Production capacity planning under different procurement strategies with considering of business objectives

Sidi Wu
Department of Industrial & Management Systems Engineering
Faculty of Science & Engineering, WASEDA University, Tokyo, Japan
sidiwu@aoni.waseda.jp
Hisashi Onari
Department of Industrial & Management Systems Engineering
Faculty of Science & Engineering, WASEDA University, Tokyo, Japan

Abstract
This study concerns the production capacity planning on products and components which are on their fast-growing stage. Capacity planning Decision making model under spot contract and supply chain contract for players with different business objectives was designed to investigate the better procurement strategy by comparing with ROA and Market share.

Keywords: Supply chain, Procurement strategy, Contract

INTRODUCTION

In this paper, we focus on the manufacturers who producing the mature stage products and supplying them to the product market. In order to finish products producing, it is necessary for them to do procurement of key components to finish products producing from the component market. Market share up strategy is usually considered by these manufacturers to get more profit to extend the surviving period in such mature market with heavy price competition. To expand market share, it means, manufacturers should do investment of production capacity continuously. Price increasing and short supply of components makes the manufacturers worry about low profit achievement and over investment. Especially, while the components are on their fast-growing stage, high price fluctuation and high supply uncertainty make components procurement risk more serious. For example, like the camera manufacturers in Japan, they are under such severe environments. Camera is a mature product in Japan, a CCD image sensor can be considered as the key component of a camera, the sell price of a camera decided by the price of a sensor. Especially, price of a high-class sensor occupies a large proportion of the price of a high-class camera. CCD image sensors are also used to produce fast-growing products such as surveillance camera, security systems for automobile and so on.

We will discuss the component procurement strategies while manufacturers taking market share up strategy in this paper. Two kinds of procurement strategies of manufacturers were considered. The first one is that manufacturers do procurement from

component suppliers with spot contracts. Manufacturers and component suppliers determine the trading volume of components with the market price by negotiation after investment and production capacity preparation. The second one is that manufacturers do procurement from component suppliers with supply chain contracts. Manufacturers and component suppliers should determine the trading volume of components and trading price by negotiation before investment and production capacity preparation.

The purpose of this paper is to reveal the effectiveness of supply chain contract procurement of components while manufacturers planning the production capacity of model changing products with market share up strategy. The evaluation items are considered as ROA and market share.

LITERATURE REVIEW

With considering of the uncertainty of trading price in spot market, the decision-making model for each collaboration level of the supplier and the buyer was proposed with using a long-term supply chain contract and a short term sales contract simultaneously (Karl Inderfurth et al., 2011). Effectiveness of the proposal was proved with comparing with the supply chain total profit. In high-tech industry, it is difficult for component suppliers to expand their production capacities with constraints of investment capital. As a result, opportunity loss of whole supply chains occur due to buyers cannot get enough volume of components to meet the needs of product demand. A contract called deductible reservation was proposed. Decision making models of players with the contract was designed. Deductible reservation contract was compared with take-or-pay contract by supply chain total profit and profit of each player. The proposed deductible reservation contract was proved as the effectiveness one (Mingzhou Jin et al., 2007) between the two contracts. The two studies discussed the effectiveness of long-term supply chain contract while doing decision-making of production capacity planning under uncertain market environment. The effectiveness of contract preconditions was also discussed in many studies. Pay-to-delay contract set the trading volume and price to three levels, players will set their production capacity with considering of the preconditions about the level of volume and price (JunWu et al., 2006). Preconditions make the sales contract more flexible, and supplier and buyer can decide a fixed price of components by negotiation in the first step, trading volume can be adjusted in a decided range in the second step (Deng et al, 2002).

Many studies proposed a lot of new contract methods and preconditions of contract to hedge supply chain risks while players planning new production capacity, but few studies concerned the difference of procurement strategies. Uncertainties were taken into consideration in many previous studies, but the difference of uncertainties in mature market and fast growing market has not been revealed before.

MARKET MODEL

In this section, we will discuss the difference of market features and uncertainties between mature product market and fast growing product market.

Market Features

Figure 1 shows the demand transition of mature product market. There is almost no change of the average demand, but demand variation occurs in each period. Figure 2 shows

the price transition of mature product market. With high price competition, price decline occurs significant by time. Variation of price also occurs in each period by supply-demand unbalance.

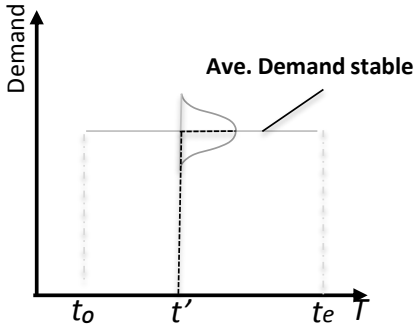


Figure 1 – Demand transition of mature mkt.

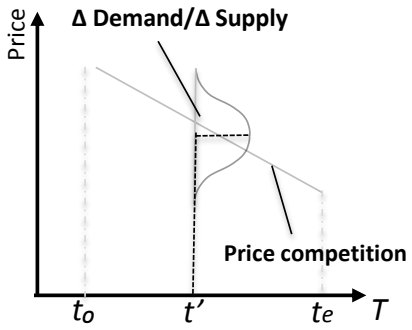


Figure 2 – Price transition of mature mkt.

Figure 3 shows the demand transition of fast-growing product market. Average demand grows by time. Demand variation also occurs in each period. Figure 4 shows the price transition of fast-growing product market. Because of demand growing faster than supply growing, the market price becomes high. Variation of price also occurs in each period by supply-demand unbalance.

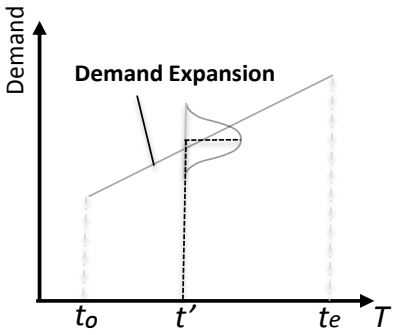


Figure 3 – Demand transition of fast-growing mkt.

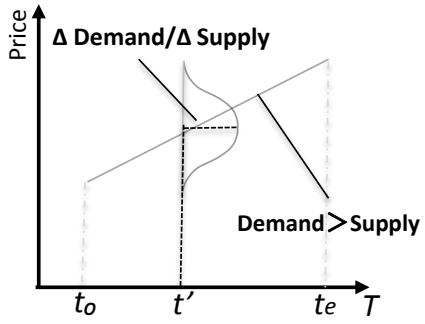


Figure 4 – Price transition of fast-growing mkt.

Uncertainties

Two kinds of uncertainties are taken into consideration in this paper.

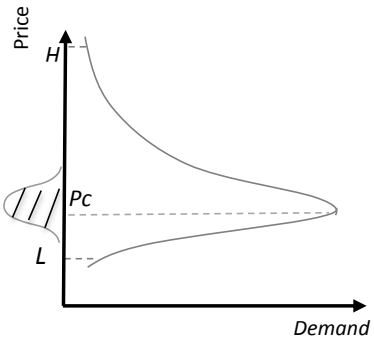


Figure 5 – Center price in mature mkt.

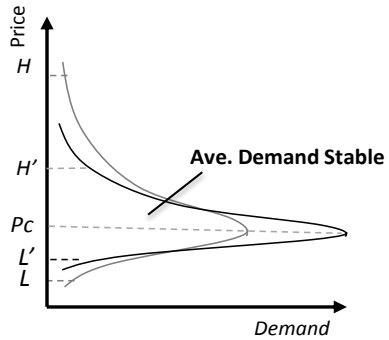
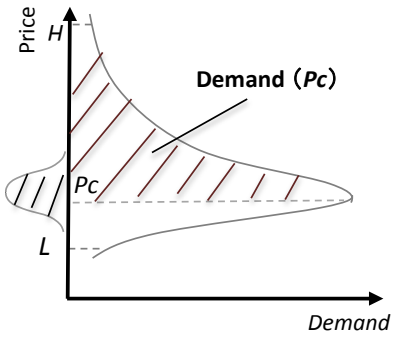


Figure 6 – Price range variation in mature mkt.



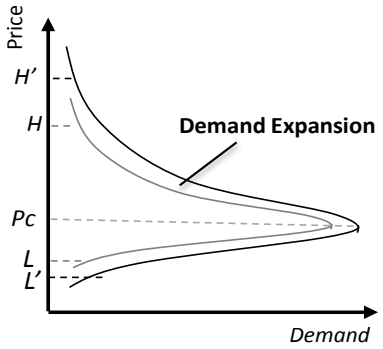


Figure 7 – Center price in fast-growing mkt. *Figure 8 – Price range variation in fast-growing mkt.*

The first one is the center price, and the second one is the variation of price range. Figure 5 shows the uncertainty of center price in mature product market. Figure 6 shows the uncertainty of variation of price range in mature product market. The range of (L, H) changes with the fixed average demand. Figure 7 shows the uncertainty of center price in fast-growing product market. Figure 8 shows the uncertainty of variation of price range in fast-growing product market. The range of (L, H) changes with demand expansion. In this paper, we use triangle to do the calculation instead of demand distribution.

CONTRACT MODEL

In this section, we will discuss the two kinds of contracts for component supply and procurement in this study. They are Spot contract and supply chain contract.

Spot Contract

Spot contract is a short term contract that a manufacturer does procurement of components with market price and the trading volume is decided by a component supplier and a manufacturer with negotiation. Usually, spot contract is to be connected by players after production capacity planning and investment. In this paper, we set the contract span as 3 month, contract cycle as 3 month, contract bucket as 3 month.

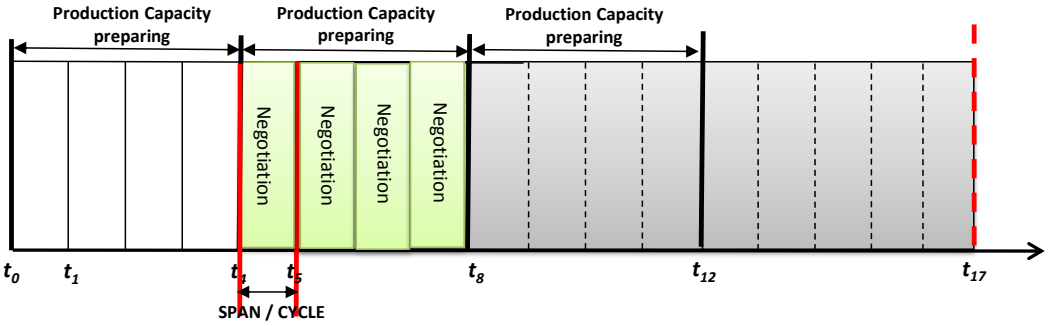


Figure 9 – Spot contract model

SC Contract

Supply chain contract is a long term contract that a component supplier and a

manufacturer decide the trading volume and trading price of components at an early time before production capacity planning and investment by negotiation. In this paper, we set the contract span as 48 month, contract cycle as 12 month, contract bucket as 3 month.

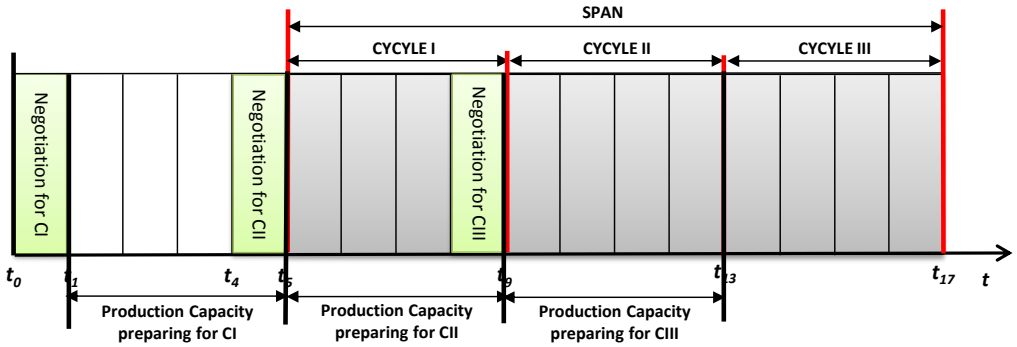


Figure 10 – Supply chain contract model

DECISION MAKING MODEL

In this section, we will discuss the decision making model of production capacity planning with spot contract and supply chain contract.

Production Capacity Planning with Spot Contract

With the estimated demand distribution of product market and supply distribution of component market, manufacturers do production capacity planning with expected profit and expected loss calculation. We consider the total value of expected profit and expected loss as the evaluation value. Manufacturers should find out the production capacity Q with the max value. Figure 11 shows the estimated demand price distribution of product market and figure 12 shows center price.

We set the range of Q as (Q_{min}, Q_{max}). Q_{min} can be calculated with the current share rate and total demand of market. Q_{max} can be calculated with the desired share rate and total demand of market. If the actual center price of product were lower than the estimated one, like P_c' in figure 12, expected share rate becomes low as well as the profit also becomes low. Otherwise, like P_c'' in figure 12, expected share can be achieved. Profit also becomes higher than the expected one.

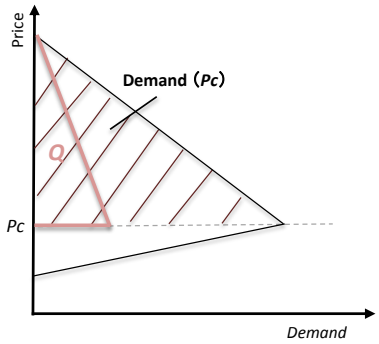


Figure 11 – Demand price distribution

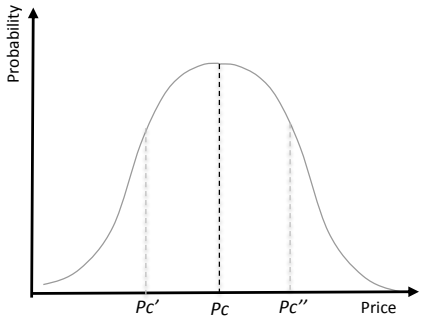


Figure 12 – Center price

Relation between demand and price can be showed with formula 1 and formula 2. Angle θ is set as a parameter to show the price elasticity of the market.

$$D = \frac{1}{2}[tan\theta \cdot (P_{max} - P')](P_{max} - P') \quad (P' \geq P_c) \tag{1}$$

$$D = \left\{D_{max} - \frac{1}{2}[tan\,\theta \cdot (P_{max} - P_c)](P_{max} - P_c)\right\} - \frac{1}{2}(P' - P_{min})\left[\frac{2D_{max}(P_c - P_{min})}{P_{max} - P_{min}}\right] + \frac{1}{2}[tan\,\theta \cdot (P_{max} - P_c)](P_{max} - P') \quad (P' < P_c) \tag{2}$$

P_{max}: Max price of market
P_{min}: Min price of market
P': The actual price in the future
P_c: Center price
D_{max}: Average total demand of market

Figure 13 shows the relation between supply and price of component market. Figure 14 shows the price rise risk in the component market which occurs by short supply to this product market.

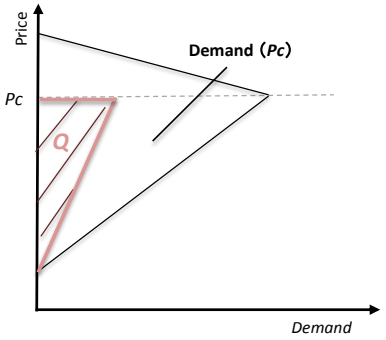


Figure 13 – Supply price distribution

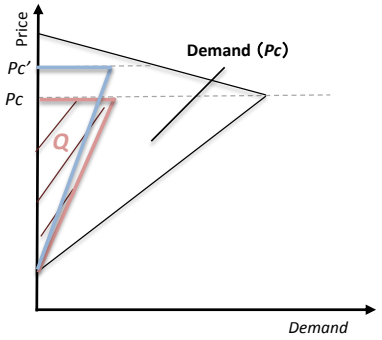


Figure 14 – Price rise with short supply

With considering of the risk and return in product market and component market. Expected profit and expected loss and value can be calculated with the formulas below:

$$\text{Expected profit} = qP'_{pc} - QP'_{cc} - Cost_m(Q) \tag{3}$$

$$\text{Expected loss} = \sum_{i=1}^{P_{pc}-Pp_{min}}[QP'_{pc} - qP_{pi}]P(P_{pi}) + \sum_{i=1}^{P_{cc}-P_{cmax}}[qP_{ci} - QP'_{cc}]P(P_{ci}) \tag{4}$$

$$\text{Value} = \text{Expected profit} + \text{Expected loss} \tag{5}$$

Q: Candidate production capacity $Q = Q_0(1 + r)$
Q_0: Current production capacity
r: Desired share rate for next term
q: Actual sell amount, we set it as $q = \frac{1}{2}(Q - Q_0)$
P'_{pc}: Center price of product market
P'_{cc}: Center price of component market

Pp_{min}: Minimum price of product market
P_{cmax}: Maximize price of component market
$Cost_m$: Production cost of manufacturer

After the calculation, the manufacturer will set the production capacity for next term as Q with the best value. After production capacity preparation, the manufacturer will make the order Q to the supplier.

Production Capacity Planning with SC Contract

In this paper, we set the supply chain contract parameters as max trading volume, min trading volume and the trading (contract) price. The manufacturer decide the min purchasing volume, the component supplier decide the max supply volume. The trading price is to be decided by the two players with negotiation.

The min purchasing volume can be considered as the current production volume Q_0. So the manufacturer set the min purchasing volume as Q_0. Besides Q_0, he also has to inform the supplier the expected supply volume Q of product with the desired market share rate. After achieving Q and Q_0, with estimated distribution of demand and price, the component supplier will decide the max trading volume.

Max trading volume and min trading volume can be calculated with the formulas as below:

$$Q_{min} = Q_0 \tag{6}$$

$$Q_{max} = [(1 - R)Q_{min}P'_{cc}]/Cost_s \tag{7}$$

R: Expected profit rate of component supplier
$Cost_s$: Production cost of component supplier

With the max trading volume and the min trading volume, supplier and manufacturer will decide the trading price with negotiation. It is necessary for the two players to do profit and loss calculation during the negotiation. In this paper, to simplify the negotiation process, we just set the middle price of expected price of the two players as the trading price.

With considering of the risk and return in product market and contract parameters. Expected profit and expected loss and value can be calculated with the formulas below:

$$\text{Expected profit} = qP'_{pc} - Qp - Cost_m(Q) \tag{8}$$

$$\text{Expected loss} = \sum_{i=1}^{P_{pc}-Pp_{min}} [QP'_{pc} - qP_{pi}]P(P_{pi}) \tag{9}$$

$$\text{Value} = \text{Expected profit} + \text{Expected loss} \tag{10}$$

Q: Candidate production capacity $Q \in (Q_{min}, Q_{max})$

After the calculation, the manufacturer will set the production capacity for next term as Q with the best value. So, the range of order is (Q_{min}, Q).

EXPERIMENT

In this section, we will discuss experiments and results

Experiment Instructions

Firstly, we confirmed profit achievement while the manufacturer taking share up strategy in the mature product market. Secondly, we compared spot procurement and supply chain procurement with return on asset and share up rate to confirm the effectiveness of supply chain procurement in this kind of situation. We set the trading period as 4 terms (48 month).

The Results

In the following section, we analyze the result of simulation based on simulator which was developed by VBA.

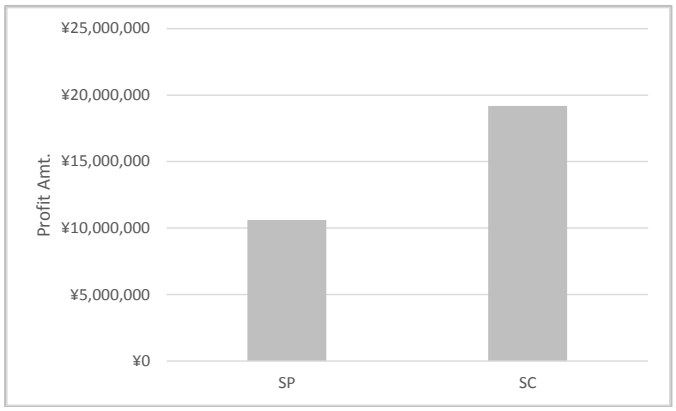


Figure 15 – Profit comparison after trading period

Figure 15 shows the profit achievement of the manufacturer with spot procurement and supply chain procurement. It is difficult for the manufacturer to expand share sustainably when deficit occurs. So, we consider that the manufacturer could not get survived while deficit occurs. During the experiment, we find that probability of deficit with spot procurement is much higher than supply chain procurement.

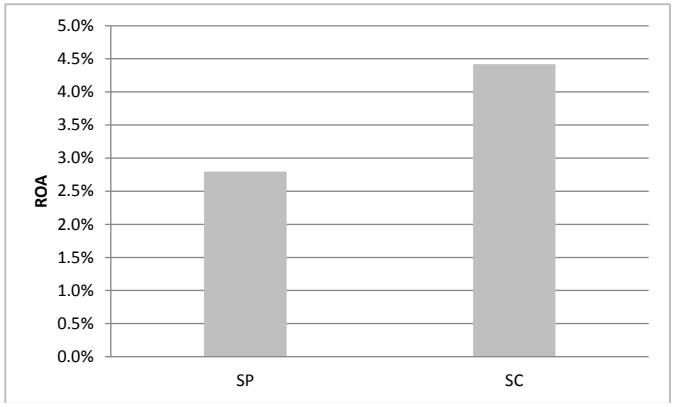


Figure 16 – ROA comparison after trading period

Figure 16 shows the ROA comparison with these two procurement methods. Because of high profit achievement and less over investment, ROA of supply chain procurement is almost 2 times as that of spot procurement.

Figure 17 shows the share rate with these two procurement methods in each trading term. It is difficult for spot procurement to expand the desired share rate of manufacturer. Especially, with the price competition of product market becoming heavy, the share rate may become lower than the initial value.

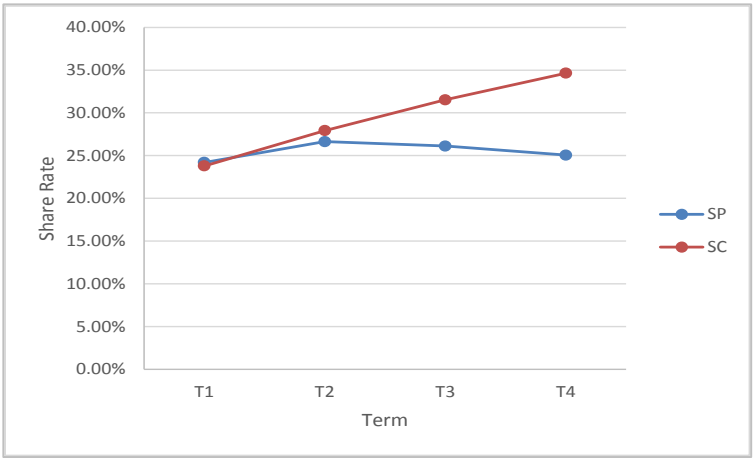


Figure 17 – Share rate comparison (each term)

DISCUSSION AND CONCLUSIONS

In this paper, we did the definition of uncertainties in mature market and fast growing market. We also create the model of short-term spot contract and long-term supply chain contract. After that, we designed the manufacturer's decision-making model of production capacity planning with both component procurement methods. Do procurement of key components in a fast growing market with high uncertainties and supply the finish product to a mature market with heavy price competition is very difficult to manufacturers. In this kind of situation, in order to get a long survival period in the product market, it is better for the manufacturer to do investment to expand the market share.

With the market model and the decision making model, we used evaluation items of profit achievement, ROA and share rate expansion to do the comparison between spot procurement and supply chain procurement. We proved the effectiveness of production capacity planning with considering of share rate up strategy by use of the supply chain contract quantitatively.

Tasks such as negotiation of the contract price, different desired share rate setting are to be discussed in our future studies.

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