OR	LP	Dantzig, G B	Aircraft Allocation Under Uncertain Demand
009	PRODSCH	Management Science and OR	MIP	CDC	APEX - Production Scheduling Model
010	PDI	Management Science and OR	LP	ARCNET	ARCNET - Production Distribution and Inventory
011	UIMP	Management Science and OR	LP	Elison, E F	UIMP - Production Scheduling Problem
012	MAGIC	Management Science and OR	MIP	Garver, L L	Magic Power Scheduling Problem
013	FERTS	Micro Economics	LP	Chokis, A M	Egypt - Static Fertilizer Model
014	FERTD	Micro Economics	MIP	Chokis, A M	Egypt - Dynamic Fertilizer Model
015	MEXSS	Micro Economics	LP	Kendrick, D	Mexico Steel - Small Static
016	MEXSD	Micro Economics	MIP	Kendrick, D	Mexico Steel - Small Dynamic
017	MEXLS	Micro Economics	LP	Kendrick, D	Mexico Steel - Large Static
018	WEAPONS	Management Science and OR	NLP	Bracken, J	Weapons Assignment
019	BID	Micro Economics	MIP	Bracken, J	Bid Evaluation
020	PROCESS	Chemical Engineering	NLP	Bracken, J	Alkylation Process Optimization
021	CHEM	Chemical Engineering	NLP	Bracken, J	Chemical Equilibrium Problem
022	SHIP	Engineering	NLP	Bracken, J	Structural Optimization
023	LINEAR	Econometrics	DNLP	Bracken, J	Linear Regression with Various Criteria
024	LEAST	Econometrics	NLP	Bracken, J	Nonlinear Regression Problem
025	LIKE	Econometrics	NLP	Bracken, J	Maximum Likelihood Estimation
026	CHANCE	Agricultural Economics	NLP	Bracken, J	Chance Constrained Feed Mix Problem
027	SAMPLE	Statistics	NLP	Bracken, J	Stratified Sample Design
028	PINDYCK	Energy Economics	NLP	Pindyck, R S	Optimal Pricing and Extraction for OPEC
029	ZLOOF	Management Science and OR	GAMS	Zloof, M M	Relational Database Example
030	VIETNAM	Micro Economics	MIP	Manne, A S	Vietnam's Manne Fertilizer Model 1961
031	ALUM	International Trade	MIP	Brown, M	World Aluminum Model
032	MARCO	Micro Economics	LP	Aronofsky, J	Mini Oil Refining Model
- Parameters Window:** Shows the definition of parameters for the model:


```

Parameters
  a(i) capacity of plant i in cases
      / seattle 350
        san-diego 600 /

  b(j) demand at market j in cases
      / new-york 325
        chicago 300
        topeka 275 / ;

Table d(i,j) distance in thousands of miles
      new-york    chicago    topeka
seattle    2.5        1.7        1.8
san-diego  2.5        1.8        1.4 ;

Scalar f freight in dollars per case per thousand miles /90/ ;

Parameter c(i,j) transport cost in thousands of dollars per case
            
```
- No active process Window:** Shows the execution log:


```

--- Job trnsport.gms Start 07/03/07 10:25:45
GAMS Rev 148 Copyright (C) 1987-2007 GAMS Development. All rights reserved.
Licensee: Jan-Hendrik Jagla G070418/0001C
GAMS Software GmbH
--- Starting compilation
--- trnsport.gms(69) 3 Mb
--- Starting execution
--- trnsport.gms(45) 4 Mb
--- Generating LP model transport
--- trnsport.gms(66) 4 Mb
--- 6 rows 7 columns 19 non-zeroes
--- Executing CPLEX

GAMS/Cplex Jun 1, 2007 WIN.CP.CP 22.5 034.037.041.VIS For Cplex 10
Cplex 10.2.0, GAMS Link 34
            
```




Types of Variables

- Continuous Variables
 - Free/Positive/Negative
 - Lower and/or upper bound
- Binary Variables
 - Either 0 or 1
- Integer Variables
 - by default ranging between 0 and 100
- Semicont/Semiint Variables
 - 0 or above a given minimum
- Special Ordered Set Variables (SOS1, SOS2)



Binary Variables

- Powerful Tool to model yes/no decisions
- Models with discrete variables (MIP)
 - Solved using Branch-and-Cut algorithms (lots of LPs)
 - Theoretically difficult problem class
 - Practical:
 - mixed bag
 - *Art of Modeling*
- Example: Minimum Shipment
 - Ship at least 100 tons or don't ship



Minimum Shipment

- Continuous Variable x (shipment)
- Binary Variable $ship$ (indicator for minimum shipment):
 - $ship=1$ if $x \geq 100$
 - $ship=0$ if $x = 0$
- Coupling Constraints:
 - $x \geq 100 * ship$
 - $x \leq bigM * ship$
- How big do we have to make bigM?



Implement Min/Max Shipments (MIP)

```
Parameter rep1(i,j,*)    Shipments between plants and markets
          rep2(*)        Objective value;
```

```
rep1(i,j,'lp') = x.l(i,j);
rep2('lp')     = z.l;
```

```
scalars xmin / 100 /
          xmax / 275 /;
```

```
binary variables ship(i,j)    decision variable to ship
equations      minship(i,j) minimum shipments
               maxship(i,j) maximum shipments ;
```

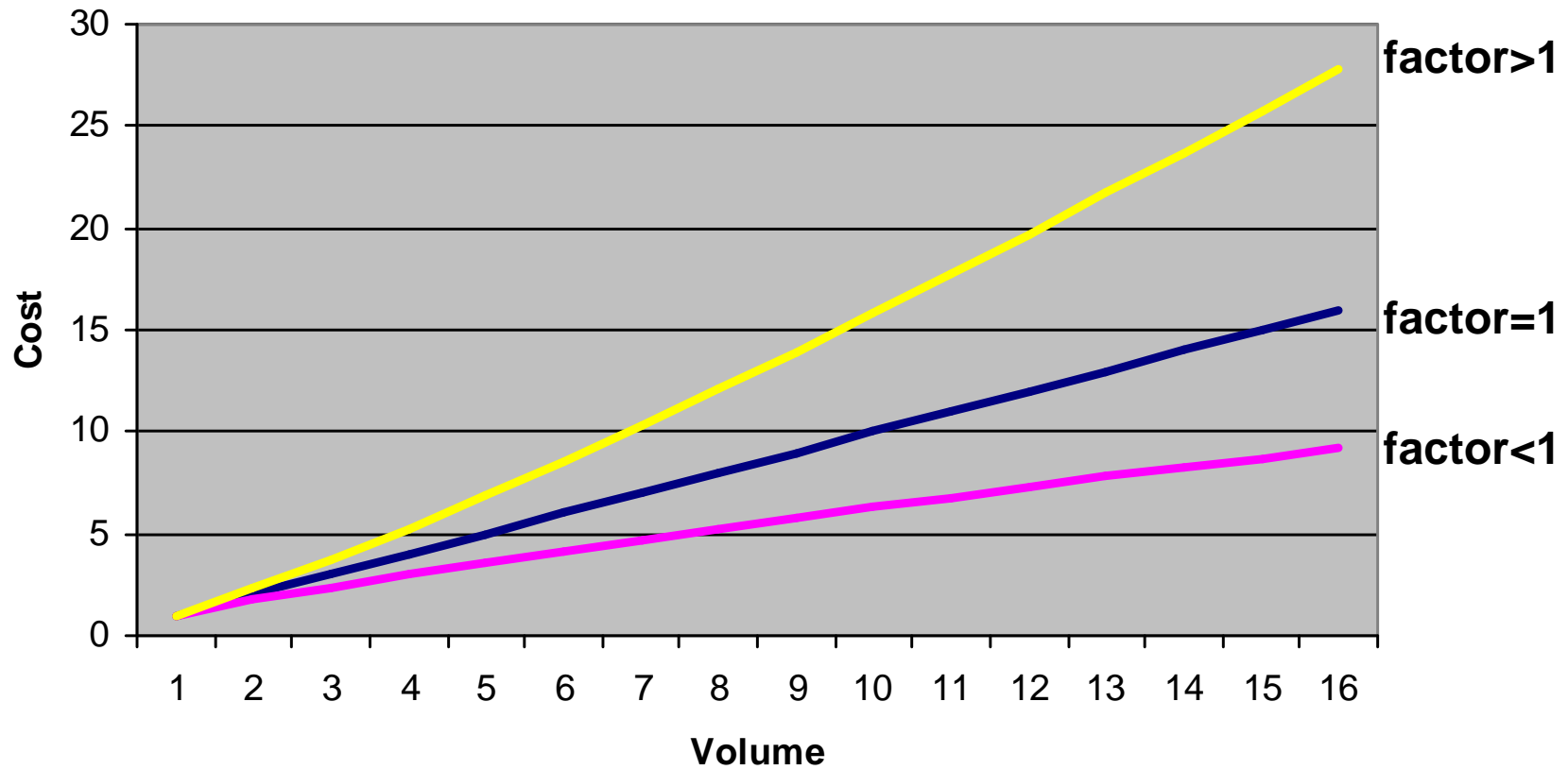
```
minship(i,j).. x(i,j) =g=  xmin*ship(i,j);
maxship(i,j).. x(i,j) =l=  xmax*ship(i,j);
```

```
model m2 min shipments / all /;
solve m2 using mip minimizing z;
rep1(i,j,'mip') = x.l(i,j);
rep2('mip')     = z.l;
```

```
option mip=coincbc
solve m2 using mip minimizing z;
rep1(i,j,'mip-coincbc') = x.l(i,j);
rep2('mip-coincbc')     = z.l;
display rep1,rep2;
```



Economy of Scales: $\text{Cost} = \text{Volume}^{\text{factor}}$





Implement Nonlinear Cost (NLP)

```
* nonlinear cost
equation nlcost nonlinear cost function;
scalar beta;

nlcost.. z =e= sum((i,j), c(i,j)*x(i,j)**beta);

model m3 / nlcost,supply,demand /;

beta = 1.5;
solve m3 using nlp minimizing z;
rep1(i,j,'nlp-convex') = x.l(i,j);
rep2('nlp-convex')      = z.l;

beta = 0.6;
solve m3 using nlp minimizing z;
rep1(i,j,'nlp-concave') = x.l(i,j);
rep2('nlp-concave')     = z.l;

option nlp=baron;
solve m3 using nlp minimizing z;
rep1(i,j,'nlp-baron') = x.l(i,j);
rep2('nlp-baron')     = z.l;

display rep1,rep2;
```



Implement Min/Max and Nonlinear (MINLP)

```
* min/max and nonlinear objective

model m4 / nlcost,supply,demand,minship,maxship /;

option minlp=baron;
solve m4 using minlp minimizing z;
rep1(i,j,'minlp-bar') = x.l(i,j);
rep2('minlp-bar')      = z.l;

option minlp=lindoglobal;
solve m4 using minlp minimizing z;
rep1(i,j,'minlp-lin') = x.l(i,j);
rep2('minlp-lin')     = z.l;

display rep1,rep2;
```



Sources of GAMS Information

Download: <http://download.gams-software.com/>

Release Notes: <http://www.gams.com/docs/release/release.htm>

Contributed Documentation: <http://www.gams.com/docs/contributed>

Contributed Software: <http://www.gams.com/contrib/contrib.htm>

Presentations: <http://www.gams.com/presentations>

Workshops: <http://www.gams.com/courses.htm>

Bruce McCarl's Newsletter: <http://www.gams.com/maillist/newsletter.htm>

GAMS User Group: http://www.gams.com/maillist/gams_1.htm

GAMS Google Group: <http://groups.google.de/group/gamsworld>

Other relevant sites on the Web: <http://www.gams.com/hotlinks.htm>



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