Evaluation of Market Entry Tactics for Sustainable SCM by Using Agent-Based Simulation

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***Abstract*—Sustainable supply chain management (SSCM) is gathering business people's attention as more consumers see sustainability as a companies' long-term success. To realize SSCM, achieving high performance in three areas, environmental, social and financial performance, is considered to be necessary. This concept is called triple bottom line, and earning profit from SSCM activities is a key to success. One way for companies to earn profits is to provide environmentally and socially friendly goods (ES goods) to consumers who see the value of these goods. However, how to approach these customers, which are the tactics for selling these goods, is not well understood. This study develops a market model using an agent-based simulation, evaluates the possible tactics, and shows characteristics of each tactic as well as those when tactics are combined. These findings will help companies who try to enter a new ES goods market to decide which tactics they should take and how to combine them.**

***Index Terms*—Sustainable supply chain management, agent-based simulation, decision support system.**

I. Introduction

To respond to an increasing+g trend of consumers who think profits and profitability are only one element of companies' long-term success, companies start paying attention to sustainability in their activities [1], [2]. Sustainability in supply chain management (SCM) is one of them. In the sustainable SCM (SSCM), it is said that not only social and environmental but also financial aspect of the SCM is important. This is because even though goods are produced and delivered in environmentally and socially friendly ways the company cannot earn profits if the product is too expensive to attract consumers. Triple bottom line, achieving high environmental, social and financial performance, is crucial in SSCM [3], [4].

There are two types of activities that a company can take in SSCM; one is to reduce cost by introducing them, and the other is to incur additional cost by introducing them [5]. One example of the former is introducing fuel efficient vehicles for the goods transportation. By using these vehicles, the company achieve both fuel cost reduction and carbon di-oxide reduction. One example of the latter, on the other hand, is introducing organic cotton for shirt product. By using organic cotton, the company can appeal that they are eco-friendly company but the profit of the company might go down because organic cotton is more expensive than normal one.

Companies only introduce innovative technologies and/or re-engineer their business process and realize SSCM if they take activities in which profitability and social/environmental achievement co-exist. However, companies need to choose tactics carefully if they take activities in which co-existence of profitability and social/environment achievement is difficult. To earn profits by taking these activities, companies need to sell these environmentally and socially friendly goods (hereafter referred to as ES goods) to consumers who are willing to spend more money to these goods than normal ones.

There is a marketing practice called cause-related marketing (CRM), which enables companies to differentiate their goods from others and sell their goods at premium prices. In CRM, companies appeal to consumers by taking responsibility for the company's actions on environmental and social wellbeing [6], [7]. Since the objective of SSCM is to produce and deliver goods with a socially and environmentally friendly way, CRM and SSCM share the similar objectives, and we investigate CRM studies as a literature review of this study.

In CRM, researchers try to understand companies' activities that suit for CRM and how they should execute CRM. There are two types of literature in CRM. One is to identify overall benefits of CRM, and the other is more practical and to identify how companies should execute CRM, such as what kind of cause and what kind of product type they should choose. The literature in the former identified that effects of CRM include enhancing brand awareness, improving corporate image, and increasing loyalty of the customers [8], [9]. Recruit and employee retention is also considered to be a benefit of CRM [10].

The theme of the literature in the latter ranges from types of cause activities that company should choose to how they should disclose the CRM information. Pracjus et al. insisted that the effect of CRM is amplified substantially if brand of goods and the social cause are aligned [11]. Nan et al. also insisted on the importance of the brand/cause fit [12]. Chang insisted that cause subject, cause framing, and product type for CRM are mutually related and that companies should carefully choose what and how they should execute CRM [13]. Venhamme et al. provided a useful insight when practitioner choose activities for CRM. They suggested that cause for life necessities has more effective than that for life quality and that local/national cause is more effective than international one [14].

This study is also categorized in the second type since it also tries to identifies practical tactics that companies should take when entering a new market. However, this study is different from existing ones in how to see the market. The existing literature sees market to be static and try to understand benefits for companies and consumers in the

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market, whereas, our study sees market to be dynamic and try to evaluate tactics of how companies should enter the market.

This study deals with a situation in which no company has provided ES goods to a certain types of product category to potential consumers. In this case, a company who wants to sell the ES goods needs to decide which tactics to take by analyzing consumer preferences, willing to pay price as well as potential market size of the goods. We take these things into consideration in proposing a market model. Entering the existing ES goods market that has been developed by other companies is out of the scope of this study.

II. Model between Tactics and Market Share

This section proposes a market model used in this study. Since this study considers a situation where there is a potential market of a certain types of ES goods and a company enters the market as a pioneer, ultimate goal of the company is to acquire 100% share of this potential market. However, in reality it is difficult to get 100% share because the price they offer is too expensive for some of the potential customers, the number of stores that sell the goods is not enough, and/or potential customers just do not know the goods, which may be caused by a poor advertisement.

There are measures that the company can take to improve the situation. Basically what the company can do is to attract consumers who see the value of the ES goods and ask them to pay more than they pay for normal goods. This is the basic assumption of this study, and we call these measures as tactics, these consumers as potential customers, and the price difference that they are willing to cover as a premium price in this study.

This study assumes that the market share of the ES goods is expressed as a sum of effects of the individual tactics and combination of these tactics. Equation 1 shows the market share model assumed in this study.

Companies who do business in the ES goods market but not have a sufficient share spend resources (e.g., money) to increase market share, and to understand impacts of the possible tactics on the market share including the impact of the combination of them is essential to these companies. This study tries to understand the characteristics of these tactics by using an agent-based simulation.

$$P(\boldsymbol{c}, i, j, k, \cdots) = \sum_{i \in N} s_i(c_i) + \sum_{i \neq j \in N} t_{i,j}(c_i, c_j) + \sum_{i \neq j \neq k \in N} u_{i,j,k}(c_i, c_j, c_k) + \cdots \quad (1)$$

$\boldsymbol{c} = \{c_1, c_2, \cdots\}$: *Cost to execute each tactic*
N: *Set of tactics that companies can take*
$P(\,)$: *Market share*
$s_i(m)$: *Market share increase when tactic i is taken*
$t_{i,j}(m)$: *Market share increase when i, j are taken* $(i \neq j)$
$u_{i,j,k}(m)$: *Market share increase when i, j, k are taken* $(i \neq j \neq k)$

III. Evaluation Method

A. Simulation Model

This section introduces a market simulation model assumed in this study. Table I shows the agents used in this simulation.

TABLE I: Agents in Simulation

Agents	Description
Customer agent	Agents who buy goods in the subjected product category from the market - Purchase preference: The agent buys the ES goods if the price difference between the ES goods and the normal goods is smaller than its pre-defined premium price. Once the agent buys the ES goods, it continuously buys the same goods. - Search area: The agent has a pre-defined search distance and search the cheapest normal and ES goods within the area. - Location: The agent is randomly distributed in the market.
Store agent	Agents who sells goods in the subjected product category in the market - Goods: All the agents deal with normal goods, but whether the agent deals with ES goods or not is defined as a simulation parameter. - Sales price: Sales prices of both normal and ES goods are equally distributed between pre-defined uppermost and lowermost prices. The uppermost and lowermost prices of normal and ES goods are different, and those of ES goods are higher. - Location: The agent is randomly distributed in the market.
Market agent	An agent who controls the ES goods sales timing

B. Tactics for Evaluation

The tactics evaluated in this study is shown in Table II.

TABLE II: Tactics for Evaluation

Tactics	Description
Tactic 1: Increase store numbers	With this tactic, companies use resources to increase stores that sell their goods so that more potential customers have a chance to buy their goods.
Tactic 2: Reduce search cost	With this tactic, companies use resources to reduce search cost incurred to potential customers so that potential customers can find their goods with less cost. Making an advertising campaign is an example of this tactic.
Tactic 3: Increase willing to pay	With this tactic, companies use resources to make potential customers have a higher willing to pay (WTP) for the ES goods so that more potential customers choose the ES goods. Promoting the value of the ES goods is an example of this tactic.

C. Simulation Parameters

Simulation parameters used in this study is shown in Table III and IV.

TABLE III: Common Parameters

Parameters	Description
Market	A two dimensional grid with 50x50 cells is used for the market. The periodic boundary condition is employed.

Number of potential customers	Total number is 1000.
Number of stores	Total number is 100. The percentage of the stores that deals with ES goods are defined in each tactic.
Prices of goods	Prices of normal goods are equally distributed between 600 and 800 yens. Those of ES goods are equally distributed between 800 and 1000 yens.
Premium prices	A distribution proposed in [15] is used to calculate premium prices. The equation 2 shows the cumulative distribution function. This premium price is a difference between WTP for the ES goods and that of normal goods.
Lifespan of goods	Lifespan of goods is finite and equally distributed between 1000 and 1500 simulation clocks.
ES goods entry time	ES goods start selling from 200 simulation clock.

$$F(d) = \frac{1}{1+exp(\alpha+\beta d)} \quad (2)$$

$F(): Cumulative\ distribution\ function\ of\ the\ premium\ price$
$d: Price\ difference$
$\alpha, \beta: Any\ real\ number\ defined\ in\ each\ tactic$

TABLE IV: PARAMETERS USED IN EACH TACTIC

Tactics	Description
Tactic 1: Increase store numbers	To assess the impact of number of stores, the percentage of the stores that sells the ES goods is changed from 0.1 to 0.9. Default value is 0.1 of the total number of stores.
Tactic 2: Reduce search cost	To assess the impact of search cost of potential customers, search distance of customer agent is changed from 7.5 to 32.5 cells on average. The search distance is equally distributed within 5 cells. Default value is 7.5 cells, which means search distance of each agent is equally distributed between 5 and 10 cells.
Tactic 3: Increase willing to pay	To assess the impact of premium price increase of potential customers, premium prices of customer agent is changed from 150 to 250 yens on average. The value α and β of equation 2 is defined by setting 100 yen as prices difference between 95 percent and 5 percent of the cumulative distribution function.

This study uses Repast Simphony, an open source simulation software for agent-based simulation [16]. Fig. 1 shows the simulation console screen of Repast Simphony.

IV. EVALUATION

A. Parameter Validation

Before running a simulation, we verify the validity of the simulation parameters. It is assumed that the state of the market reaches an equilibrium with the normal goods before ES goods' market entry. This means potential customers can reach stores that sell the normal goods. If the condition is not met in the simulation, the number of customers who use the normal goods will decrease.

To verify the condition, we run simulation without ES goods entry. Fig. 2 shows the result. From this figure, the number of customers is 1,000 throughout the simulation period and we confirm that the simulation parameters are valid.

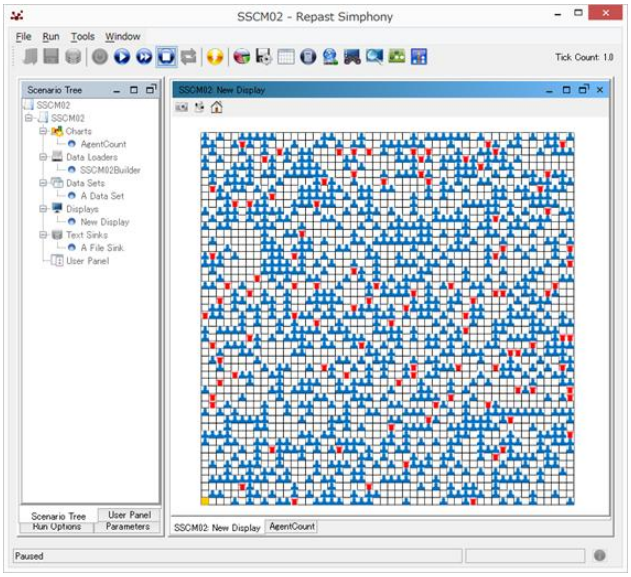

Fig. 1. Simulation console screen of repast Simphony.

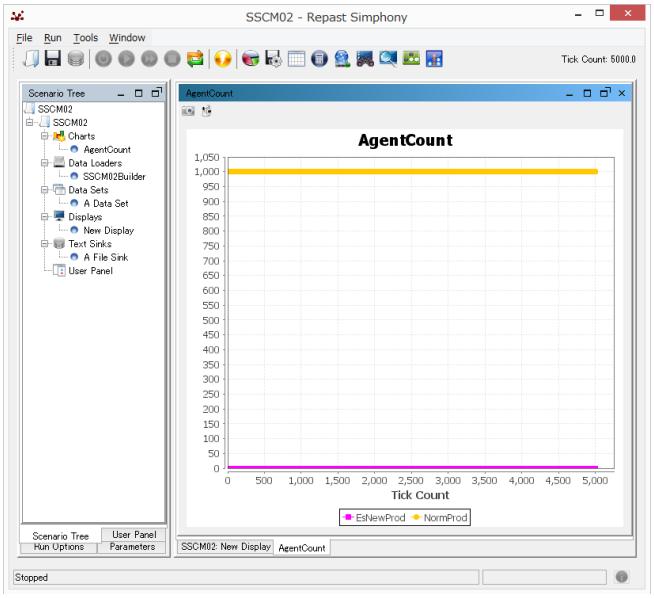

Fig. 2. Simulation parameter verification

B. Effect of Single Tactic

1) Tactic 1: Increase store numbers

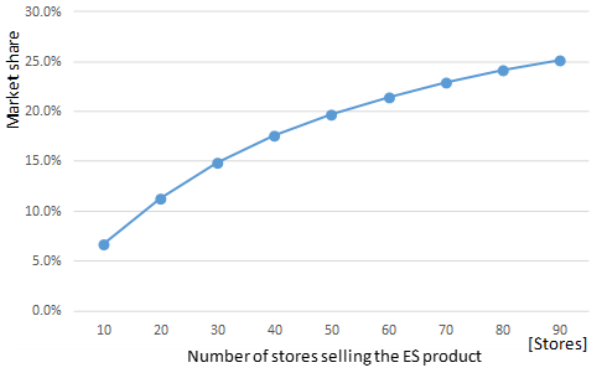

Fig. 3. Market share and number of stores in tactic 1

Fig. 3 shows the simulation result of this tactic. The market share of the ES goods is 6.7 % at the initial 10 stores and the share increases as the number of stores increases. However, the share increase is saturated as the number increases.

To assess the impact of cost to execute this tactic, we modify the figure to the relation between market share and additional stores necessary for one percent market share increase. Fig. 4 shows the result. This result finds that two additional stores are necessary to increase one percent share when market share is at around 10 %, whereas ten stores are necessary at around 25 %.

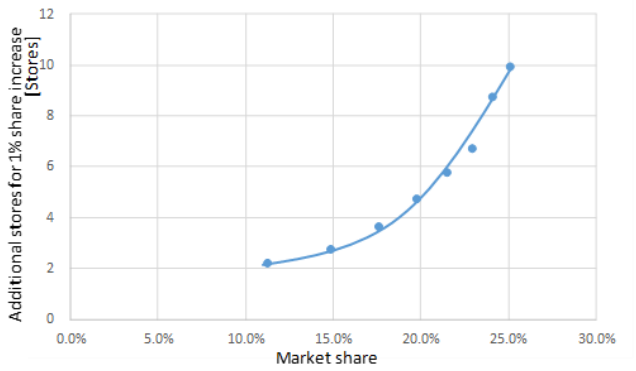

Fig. 4. Market share and additional stores for 1% share increase.

If the cost incurred to increase one store is equivalent in any market share situation, that is, the cost for eleventh store is equivalent to that for twenty first store, it is favorable to take this tactic when the market share is low. Once the company acquires the market share, the effect of this store increase tactic becomes limited.

2) Tactic 2: Reduce search cost

Fig. 5 shows the simulation result of this tactic. The market share of the ES goods is 6.7 % at the initial 7.5 cells on average and the share increases as the number of cells increases. However, the share increase is saturated around 20 cells.

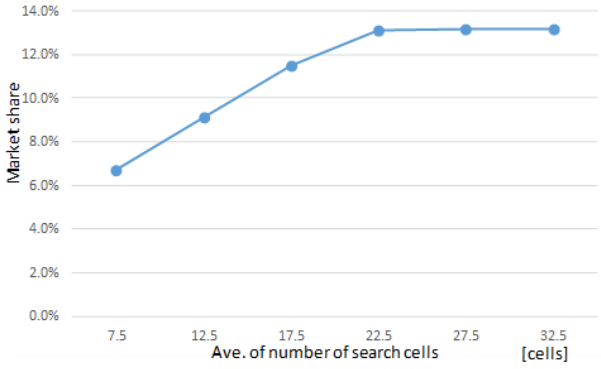

Fig. 5. Market share and average number of search cells in tactic 2.

To assess the impact of cost to execute the tactic, we modify the figure to the relation between market share and additional cells necessary for one percent market share increase. Fig. 6 shows the result. This result finds that two additional cells are necessary to increase one percent share when market share is at around 10%, whereas three cells are necessary at around 13%. In addition, market share does not increase anymore by adding search cells when the market share reaches at around 13%.

If the cost incurred to reduce search cost is equivalent in any market share situation, it is favorable to take this tactic when the market share is low. It is also noted that the reduction of search cost may not have any impact on market share when the market share reaches at a certain level.

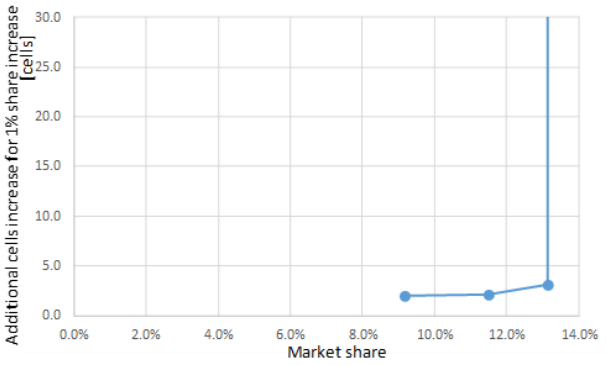

Fig. 6. Market share and additional cells for 1% share increase.

3) Tactic 3: Increase willing to pay

Fig. 7 shows the simulation result of this tactic. The market share of ES goods is 6.7 % at the initial 150 yen on average and the share increases as the premium price increases.

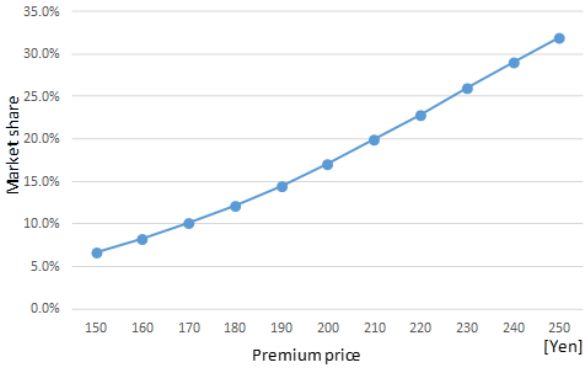

Fig. 7. Market share and premium price increase in tactic 3.

To assess the impact of cost to execute the tactic, we modify the figure to the relation between market share and additional premium price necessary for one percent market share increase. Fig. 8 shows the result. This result finds that about six-yen increase is necessary to increase one percent share when market share is at around 10%, whereas three-yen increase is necessary at around 30%. However, the decreasing trend is saturated at around three-yen increase.

If the cost incurred to increase willing to pay (WTP) is equivalent in any market share situation, that is, the cost to increase from 150 yen to 160 yen is equivalent to that from 200 yen to 210 yen, it is favorable to take this tactic when the market share is high.

From these simulation results, we see that a company that start ES goods business in a new market should spend resource to increase stores that sell their goods and/or make marketing campaign to let potential customers know and access to their goods at the beginning. Then, when the market share reaches to a certain point, the company should shift its tactics and make another campaign to let potential customers know the value of the goods to convince potential customers to increase their WTP of the goods.

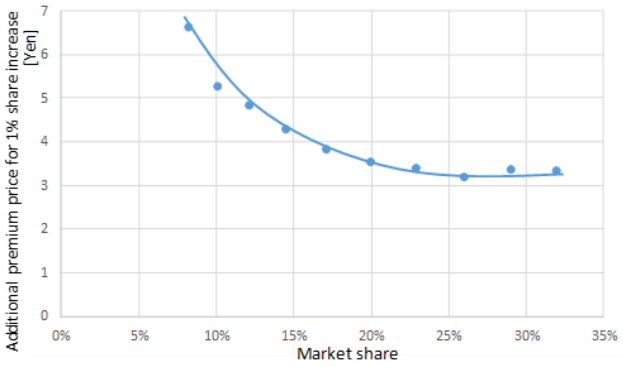

Fig. 8. Market share and additional premium price for 1% share increase.

C. Effect of Combination of Tactics

1) Combination of tactic 1 and tactic 2

To assess the combined effects of Tactic 1, to increase store numbers, and Tactic 2, to reduce search cost, we fix a search distance in three cases, 7.5 cells, 17.5 cells, and 27.5 cells, and change number of stores from 10 to 90. Fig. 9 shows the result of the simulation. Even with 7.5 cell search distance, the company needs to add relatively many stores to earn 1% market share increase, but it is almost impossible to increase market share by adding new stores with 17.5 cell and 27.5 cell search distance. Considering the result that individual tactic can increase market share in a certain extent, this combination offsets the effects of individual tactics.

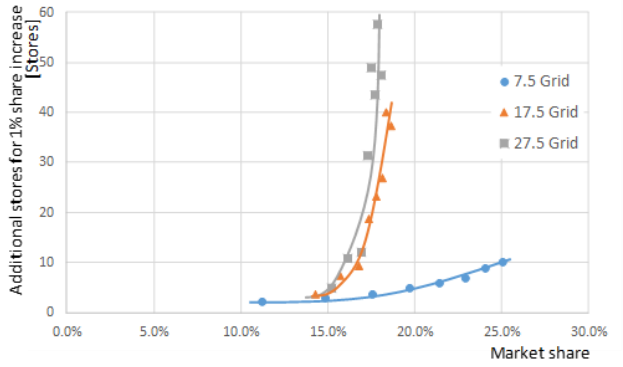

Fig. 9. Additional stores for 1% share increase in combination of Tactic 1 and Tactic 2.

2) Combination of tactic 1 and tactic 3

To assess the combined effects of Tactic 1, to increase store numbers, and Tactic 3, to increase WTP, we fix number of stores in three cases, 10 stores, 50 stores, and 90 stores, and change a premium price from 150 to 250 on average. Fig. 10 shows the result of the simulation.

From this result, the combination of two tactics, to increase number of stores and to increase WTP, has a synergy effect. Since we see that about four stores are required to increase 1% share at around 10% market share from Fig. 3, 40 store increase mean 10% increase in market share and the curve of 50 store may be shifted rightwards if the combination is mere a sum of each effect. However, the curve of 50 stores is shifted lower rightwards in the simulation, which means Tactic 1 and Tactic 3 have a positive combination effect. Since there is no significant difference between 50 store curve and 90 store curve, it is also noted that the combination effect has a limitation.

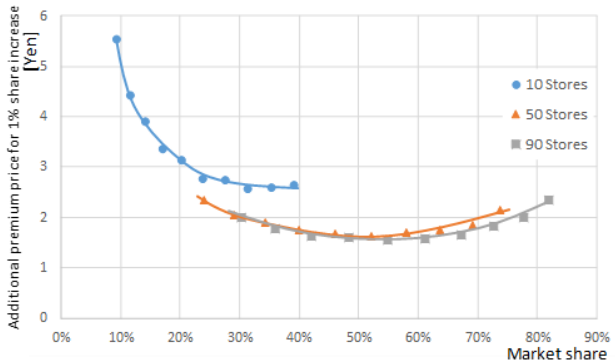

Fig. 10. Additional premium price for 1% share increase in combination of Tactic 1 and Tactic 3.

3) Combination of tactic 2 and tactic 3

To assess the combined effects of Tactic 2, to reduce search cost, and Tactic 3, to increase WTP, we fix a search distance in three cases, 7.5 cells, 17.5 cells, and 27.5 cells, and change a premium price from 150 to 250 yen on average. Fig. 11 shows the result of the simulation.

From this result, the combination of these two tactics, to reduce search cost and to increase WTP, has a synergy effect. Since we see that two or three cells are required to increase 1% share at around 10% market share from Fig. 5, 17.5 cells mean 6% increase in market share and the curve of 17.5 cells may be shifted rightwards if the combination is mere a sum of each effect. However, the curve of 17.5 cells is shifted lower rightwards in the simulation, which means Tactic 2 and Tactic 3 have a positive combination effect. Since there is no significant difference between 17.5 cell curve and 27.5 cell curve, it is also noted that the combination effect has a limitation.

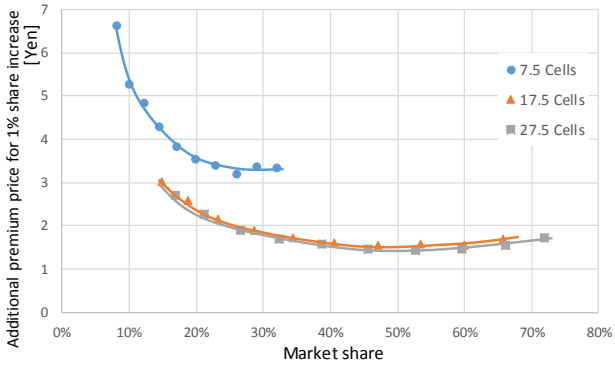

Fig. 11. Additional premium price for 1% share increase in combination of Tactic 2 and Tactic 3.

From the simulation results, we see that there are both synergy and offset effects in combination of tactics to increase market share. If a company that enter the ES market has a freedom to choose multiple tactics, they should choose a combination that has a synergy effect to effectively increase the market share of its goods.

V. Conclusion

With the increasing consumers' interests in environmental and social issues, SSCM becomes popular as a tool to realize

environmentally and socially friendly goods producton and delivery. It is said that measures to achieve three goals, environmental, social and financial goals, is important to realize SSCM. There are measures that meet both financial and environmental/social goals altogether as well as measures that incur additional cost to meet environmental/social goals. This study focuses on the latter and tries to understand the characteristics of each measure to effectively increase the market share. In this study, we call the measures as tactics and try to help company to choose the tactics.

This study not only analyze the characteristic of individual tactics but also combination of them. The tactics we evaluate are 1) to increase store numbers (Tactic 1), 2) to reduce search cost (Tactic 2), and 3) to increase WTP (Tactic 3). To evaluate these tactics, we develop a market model using an agent-based simulation. From the simulation result, we find that Tactic 1 and Tactic 2 are effective when the market share of the goods among the potential customer is relatively low, but when the share becomes high, the effects of the tactics become saturated. We also find that Tactic 3 is not so effective when the market share is low, but it becomes effective when the market share becomes relatively high. These result implies that a company should employs either Tactic 1 or 2 at the beginning, and it should shift its focus to Tactic 3 as they earn market share.

This study also evaluates the combination effects among these three tactics. First we see that the effect of Tactic 1 and Tactic 2 offset each other. The effect of the combination of these tactics is less than the mere sum of the individual effect. The effect of combination Tactic 1 and Tactic 3, and that of Tactic 2 and Tactic 3, on the other hands, has a synergy effects. The combined effect is more than the sum of the individual effect.

There is a limitation in this study. For the market we employ a 2D grid model and both potential customers and stores that sell the subjected goods are randomly distributed in the grid space. In this market model, we assume a customer only finds goods within a pre-defined search distance, since this distance search is similar to our daily purchase behavior. However, as more consumers choose to buy goods online, this distance model may not be sufficient to model actual consumer purchase behaviors. We may need to add another customer agent who searches goods based on not only distance.

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