Production Capabilities Decision Making: Biopharama, Inc, Study Case

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Abstract

This paper considers two enterprises at different countries that engage in joint production to reduce several costs. The prospect of repeated integration of simulated introduces dynamics, in that actions that enterprises take today influence the costliness and effectiveness of different actions in the close future. Repeated interaction also facilitates the use of informal agreements, but by the ongoing value system of the strategic network relationship. Authors characterize the optimal network agreement in this dynamic commercial platform. Authors show that an optimal commercial platform has a simple form that does not depend on the last period. The optimal commercial platform may require that the enterprises terminate their network with positive probability following poor performance. Authors show how process visibility, which allows the enterprises to better assess that is at fault, can substantially improve commercial network performance. The degree to which process visibility eliminates the prohibit regulation on the nature of the dynamics: If the buyer's action does not influence the dynamics, the need for termination is eliminated; otherwise, termination may be required a commercial integration.

Keywords: Production, Biopharma, Network, Decision Making, Capacity.

1. Background Description, Problem Settings And Assumptions

1.1 Background Description (for complete version see Appendix A)

In 2005, Biopharma Inc. had experienced a steep decline in profits and very high costs at its plants in Germany and Japan. The president of the company for worldwide operation knew the demand for the company products was stable across the globe, as result the surplus capacity in his global network looked like luxury that he can't longer affordBrunsson, Nils (1982). Any improvement in financial performance was dependent on having the most efficient network in place because revenues were unlikely to grow. Biopharma is global manufacturers of bulk chemicals used in pharmaceutical industry. The company holds patent on two chemicals that are called Highcal and Relax internally. The chemicals are used internally and are also sold to others drug manufacturers.

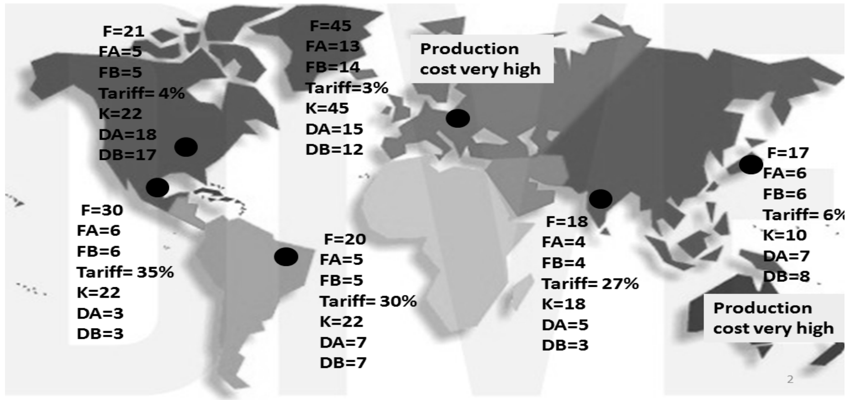

Figure 1: World diversification technology leader within Biopharma network

- The Japanese plant is a technology leader within Biopharma network in terms of its ability to handle regulatory and environmental issues. Some developments in the Japanese plant had been transferred to other plants in the network.
- German plant is a leader in terms of its production ability. Highest yield in within the global network.
- Brazilian, Indian and Mexican plants are technology outdated and are in need of an update.
- Market is stable, only region Asia w/o Japan expects to grow in sales by 10% annually during the next 5years.

Two options are being seriously considered:

- Shutting down the Japanese plant
- Limiting the German plant to a single Chemical

1.2 Problem Settings

The problem settings give separately see table 6.20 and 6.21 in the Appendix A:

- Transportation cost from plant I to market j($/Kg),
- Raw material cost for {Highcal, Relax} at plant I ($/Kg),
- Production cost for {Highcal, Relax} plant I ($/Kg).

For simplicity of Burgelman, Robert (1983)the problem authors reformulated creating 2 matrix {Highcal, Relax} with:

Production + Raw material + transportation cost from plant I to market j ($/Kg)

1.3 Assumptions

Table 1: Raw materials, Production and Transportation Costs (US$/Kg)

CA_ij	**HIGHCAL**	Raw materials, Production and Transportation Costs **(US$/Kg)**					
Region		Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.
Latin America	Brazil	8.9	9.15	9.2	9.2	9.1	9.15
Europe	Germany	11.35	11.1	11.25	11.3	11.2	11.2
Asia w/o Japan	India	8.6	8.45	8.3	8.4	8.6	8.55
Japan	Japan	11.9	11.8	11.7	11.5	11.85	11.85
Mexico	Mexico	9	8.9	9.1	9.05	8.8	8.85
U.S.	U.S.	9.05	8.9	9.05	9.05	8.85	8.8
CB_ij	**RELAX**	Raw materials, Production and Transportation Costs **(US$/Kg)**					
Region		Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.
Latin America	Brazil	11.4	11.65	11.7	11.7	11.6	11.65
Europe	Germany	13.95	13.7	13.85	13.9	13.8	13.8
Asia w/o Japan	India	11	10.85	10.7	10.8	11	10.95
Japan	Japan	14.6	14.5	14.4	14.2	14.55	14.55
Mexico	Mexico	11.5	11.4	11.6	11.55	11.3	11.35
U.S.	U.S.	11.45	11.3	11.45	11.45	11.25	11.2

Sources: Authors Calculation (2013)

2. Notatıon & Model Formulatıon

2.1 Inputs:

$i:\ index\ \{1,2..5\} correspondingto\ plant\ i$ {Brazil, Germany, India, Japan, Mexico, U. S. }
$j:\ index\ \{1,..5\} correspondingto\ market\ j\ in\ region$

A: Sub index that indicates product chemical Highcal
B: Sub index that indicates product Chemical Relax

{Latin America, Europe, Asia(w. o.) Japan, Japan, Mexico, U. S. }

K_i: Capacity of plants I (in million Kg)

F_i: Annualized fixed cost of keeping factory I open (in Millions $US)

F_{A_i}: Annualized fixed cost related to idled for Produce A at factory I (independent of quantity produced) (in Millions $US)

F_{B_i}: Annualized fixed cost related to idled for Produce B at factory I (independent of quantity produced) (in Millions $US)

$C_{A\_i\,j}$: Cost of producing and shipping product A from factory I to market region j (cost include transportation, raw materials, and production) in $US/Kg

$C_{B\_i\,j}$: Cost of producing and shipping product B from factory I to market region j (cost include transportation, raw materials, and production) in $US/Kg

D_{A_j}: Annual demand of product A from market j (in million Kg)

D_{B_j}: Annual demand of product B from market j (in million Kg)

T_j: Tariff of import product A or B to market j (Duties apply only to raw material, production and transportation costs)

2.2 Decision Variables

$X_{A\_i\,j}$: Quantity of product A shipped from plant I to market j (in million Kg)

$X_{B\_i\,j}$: Quantity of product B shipped from plant I to market j (in million Kg)

Y_i: 1 if plant I is open, 0 otherwise

Y_{A_i}: 1 if plant I is idled to produce product A, 0 otherwise (plant can be idled even not produce nothing)

Y_{B_i}: 1 if plant I is idled to produce product B, 0 otherwise (plant can be idled even not produce nothing)

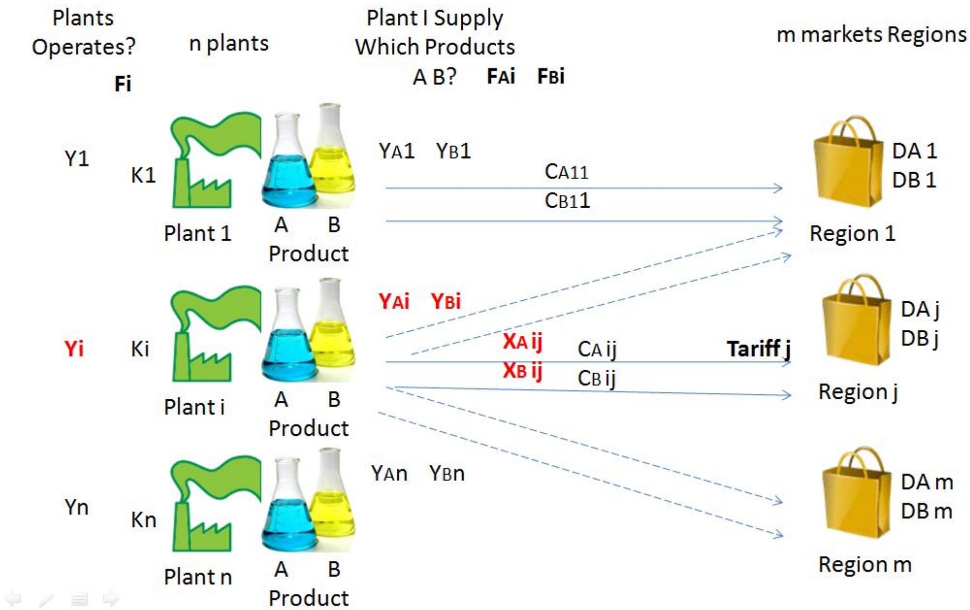

Figure 2: MODEL FORMULATION, Authors Illustration (2013)

In case to closing down a plant, plant eliminates all variable costs and saves 80% of the annual fixed cost (the remaining 20% accounts for costs that are incurred related to the plant shutdown), Dill, William, R. (1964), Donaldson, Gordon and Jay W. Lorsch (1983).

$$F_i * (0.2 + 0.8 * Y_i)$$

In case to limited and produce only one chemical (product A or B), the plant saves 80% of the fixed cost associated with that particular chemicalSchwenk, Charles R. (1985).

$$F_{A\_i} * \left(0.2 * Y_i + 0.8 * Y_{A\_i}\right) + F_{B\_i} * \left(0.2 * Y_i + 0.8 * Y_{B\_i}\right)$$

So Total fixed cost is given by

$$\sum_{j \in J} \left(F_i * (0.2 + 0.8 * Y_i) + F_{A\_i} * \left(0.2 * Y_i + 0.8 * Y_{A\_i}\right) + F_{B\_i} * \left(0.2 * Y_i + 0.8 * Y_{B\_i}\right)\right)$$

Imports duties are based on the regional trade agreements and the local production within each region is assumed to result in no import duty. (Import duties only apply in raw material, production and transportation costs), so total variable cost is given by:

$$\sum_{j \in J} \left(\sum_{\substack{i \in I \\ i \neq j}} C_{A\_ij} * X_{A\_ij} * \left(1 + T_j\right) + C_{B\_ij} * X_{B\_ij} * \left(1 + T_j\right) \right)$$

Plant capacity can be assigned to either chemical A or B, as long as plant is capable of producing both.

$$\sum_{j \in J} X_{A\_ij} + X_{B\_ij} \leq K_i * Y_i \quad for\, \forall\, i$$

Demand constraint

$$\sum_{i \in I} X_{A\_ij} = D_{A\_j} \quad for\, \forall\, j$$

$$\sum_{i \in I} X_{B\_ij} = D_{B\_j} \quad for\, \forall\, j$$

For secure XAij to be 0 when YAi=0, and secure XBij to be 0 when YBi=0

$$X_{A\_ij} \le D_{A\_j} * Y_{A\_i} \quad for \,\forall\, i,j$$

$$X_{B\_ij} \le D_{B\_j} * Y_{B\_i} \quad for \,\forall\, i,j$$

More constraints

$$Y_i \le Y_{A\_i} + Y_{B\_i} \quad for \,\forall\, i$$

$$Y_{A\_i} \le Y_i \quad for \,\forall\, i$$

$$Y_{B\_i} \le Y_i \quad for \,\forall i$$

2.3 Model completed

2.3.1 Objective Function: Minimize Z: (total cost) (in million $US)

$$\mathbf{Z} = \sum_{j \in J} \left(F_i * (0.2 + 0.8 * Y_i) + F_{A\_i} * (0.2 * Y_i + 0.8 * Y_{A\_i}) + F_{B\_i} * (0.2 * Y_i + 0.8 * Y_{B\_i}) \right)$$

$$+ \sum_{j \in J} \left(\sum_{\substack{i \in I \\ i \ne j}} C_{A\_ij} * X_{A\_ij} * (1 + T_j) + C_{B\_ij} * X_{B\_ij} * (1 + T_j) \right)$$

Subject to:

$$\sum_{j \in J} X_{A\_ij} + X_{B\_ij} \le K_i * Y_i \quad for \,\forall\, i$$

$$\sum_{i \in I} X_{A\_ij} = D_{A\_j} \quad for \,\forall\, j$$

$$\sum_{i \in I} X_{B\_ij} = D_{B\_j} \quad for \,\forall\, j$$

$$X_{A\_ij} \le D_{A\_j} * Y_{A\_i} \quad for \,\forall\, i,j$$

$$X_{B\_ij} \le D_{B\_j} * Y_{B\_i} \quad for \,\forall\, i,j$$

$$Y_i \le Y_{A\_i} + Y_{B\_i} \quad for \,\forall\, i$$

$$Y_{A\_i} \le Y_i \quad for \,\forall\, i$$

$$Y_{B\_i} \le Y_i \quad for \,\forall i$$

$$X_{A\_ij}, X_{B\_ij} \ge 0 \;\; for \,\forall\, i,j$$

$$Y_i, Y_{A\_i}, Y_{B\_i} \in \{0,1\} \; binary \quad for \,\forall\, i$$

See appendix Biopharma.xlsx the Excel file Sheet "LP_model"

Q1: How should Biopharma have used its Production network in 2005? Should any of the plants have been idled? What is the annual cost of your proposal, including import duties?

Table 2: Sales by region and production/Capacity By plant of Highcal and relax in (Million Kilograms) -2005.

			Highcal		Relax	
Region	**Plant**	**Capacity**	**Sales**	**Production**	**Sales**	**Production**
Latin America	Brazil	18	7	11	7	7
Europe	Germany	45	15	15	12	0
Asia w/o Japan	India	18	5	10	3	8
Japan	Japan	10	7	2	8	0
Mexico	Mexico	30	3	12	3	18
U.S.	U.S.	22	18	5	17	17

Sources: Authors Calculation (2013)

With a Given Production the model add two more constraints

P_{A_i}: Production of product A at plants I (in million Kg)

P_{B_i}: Production of product B at plants I (in million Kg)

$$\sum_{j\in J} X_{A\_ij} = P_{A\_i} * Y_{A\_i} \quad for\ \forall i$$

$$\sum_{j\in J} X_{B\_ij} = P_{B\_i} * Y_{B\_i} \quad for\ \forall i$$

A1: See appendix Biopharma.xlsx the Excel file Sheet “LP_model_Q1”

3. Solution Methods & Results

How should Biopharma have used its Production network in 2005?

Table 3: XA_ij, Production network

XA_ij (in million Kg)	Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.	In million Kg **production**	**Yi**	**YA_i**
Brazil	7	0	0	0	0	4	11	1	1
Germany	0	15	0	0	0	0	15	1	1
India	0	0	5	5	0	0	10	1	1
Japan	0	0	0	2	0	0	2	1	1
Mexico	0	0	0	0	3	9	12	1	1
U.S.	0	0	0	0	0	5	5	1	1
DA_j	7	15	5	7	3	18	55		

Sources: Authors Calculation (2013)

Table 4: XB_ij, Production network

XB_ij (in million Kg)	Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.	in million Kg **Produc-tion**	**Yi**	**YB_i**
Brazil	7	0	0	0	0	0	7	1	1
Germany	0	0	0	0	0	0	0	1	0
India	0	0	3	5	0	0	8	1	1
Japan	0	0	0	0	0	0	0	1	0
Mexico	0	12	0	3	3	0	18	1	1
U.S.	0	0	0	0	0	17	17	1	1
DB_j	7	12	3	8	3	17	50		

Sources: Authors Calculation (2013)

German plant Limited to produce only A

Japanese plant Limited to produce only A

The German plant has enough capacityMcNamara, G., P. Bromiley. 1997 to supply Europe Market product A, but production, raw material cost are too high. For product B, European market is supply by the Mexican plant.

The Japanese plant, for product A and B always received supplies from India, but plant in India has low capacity so can’t supply Japanese market.

Should any of the plants have been idled?

- Two options are being seriously considered:
  - Shutting down the Japanese plant
  - Limiting the German plant to a single Chemical
- Market is stable, only region Asia w/o Japan expects to grow in sales by 10% annually during the next 5years.

Table 5: Plant Capacity

		in million Kg	PRODUCTION	
Plant Capacity		Extra	PA	PB
Brazil	18	0	11	7
Germany	45	30	15	0
India	18	0	10	8
Japan	10	8	2	0
Mexico	30	0	12	18
U.S.	22	0	5	17
Totals	143	38	55	50

Sources: Authors Calculation (2013)

Surplus capacity is noted only in Japan and Germany, and the only market expected to grow 10% (0.3) is Asia w/o Japan, IncreaseRyan, A. M., L. McFarland, H. Baron, R. Page. 1999 capacity at Indian plant is an option for future. Indian plant supplies great percent of Japan Market.

Table 6: Raw materials, Production and Transportation Costs

In million $ US

RELAX	Raw materials, Production and Transportation Costs **(US$/Kg)**						Plant Fixed Cost	Highcal Fixed Cost	Relax Fixed Cost
CB_ij	Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.	**Fi**	**FA_i**	**FB_i**
Brazil	11.4	11.65	11.7	11.7	11.6	11.65	20	5	5
Germany	13.95	13.7	13.85	13.9	13.8	13.8	45	13	14
India	11	10.85	10.7	10.8	11	10.95	18	4	4
Japan	14.6	14.5	14.4	14.2	14.55	14.55	17	6	6
Mexico	11.5	11.4	11.6	11.55	11.3	11.35	30	6	6
U.S.	11.45	11.3	11.45	11.45	11.25	11.2	21	5	5

Sources: Authors Calculation (2013)

Fixed cost for Product B in Japanese Plant is lower than in German plant, so Japan plant will be idled for product B, and German plant will be limited to produce only product ASutcliffe KM, McNamara G. 2001.
What is the annual cost of your proposal, including import duties?

Adding the idled for product B at Japanese plant the Total cost is given by (in million $US):

Table 7: annual cost of the proposal

			With idled Japanese plant product B
VarCost	1100.193		1100.193
Fixed Cost	214	+ 4.8 (0.8*FB_Japan)	= 218.8
Total Cost	1314.193		1318.993

Sources: Authors Calculation (2013)

4. Conclusıon

As authors reviewed the decision analysis on this issue that have appeared in Supply Chain Management, authors have been impressed with the depth, quality, and result of decision analysis research that has supported by several in the journal. In highlighting the problem of the Supply Chain Management book, have omitted many important articles that appeared in Management Supply Chain but did not fit clearly into the research solution streams that authors chose to emphasize, as well as many important contributions published elsewhere. My choice of topics was intended to make a methods solution on decision-making research builds on the foundations of normative and descriptive research on decision-making.

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Appendıx A: Data Tables

Table 8: Sales by region and production/Capacity By plant of Highcal and relax in (Million Kilograms) - 2005

			Highcal		Relax	
Region	**Plant**	**Capacity**	**Sales**	**Production**	**Sales**	**Production**
Latin America	Brazil	18	7	11	7	7
Europe	Germany	45	15	15	12	0
Asia w/o Japan	India	18	5	10	3	8
Japan	Japan	10	7	2	8	0
Mexico	Mexico	30	3	12	3	18
U.S.	U.S.	22	18	5	17	17

Sources: Authors Calculation (2013)

Table 9: Fixed and variable Production cost at each Biopharma Plant in 2005(US$)

	Plant Fixed Cost (milliions $)	Highcal Fixed Cost (milliions $)	Relax Fixed Cost (milliions $)	Highcal Raw Material **($/Kg)**	Highcal Production cost ($/Kg)	Relax Raw Material ($/Kg)	Relax Production cost ($/Kg)
Brazil	20	5	5	3.6	5.1	4.6	6.6
Germany	45	13	14	3.9	7	5	8.5
India	18	4	4	3.6	4.5	4.5	6
Japan	17	6	6	3.9	7.5	5.1	9
Mexico	30	6	6	3.6	5	4.6	6.5
U.S.	21	5	5	3.6	5	4.5	6.5

Sources: Authors Calculation (2013)

Table 10: Transportation Costs from plants to markets (US$/Kg)

	Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.
Brazil	0.2	0.45	0.5	0.5	0.4	0.45
Germany	0.45	0.2	0.35	0.4	0.3	0.3
India	0.5	0.35	0.2	0.3	0.5	0.45
Japan	0.5	0.4	0.3	0.1	0.45	0.45
Mexico	0.4	0.3	0.5	0.45	0.2	0.25
U.S.	0.45	0.3	0.45	0.45	0.25	0.2

Sources: Authors Calculation (2013)

Table 11: Import Tariffs (Percent of Values of Product Imported, Including Transportation)

Latin America	Europe	Asia w/o Japan	Japan	Mexico	U.S.
30%	3%	27%	6%	35%	4%

Sources: Authors Calculation (2013)

Table 12: History of Exchange Rates in Currency/US$1(at the Beginning of each year)

	Brazilian real	Euro	Indian Rupee	Japanese Yen	Mexican Peso	U.S, Dollar
2005	2.7	0.74	43.47	103.11	11.21	1
2004	2.9	0.8	45.6	107	11.22	1
2003	3.5	0.96	48	119.25	10.38	1
2002	2.3	1.11	48.27	131.76	9.12	1
2001	1.95	1.06	46.75	114.76	9.72	1
2000	1.81	0.99	43.55	102.33	9.48	1

Sources: Authors Calculation (2013)