

Université Catholique de Louvain
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Coordinating Capacity Investments with Joint Ventures

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International Workshop on Supply Chain Models for Shared
Resource Management @ Brussels January 21-22, 2010

Agenda

2

- Motivations
- Related work
- The model
- Capacity-leasing contract: single leasing price
- Capacity-leasing contract: different leasing prices
- Conclusions and future research

Motivations

3

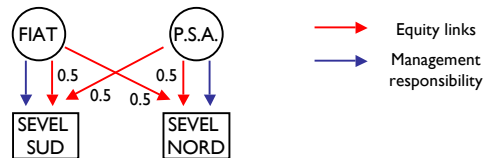
Joint venture of Fiat and PSA (1988): Multi Purpose Vehicles

- Uncertain demand with small market size (10%)
- High entry cost
- To share investment and risks



Facing the difficulty

- Investment decision Vs. operational decisions

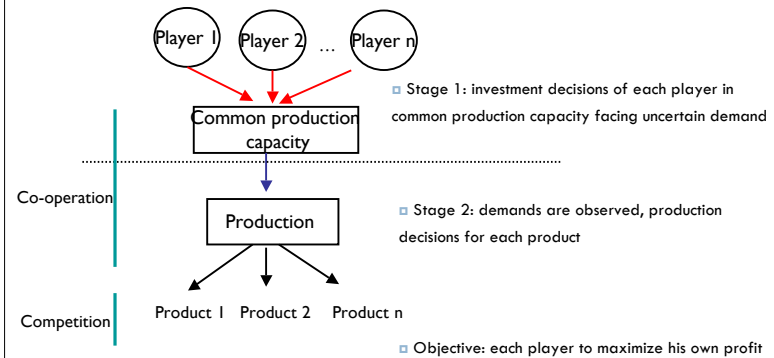


[Source: D. Jolly, 1997. Co-operation in a niche market: the case of Fiat and PSA in multi purpose vehicles. European Management Journal, Vol. 15, No. 1 , pp.35-44.]

JV: Problem formulation

4

Two-stage decision problem from the decentralized perspective



Research question

5

- To find efficient contracts that coordinate
 - (i) the joint investment decisions and
 - (ii) the product mix decisions

- The contracts should be
 - Easy to enforce
 - Efficient in their use of capacity investment
 - Incentive compatible for the different players

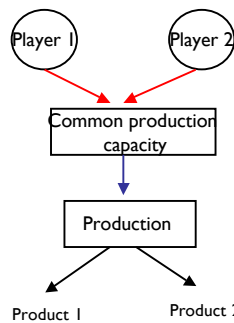
Related work

6

- Flexible capacity investment
 - Van Mieghem (2003) : review
 - Van Mieghem (1998); Harrison and Van Mieghem (1999): multidimensional news vendor model
 - Van Mieghem (1999): one-way transfer of capacity
- Supply chain contracts and coordination
 - Vertical competition: price only contracts (Lariviere and Porteus, 2001; Cachon and Lariviere 2001; Perakis and Roels, 2007); smart contracts (revenue sharing and profit sharing) ; contracts on shelf space (Martinez-de-Albeniz and Roels, 2009)
 - Horizontal competition: Netessine and Rudi (2003), Jiang, Netessine and Savin (2009)
 - Co-opetition: Anupindi, Bassok and Zemel (2001)
- Empirical studies on joint ventures
 - Cases: Nummi (GM-Toyota); FIAT-PSA; Chrysler and Fiat; etc.
 - Bai, Tao and Wu (2004)

Starting with a simple model

7



- Two players: $i=1,2$
- Two products: $p_1 > p_2$
- Random demand: D_1 and D_2
- One flexible resource with unit cost c and capacity y
- System-optimal production level: maximizing the value of the production given the capacity constraint and the realized demand
- The priority of satisfying demand D_1
 - Expected sales: $S_1(y) = E[\min(y, D_1)]$
 - $S_2(y) = S(y) - S_1(y)$, with $S(y) = E[\min(y, D_1 + D_2)]$

Analysis of existing contracts

8

□ Profit sharing contract:

- Each player gets fixed proportion of global profit
 - ⇒ Coordination of global investment
 - ⇒ No rule for sharing ratio
 - ⇒ Revenues have to be disclosed completely and shared

Analysis of existing contracts

9

- Revenue sharing contract:
 - ▣ Each player gets fixed proportion of global revenue

 - ⇒ Not possible to coordinate global investment
 - ⇒ Fixed shares will lead to under investments
 - ⇒ Proportional shares will lead to over investments
 - ⇒ Equal shares is a Nash equilibrium
 - ⇒ Revenues have to be disclosed completely and shared

Analysis of existing contracts

10

- State Dependent Transfer Prices:
 - ▣ Inventory is bought in first period, it can then be shared in second period with a transfer price that is determined based on the dual variable of the allocation problem

 - ⇒ Coordination of global investment
 - ⇒ It must always be optimal to serve the player's own market first if possible
 - ⇒ Not easy to enforce, because a lot of information is needed (demand, revenues, transfer prices, ...)

Desirable properties for JV contract

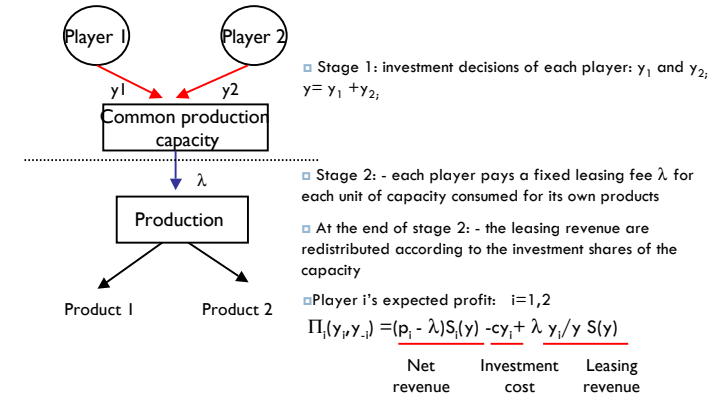
11

- Coordination
 - ⇒ Leads to optimal (coordinated) investment
- Ex-ante incentive compatible (Individual rationality)
 - ⇒ Players have incentive to cooperate in investment
- Ex-post incentive compatible
 - ⇒ Players have incentive to cooperate for operational decisions
- Easy to enforce
 - ⇒ Least sensitive to information distortion
 - ⇒ Contract parameters are fixed ex-ante

Capacity leasing contract: fixed single leasing fee

12

- Working scheme of capacity leasing contract



Nash equilibrium

13

- Existence of N.E.
 - If distribution of sum of demand is log-concave, there exists a pure-strategy Nash equilibrium in the capacity investment game under a capacity-leasing contract.

- Uniqueness of N.E.
 - If distribution of sum of demand is log-concave, there exists a unique pure-strategy Nash equilibrium in the capacity investment game under a capacity-leasing contract.

Under some technical condition on demand parameters, that is not very restrictive

Stability of the solution

14

- We can show that a very simple negotiation process will convergence to First-best Nash Equilibrium

Step 0 :
Leasing fee and initial investment proposals are fixed arbitrarily

Step 1 :
Player 1 proposes investment to maximise its own total profit

Step 2 :
Player 2 proposes investment to maximize its own total profit

Step 3 :
If player 2 changed its investment proposal, go to Step 1

Step 4 :
Both investment proposals are added
New leasing fee is computed based on global investment
Go back to Step 1 until there is no change in investment decisions

Numerical illustration

15

```
Player 2 suggests : {10, 1, 7}{-2, 8, 7}
Player 1 suggests : {14, 1, 7}{-2, 8, 7}
Player 2 suggests : {14, 1, 7}{-5, 8, 7}
Player 1 suggests : {16, 1, 7}{-5, 8, 7}
Player 2 suggests : {16, 1, 7}{-6, 8, 7}
Player 1 suggests : {17, 1, 7}{-6, 8, 7}
Player 2 suggests : {17, 1, 7}{-7, 8, 7}
Player 1 suggests : {17, 1, 7}{-7, 8, 7}
Player 2 suggests : {17, 1, 7}{-7, 8, 7}
Player 1 suggests : {17, 1, 7}{-7, 8, 7}
Players agree on : {17, 1, 7}{-7, 8, 7}
Expected sales : {3.5606, 5.52406}
Expected profit : {50.1377, 29.3614}Total : 79.4991
New lambda : {2.80852, 1.62924, 3.08212}
Player 2 suggests : {17, 1, 7}{-7, 8, 7}
Player 1 suggests : {17, 1, 7}{-7, 8, 7}
Players agree on : {17, 1, 7}{-7, 8, 7}
Expected sales : {3.5606, 5.52406}
Expected profit : {50.2695, 29.2296}Total : 79.4991
New lambda : {2.80852, 1.62924, 3.08212}
```

Desirable property analysis

16

- Coordination
⇒ OK
- Ex-ante incentive compatible (Individual rationality)
⇒ Maybe
- Ex-post incentive compatible
⇒ No
- Easy to enforce
⇒ OK

Capacity leasing contract: differentiated leasing fees

17

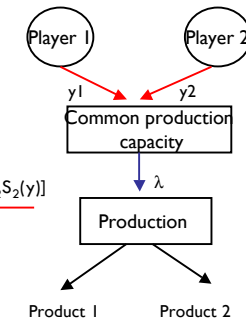
- Drawback of the fixed leasing contract:
 - When demand is revealed, the players do NOT have a common incentive to carry out the global profit maximizing production
 - It might not seem natural to the players that they pay de same price but do not have the same priority of using the capacity

Capacity leasing contract: differentiated leasing fees

18

- Differentiated leasing contract:
 - λ_1 and λ_2
- Expected profit function for player $i, i=1,2$:

$$\Pi_i(y_i, y_{3-i}) = \underbrace{(p_i - \lambda_i)S_i(y)}_{\text{Net revenue}} - \underbrace{c y_i}_{\text{Investment cost}} + \underbrace{(y_i/y) * [\lambda_1 S_1(y) + \lambda_2 S_2(y)]}_{\text{Leasing revenue}}$$



Existence of Nash Equilibrium

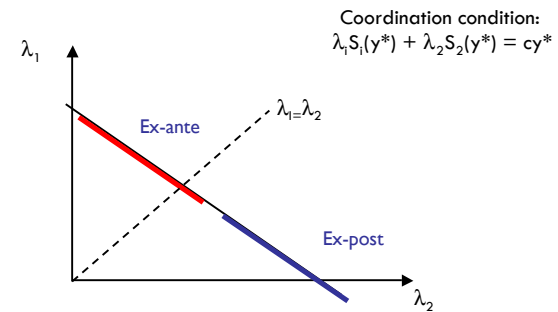
19

- Existence of Nash equilibrium
 - If $p_1 \geq \lambda_1 \geq p_2 \geq \lambda_2$, and distribution of sum of demand is log-concave, there exists a pure-strategy Nash equilibrium.

Under some technical condition on demand parameters, that is not very restrictive

Differentiated leasing fee

20



Desirable property analysis

21

- Coordination
 - ⇒ OK
- Ex-ante incentive compatible (Individual rationality)
 - ⇒ No (can be recovered with side-payment)
- Ex-post incentive compatible
 - ⇒ OK
- Easy to enforce
 - ⇒ OK

Conclusions

22

- Coordinating capacity investments and production decisions from the decentralized perspective
 - Desirable properties
- For a simplified model,
 - Capacity leasing contract
 - Fixed single leasing fee decided ex-ante.
 - Differentiated leasing fee
- Possible extensions to multiple resources, multiple players and multiple products