A formal model for production order selection considering synergies

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A formal model for production order selection

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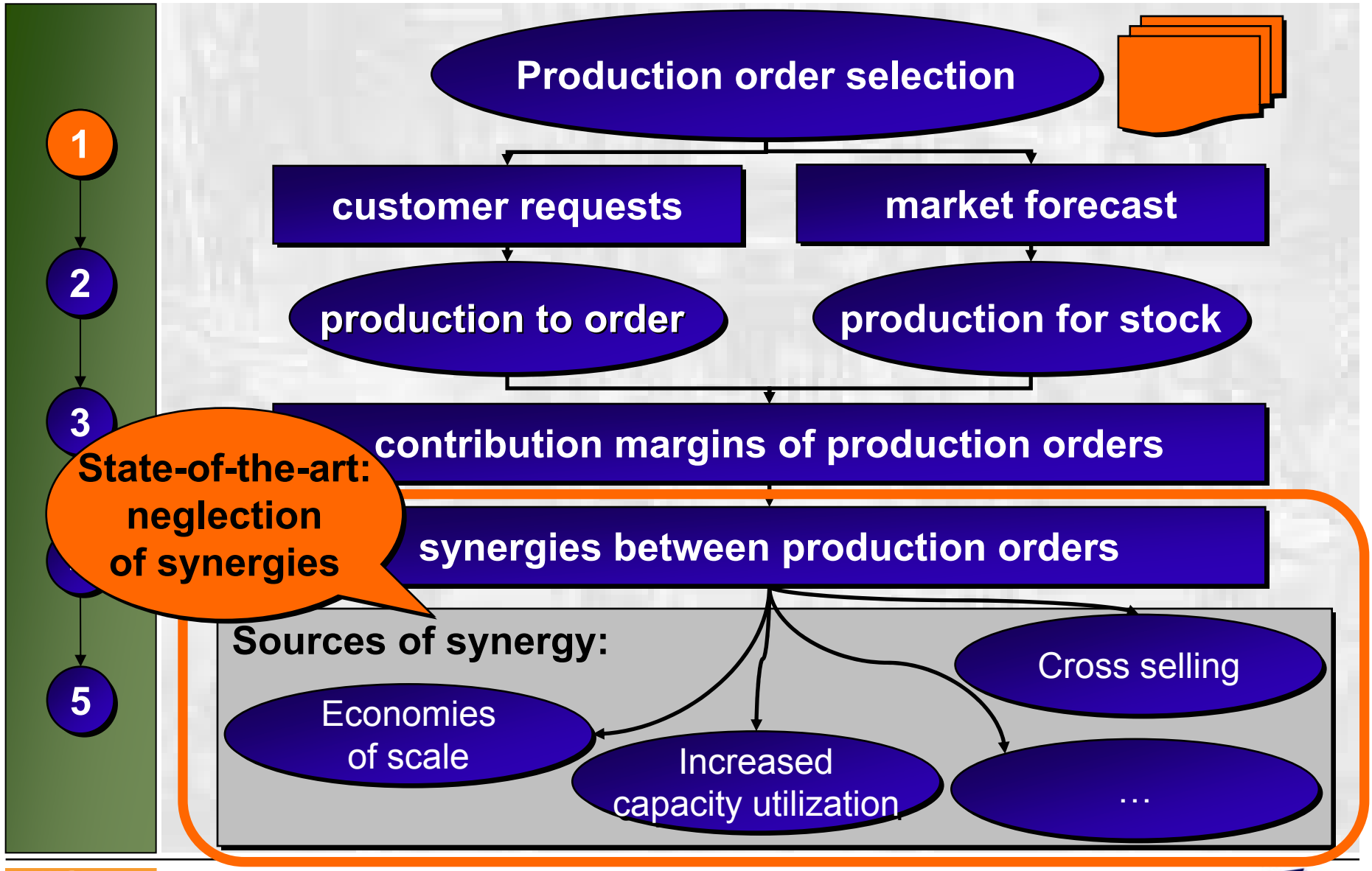
A formal model for production order selection
Problem identification



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Input data preparation

1
2
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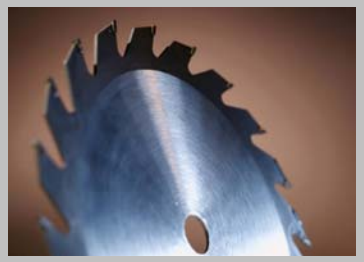
Available capacity of each type of capacity



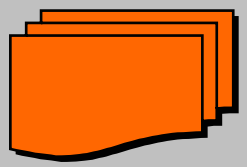
Example: Capacity type “machine saw”

4 machine saws à 60 h operating time per week

Available capacity of capacity type “machine saw” per week:

4 * 60 h = 240 h

Production orders



- **Required capacity of each type of capacity**
- **Contribution Margins**

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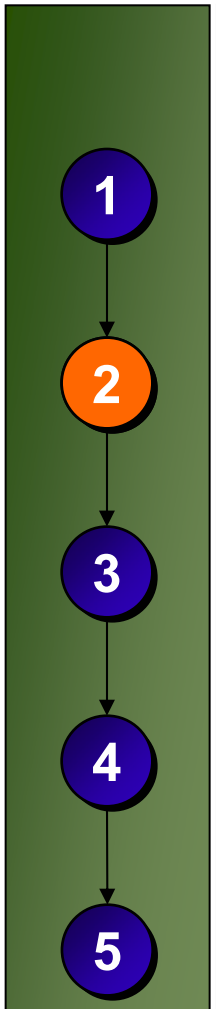
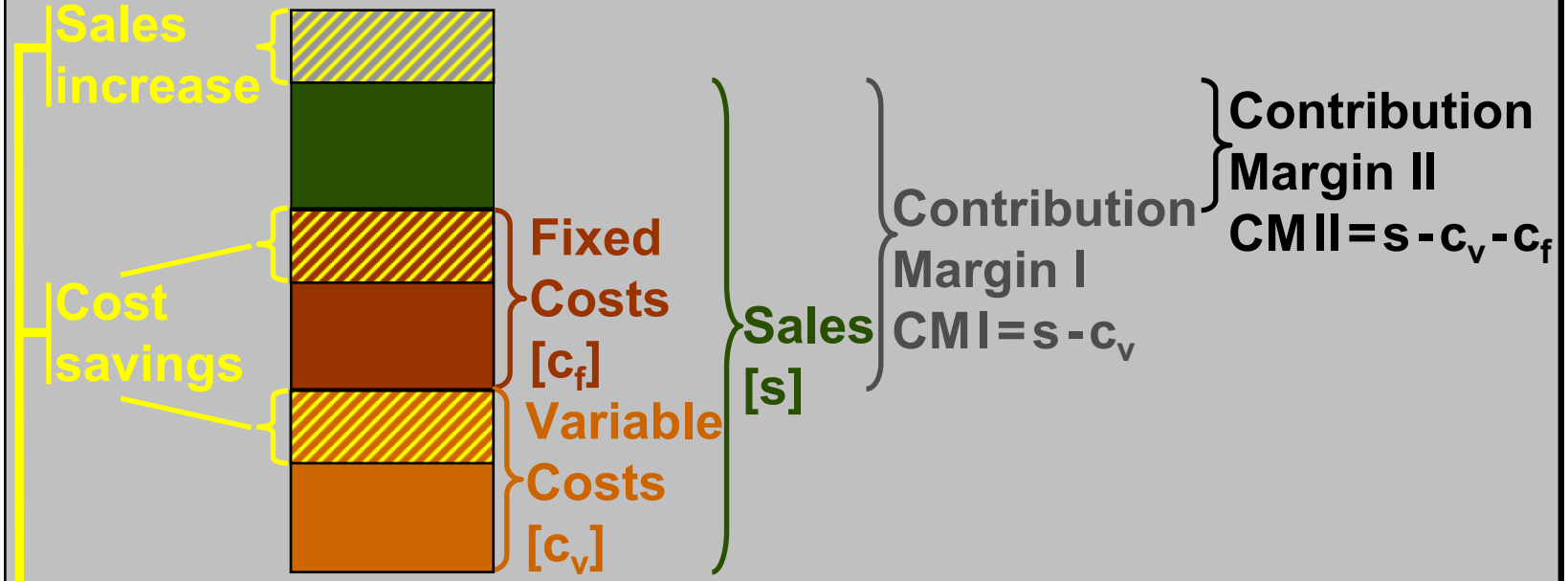
Input data preparation



Synergies between two production orders



Synergy $s_{i,j}$

Production orders	1	2	…	n
1	0	$s_{1.2}$		$s_{1.n}$
2		0		$s_{2.n}$
…			0	
n				0

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Problem Solution – Simple knapsack model

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n number of potential production orders

M_i contribution margin of production order i

u_i binary variable,

$u_i = 1$, if production order i is selected.

$u_i = 0$, if production order i is not selected.

c_i required capacity for production order i

C available capacity

single type of capacity

neglection of synergies

Extended knapsack model

Objective function:

$$Max \sum_{i=1}^{n} u_i * M_i$$

subject to the constraints:

$$\sum_{i=1}^{n} c_i * u_i \leq C$$

$$u_i \in \{0,1\} \quad \forall i = 1,\ldots,n$$

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Problem Solution – Extended knapsack model

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$c_{i,k}$ required capacity of type k for production order i

C_k available capacity of type k

Different types of capacity

K number of types of capacities

u_j binary variable,

Second binary variable

$u_j = 1$, if production order j is selected

$u_j = 0$, if production order j is not selected

$s_{i,j}$ synergy, if production order i and production order j are selected

Synergies

Objective function:

$$Max \sum_{i=1}^{n} u_i * M_i + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j>i}}^{n} s_{i,j} * u_i * u_j$$

subject to the constraints:

$$\sum_{i=1}^{n} c_{i,k} * u_i \leq C_k \quad \forall k = 1,\ldots,K$$

$$u_i \in \{0,1\} \quad \forall i = 1,\ldots,n$$

$$u_j \in \{0,1\} \quad \forall j = 1,\ldots,n$$

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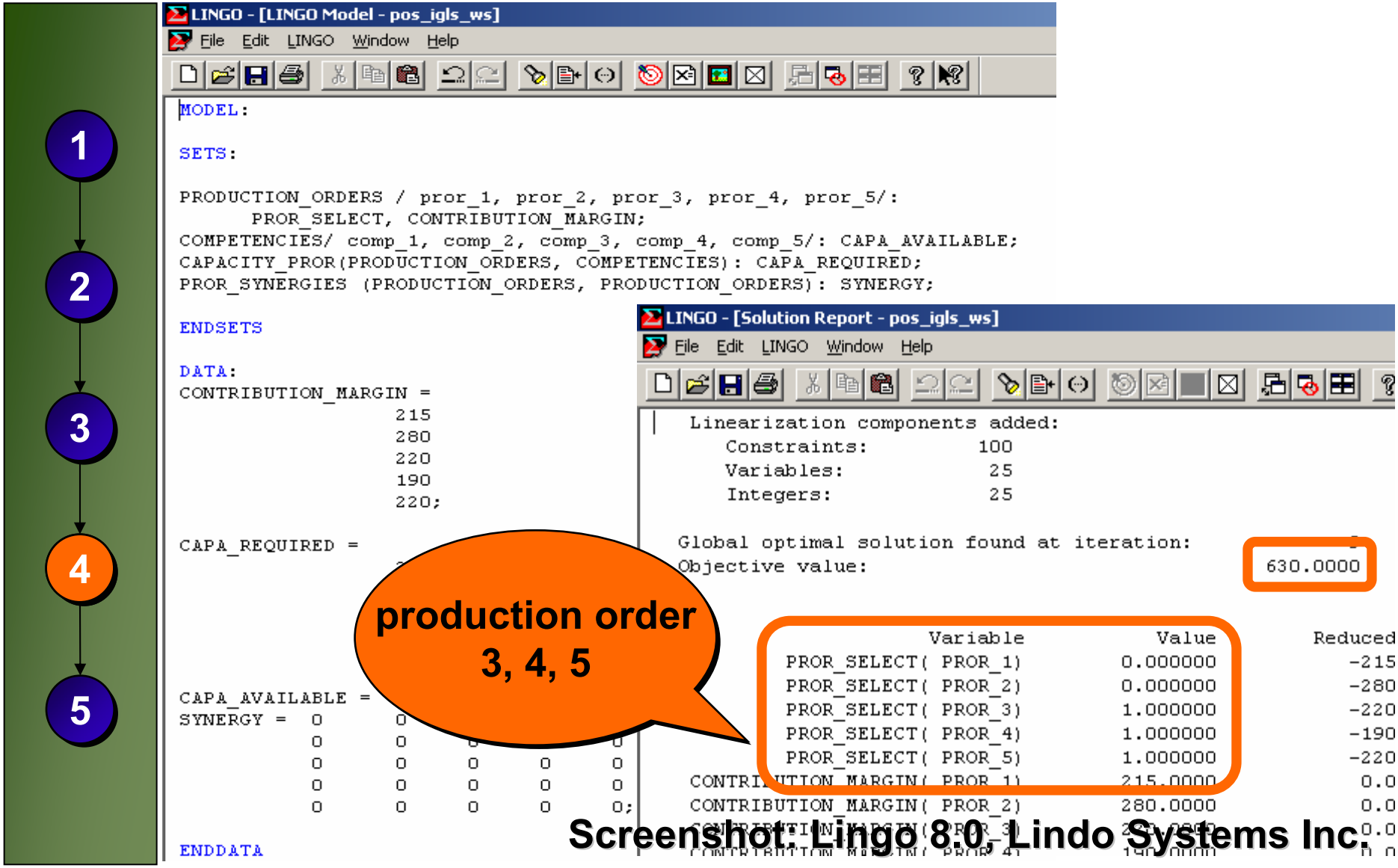
Numerical Example – without consideration of synergies



Screenshot: Lingo 8.0, Lindo Systems Inc.

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Numerical Example – with consideration of synergies

1
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LINGO - [LINGO Model - pos_igls]

File Edit LINGO Window Help

```
MODEL:

SETS:

PRODUCTION_ORDERS / pror_1, pror_2, pror_3, pror_4, pror_5/:
      PROR_SELECT, CONTRIBUTION_MARGIN;
COMPETENCIES/ comp_1, comp_2, comp_3, comp_4, comp_5/: CAPA_AVAILABLE;
CAPACITY_PROR(PRODUCTION_ORDERS, COMPETENCIES): CAPA_REQUIRED;
PROR_SYNERGIES (PRODUCTION_ORDERS, PRODUCTION_ORDERS): SYNERGY;

ENDSETS

DATA:
CONTRIBUTION_MARGIN =
                    215
                    280
                    220
                    190
                    220;

CAPA_REQUIRED =
                    25

CAPA_AVAILABLE =
SYNERGY =   0
            0       0
            0       0       0       0       30
            0       0       0       0       10
            0       0       0       0       0;

ENDDATA
```

LINGO - [Solution Report - pos_igls]

File Edit LINGO Window Help

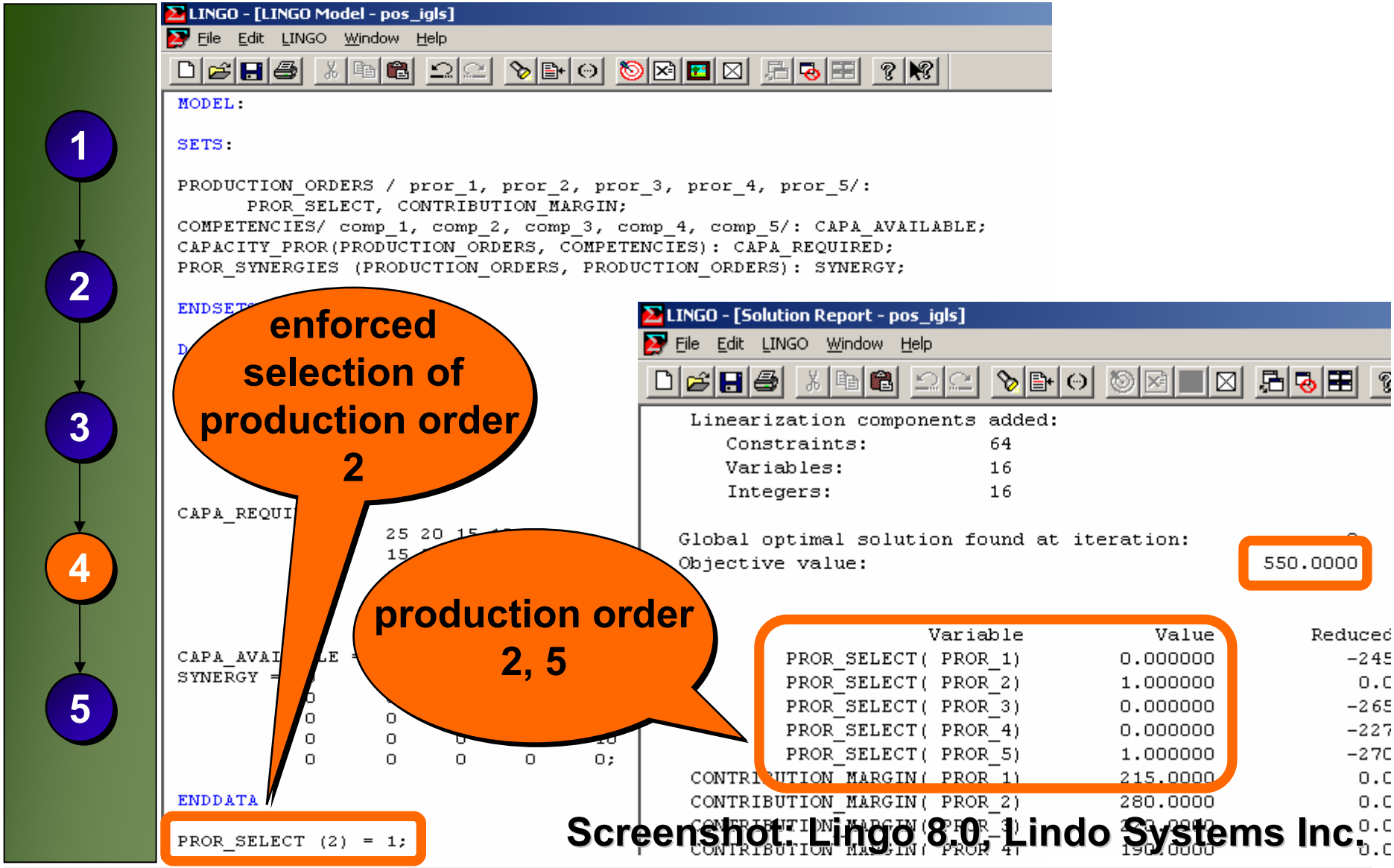
```
  Linearization components added:
     Constraints:          100
     Variables:             25
     Integers:              25

  Global optimal solution found at iteration:
  Objective value:                                705.0000

                        Variable           Value        Reduced
   PROR_SELECT( PROR_1)                 1.000000            -215
   PROR_SELECT( PROR_2)                 0.000000            -280
   PROR_SELECT( PROR_3)                 1.000000            -220
   PROR_SELECT( PROR_4)                 1.000000            -190
   PROR_SELECT( PROR_5)                 0.000000            -220
  CONTRIBUTION_MARGIN( PROR_1)          215.0000             0.0
  CONTRIBUTION_MARGIN( PROR_2)          280.0000             0.0
  CONTRIBUTION_MARGIN( PROR_3)          220.0000             0.0
  CONTRIBUTION_MARGIN( PROR_4)          190.0000             0.0
```

production order 1, 3, 4

Screenshot: Lingo 8.0, Lindo Systems Inc.

A formal model for production order selection

Numerical Example – key customer production order



Screenshot: Lingo 8.0, Lindo Systems Inc.

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Difficulties

1
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Increased effort

Capacity requirements planning for production orders

Estimation of synergies between production orders

Difficulties concerning the anticipation of synergies

Example:

Cross selling –
Estimating the amount of sales (increase)

A formal model for production order selection

1
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Thank you for your time and attention!

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