The Conceptual Model

Motivated by the SKIN model of Gilbert, Ahrweiler and Pyka, the model presented here includes three types of agents comprising suppliers, manufacturers, and applicators (see Ahrweiler et al., 2004; Gilbert et al., 2001). The agent-based model starts with the individual decision making of the supplier. He tries to promote innovations (functionality driven, process driven, or really new) via cooperative or non-cooperative Value Chain Marketing (VCM). Next, the supplier chooses one manufacturer and/or applicator as target of his marketing attempt. The performance of a supplier's attempt is measured in terms of the acceptance and implementation of an innovation as well as the marketing resources used. The basic VCM model is extended with a representation of knowledge dynamics in and between the firms. In particular, the supplier tries to increase the marketing success by improving his knowledge base through adaptation to applicators' needs and learning.

In the next paragraphs, the elements and processes of the model are described in further detail. Existing theories and results of studies are used as the grounds in building the model. Some assumptions are specific to the coatings and sealants industry, following our results of multiple case studies. Still, the model can be extended or adapted to be used in a wider scope. The description of this conceptual model will follow the protocol developed by Grimm et al. (2006).

Purpose

The first goal of this model is to compare the marketing performance of cooperative and non-cooperative VCM. The performance is measured based on the effectiveness and efficiency. Effectiveness represents the rate of successfully implemented supplier innovations, whereas efficiency is related to money and time a supplier spends to perform his marketing attempt.

The second objective is to systematically study the effect of the newness of innovation and the knowledge overlap through a relative comparison of the marketing performance of both VCM strategies.

Entities, State Variables, and Scales

In the VCM process, there are different actors playing distinct roles. These actors are represented as agents and are conceptualized as heterogeneous agents with respect to their perceptions, actions, and particular attributes. They interact within the value chain. An agent uses its knowledge to interact according to its behavior rules in order to reach its goal. The goal of the supplier is to promote his innovation. Therefore, the supplier gets the ability to adapt his parameters of action over time. The basic variable of each agent is its kene set.

Kenes

Each agent is specialized and starts the simulation with specific attribute values and with different knowledge bases. In the VCM model, the representation of the agents' knowledge base draws on the concept of 'kene' developed by Ahrweiler, Pyka and Gilbert (2004). A kene consists of a vector containing different units of knowledge called triples. Each triple is characterized by three different elements: K, A, and E. The K in the VCM model describes the knowledge field. It represents an area in which a firm has specialized knowledge (e.g. chemical composition and transformation of materials). The second element, labeled A, refers to the amount of knowledge a firm has achieved in a specific knowledge field. The third element, labeled E, represents the expertise which reflects a firm's expertise gathered in communicating its knowledge across the respective value chain. This element is integrated to take the communication aspect of the VCM process into account.

In the VCM model, a firm's kene set consists of eight triples. A real firm might have more units of knowledge than eight triples. But a standard amount is applied to represent the small range of knowledge fields that are appropriate for specific innovations like supplier innovations. Also, it shapes up as an adequate knowledge space size which reports stable results. The focus here is on the composition of a firm's knowledge set, thereby the assumption is made that all actors have the same size of their respective knowledge set (Conti and Hoisl, 2012). Figure 1 visualizes the kene set of a firm.

$$\begin{bmatrix} K_0 \\ A_0 \\ E_0 \end{bmatrix} \begin{bmatrix} K_1 \\ A_1 \\ E_1 \end{bmatrix} \begin{bmatrix} K_2 \\ A_2 \\ E_2 \end{bmatrix} \cdots \begin{bmatrix} K_7 \\ A_7 \\ E_7 \end{bmatrix}$$

Fig. 1 A firm's kene set

The first kene component, the knowledge fields, refers to the breadth of knowledge a firm has (see Prabhu et al., 2005). Dosi et al. (2003) define organizational knowledge as the ability of an organization to perform its characteristic actions in order to develop products. These fields include the series of knowledge required to convert materials into final products (see Table 1). The Ks are sorted starting with those most related to suppliers placed in the upstream position of a value chain and ending with those most related to applicators placed in the downstream position of a value chain. An integer from 1 to 6 is assigned to each K that will be used in the mapping or calculation throughout the model.

Table. 1 Specification of the relevant agent's fields of knowledge

K	Fields of knowledge
1	Chemical properties of substances and ingredients
2	Chemical composition and transformation of materials
3	Formulation and testing of solutions
4	Converting and finishing of solutions
5	Functionality and aesthetics of final products
6	Market trends and regulations

The selection of knowledge fields is based on pilot and case study interviews as well as papers that deal with the coatings and sealants industry. Accordingly, the fields are divided into three different categories: chemical (K 1-2), technical (K 3-4), and application-related knowledge fields (K 5-6).

The second kene element, the amount of within-field knowledge, refers to the depth of understanding a firm has with regard to a specific knowledge field (Prabhu et al., 2005). It is described by qualitative degrees. Each level of knowledge amount is represented by an integer from 1 to 3 (see Table 2). Higher integer symbolizes a deeper understanding of a firm in a certain field. It represents a firm's core competence that is applied in many cases.

Table. 2 Specification of the agent's amounts of within-field knowledge

A	Amounts of within-field knowledge
1	Small amount of within-field knowledge (basic knowledge)
2	Medium amount of within-field knowledge
3	High amount of within-field knowledge (deep knowledge)

The third kene element is the expertise level, which refers to the skill level that a firm has achieved from past experience in communicating its knowledge along the value chain. As mentioned before, it is integrated to consider the communication aspect of the VCM process. Similar to the amount of within-field knowledge, the past experience is ordered into qualitative degrees (see Table 3). High degree of expertise implies that an actor has applied its knowledge in different projects.

Table. 3 Specification of the agent's expertise levels in communication

E	Expertise levels
1	Low expertise level (lack of experience in communication)
2	Medium expertise level
3	High expertise level (high experience in communication)

Marketing Concept

Another variable of the agents is their marketing concept. It corresponds to the idea of the innovation hypothesis used in the SKIN model where firms apply their knowledge to create innovations (see e.g. Ahrweiler et al., 2011, 2004).

In the VCM model, the marketing concept represents a firm's strategy or philosophy to satisfy the needs of the target market. Therefore, it describes the source a firm uses for its attempts to make profits on the relevant market. The marketing concept is built by two triples that are selected from a firm's kene set. These triples represent different business units or teams in a firm who are working together to address potential business partners. Each supplier and each applicator has his own marketing concept. Still, the idea of this concept is slightly different for these two types of agents. From the supplier's perspective, the concept (MC^S) describes the source he uses for his attempts to implement his innovation along the value

chain. On the applicator's side, the concept (MC^A) is the source he uses for his attempts to signalize his needs to direct and indirect suppliers in the value chain.

Newness of innovation

In the VCM model, the newness or type of innovation is derived using the two Ks that are available in the supplier's marketing concept (MC^S). As already mentioned, the main goal of the supplier is to satisfy expressed or future needs of customers, especially downstream customers.

If both Ks range from 3 to 4, the supplier focuses on technical fields and offers a *process-driven innovation*. If both Ks are within 5 to 6, the supplier focuses on product-related fields and tries to implement a *functionality-driven innovation*. If one of the Ks is within 3 to 4 and the other K is within 5 to 6, the supplier offers a *really new product*.

Knowledge overlap

Concerning the knowledge overlap, the knowledge similarity of two firms is measured. This value is derived from the Ks in a firm's kene set. The knowledge overlap equals the number of common Ks that belong to the two firms of interest (Conti and Hoisl, 2012). In case of non-cooperative VCM, the knowledge fields of the supplier and that of the applicator are compared. If the supplier decides to integrate the manufacturer, the knowledge fields of the supplier and the manufacturer are summed and then compared to the fields of the applicator. This is based on the fact that the manufacturer supports the supplier's attempt to implement a present innovation. The manufacturer can improve the supplier's kene set. He has experience in interacting with downstream customers as it is his daily business.

Supplier Size and Marketing Capital

In the model, a supplier is active if he has an innovation and tries to implement it. In order to perform his marketing attempt, a supplier needs to have capital, which refers to the amount of budget that can be used for marketing. Like in reality, the specific amount of capital depends on the firm's size. In the model presented here, big supplier firms have twice as much capital as "normal" supplier firms. If a supplier firm runs out of capital, it cannot perform anymore attempts.

Initialization

At the beginning of each simulation experiment, the first step is the initialization of the agents' kenes which is based on the pilot and case study results. As mentioned before, a kene represents a firm's knowledge base. In fact, it is possible that identical triples appear in a firm's kene. It shows the possibility of having more than one group in a firm which focuses on the same field of knowledge and has acquired the same amount of knowledge as well as expertise. The initialization rules are summarized in Table 4.

For every type of agent, specific rules are defined and different thresholds regarding the distribution of Ks and As are developed. This is based on the fact that suppliers, manufacturers, and applicators play different roles due to their respective position in a value chain. Suppliers have special know-how in chemical fields, manufacturers are experts in technical fields, and applicators specialize in product-related fields. In other words, every type of agent is characterized by a specific breadth of knowledge (K) and a specific depth of knowledge (A). They are more familiar with their own knowledge field than with surrounding fields. By contrast, the agent's expertise level (E) does not depend on its value-chain position. This implies that Es are distributed randomly without following any rules.

Table. 4 Initial distribution of agent's kene elements

Agent	Kene triple's element	Distribution
Supplier	K	Three of the kene triples are randomly distributed within the range of 1-2. Three of the kene triples are randomly distributed within the range of 3-6. - If the first of these three Ks is within the range of 3-4, all of these three triples are within the range of 3-4. - If the first of these three Ks is within the range of 5-6, all of these three triples are within the range of 5-6. Two of the kene triples are randomly distributed within the range of 4-6.
	A	For the triples with a K from 1-2, the A of those triples is 3. For the triples with a K from 3-6, the A is randomly distributed within the range of 1-3.
Manu-facturer	K	Four of the kene triples are randomly distributed within the range of 3-4. Two of the kene triples are randomly distributed within the range of 1-2. Two of the kene triples are randomly distributed within the range of 5-6.
	A	For the triples with a K from 3-4, the A of those triples is 3. For the triples with a K from 1-2 or 5-6, the A is randomly distributed within the range of 1-3.
Applicator	K	Five of the kene triples are randomly distributed within the range of 5-6. Three of the kene triples are randomly distributed within the range of 1-4.
	A	For the triples with a K from 5-6, the A of those triples is 3. For the triples with a K from 1-4, the A is randomly distributed within the range of 1-3.

During the initialization, the agents' marketing concepts are built from their kene sets. As mentioned before, a marketing concept describes a firm's strategy to fulfill customer needs. The goal of the supplier is to satisfy the needs of his immediate and downstream customers. Thus, his marketing concept (MC^S) is composed by two triples that provides technical (K 3 or 4) and/or product-related improvements (K 5 or 6). In other words, K is higher than or equal to 3. In addition, the two triples represent Ks which occur most often. This rule is based on the understanding that a firm builds its marketing concept based on the knowledge fields it has focused on. These fields are highly relevant in the value chain in which a firm operates. Figure 2 visualizes the formulation of a supplier's marketing concept.

In the presented kene set, it can be seen that triple-3 to -7 (highlighted in gray) are the triples with Ks higher than or equal to 3. These are the triples that are qualified to be selected into the supplier's marketing concept because they can provide a new product with enhanced productivity, resource efficiency, and product functionality. Here, K 5 and 6 are the fields which occur more than once. These fields

have main importance in the respective value chain. In building a marketing concept, one of the triples with K 5 and one with K 6 are selected randomly. Here, triple-3 and -6 are selected and represent the supplier's marketing concept.

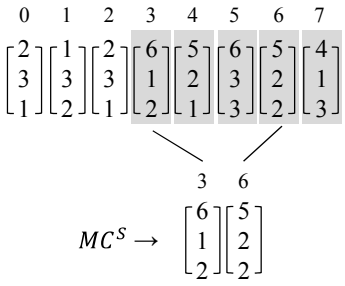

Fig. 2 Selection process of a supplier's marketing concept

Process Overview and Scheduling

After the initialization, all agents are created and ready to play their roles. The process is started by suppliers. A single process ends if there is an implementation or a rejection of the innovation. If an innovation is rejected, the supplier tries to improve his marketing concept and starts a new attempt. If possible, the supplier searches through the qualified triples ($K \geq 3$) and selects a triple with a higher A.

An example is shown in Figure 3. In the first step, the supplier selects triple-3 and -6 in his marketing concept (highlighted in light gray). Triple-3 is characterized by a low A (1). To be successful in the second step, the supplier searches for a triple with the same K (6) but a higher A (2 or 3). These conditions are fulfilled in triple-5 (highlighted in dark gray). As a result, the new marketing concept of the supplier consists of triple-5 and -6. Furthermore, E of triple-3 and triple-6 has increased by one because these triples have been used in the initial marketing concept and the supplier has obtained learning experience. He gets some feedback from (potential) customers.

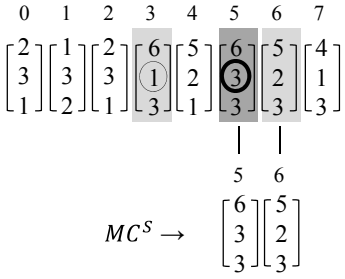

Fig. 3 Improvement process of a supplier's marketing concept

The users of the VCM model are given the options to run the process using cooperative and non-cooperative VCM. These two processes are separated to enable

a comparison of their effectiveness and efficiency. The process of each strategy is described as follows.

Non-Cooperative VCM

The process of non-cooperative VCM starts with the supplier selecting one applicator randomly as a target of his marketing attempt. A single non-cooperative process by a single supplier is visualized in a flow chart and shown in Figure 4. A detailed description of each step is given as follows.

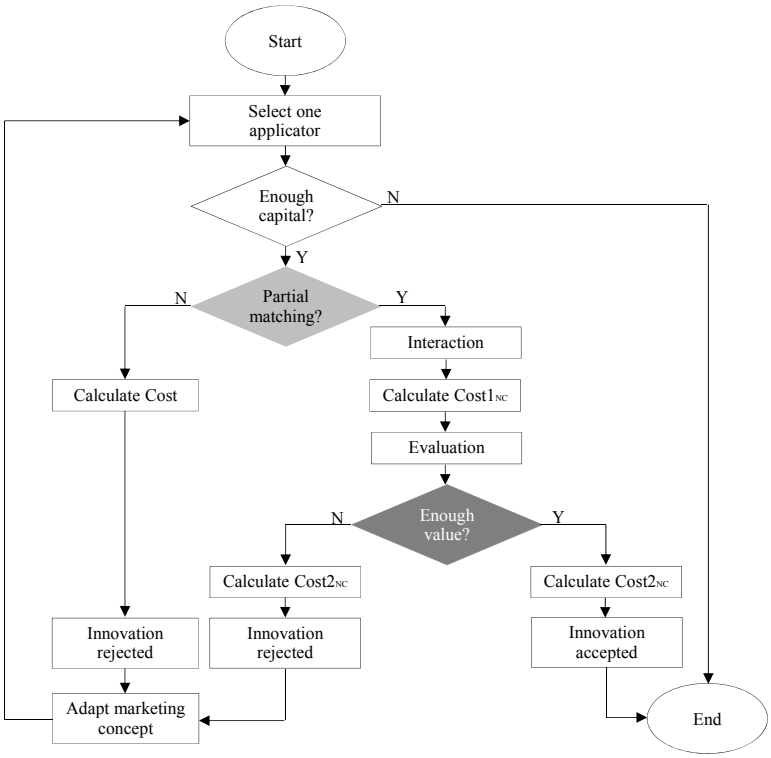

Fig. 4 Non-cooperative VCM process

Evaluation of the Marketing Objectives

At first, the supplier addresses an applicator to present his innovation and to create awareness for the new idea. The decision of the applicator to invite the supplier to gain further knowledge about the innovation depends on the comparison of the supplier's marketing objectives and his own objectives. As depicted in (1), the applicator compares the knowledge fields (Ks) used in the supplier's marketing concept (MC^S) with his own Ks used in his marketing concept (MC^A).

$$\textit{Invitation:} \begin{cases} yes, if\ K_1^S = K_1^A\ or\ K_1^S = K_2^A\ or\ K_2^S = K_1^A or\ K_2^S = K_2^A \\ no, if\ K_1^S \neq K_1^A\ or\ K_1^S \neq K_2^A\ or\ K_2^S \neq K_1^A\ or\ K_2^S \neq K_2^A \end{cases} \quad (1)$$

As mentioned, the applicator is open to supplier innovations. He does not expect a perfect match as he is interested in new ideas to solve existing and future problems as well as differentiate himself from competitors. Actually, applicators perceive suppliers as an important and attractive source of innovation. This implies that if at least one of the Ks is present in both marketing concepts, the applicator develops an interest and invites the supplier. To summarize, the supplier and the applicator must have at least one same first item on the marketing agenda.

If there is no partial match, the supplier information is not relevant to the applicator. Thus, the applicator rejects the innovation. Next, the supplier tries to adapt his concept by replacing one of the selected triples and by drawing another triple with a higher A (cf. Figure 3). Furthermore, the Es of the used triples increase by one as the supplier learn about the audience to transmit more relevant information.

Interaction Process

After comparing the marketing objectives, the interaction process between a supplier and an applicator starts. Both create a marketing message and transmit it to the other party. To create a message, the agents use their marketing concept. As mentioned before, MC^S describes the source a supplier uses for his attempt to implement his present innovation. Developing this concept into a message (M) is a mapping procedure where the Ks and the As of the marketing concept are used to compute an index number that represents the supplier's message (see Equation 2).

$$M = \sum_{i \in MC^S} (K_i \times A_i) \quad (2)$$

On the other side, the marketing concept of the applicator (MC^A) describes the source he uses to signalize his needs to the supplier. This concept is applied to generate the expected message (EM) of the applicator that is described by

$$EM = \sum_{i \in MC^A} (K_i \times A_i) \quad (3)$$

Calculation of the Non-Cooperative Marketing Cost 1 ($Cost1_{NC}$)

In non-cooperative VCM, the first cost that a supplier spends is the cost to address an applicator in order to transmit his marketing message. If the supplier tries to match M to EM, there is communication going on. Two parties could effectively communicate if they share common knowledge. In this case, the supplier could transmit his message to the applicator easier. If M and EM are totally different, the supplier would need to spend more efforts to interact. Based on this argumentation, the first cost factor in non-cooperative VCM is proportional to the difference of M and EM as depicted in (4). The equation is scaled using a constant ($C1_{NC}$) to

enable a comparison with other cost factors. More details on the cost calculation can be found in the Appendix.

$$Cost1_{NC} = (C1_{NC} \times |M - EM|) \quad (4)$$

Evaluation process

After the interaction process, the applicator attempts to judge the value the supplier innovation offers. The value as perceived by the applicator depends on the supplier's marketing performance. The applicator could sense the value of the innovation only if the supplier has a deep understanding regarding certain fields of knowledge and if the supplier is also able to transmit this understanding appropriately to the applicator. Using this argumentation, the customer value as perceived by the applicator is a function of K, A, and E.

The customer value offered by the supplier is derived from his marketing concept (MC^S). It describes the value the supplier innovation offers to the applicator. This value is proportional to his fields of knowledge (K_j) and his expertise (E_j). It can only be created with at least an average amount of within-field knowledge ($A_j \in \{2,3\}$) (see Equation 5, 6, and 7). A low amount ($A_j \in \{1\}$) does not contribute to the customer value because it refers to a missing competence of the supplier to speak on a subject.

$$CV_{NC} = \sum_{j \in MC^S} (cv_j) \quad (5)$$

where

$$cv_j = K_j \times E_j \quad \text{if} \quad A_j \in \{2,3\} \quad j \in MC^S \quad (6)$$
$$cv_j = 0 \quad \text{if} \quad A_j \in \{1\} \quad j \in MC^S \quad (7)$$

Besides the value offered by the supplier, the applicator also has a certain expected or desired value (ECV_{NC}). This expected value is what the applicator looks for in order to achieve his main goal (Flint et al., 1997). In the model, the expected value is derived from the applicator's marketing concept (MC^A). It is proportional to his fields of knowledge (K_j) and his expertise (E_j). The calculation is similar to the one of the offered value (CV_{NC}) (see Equation 8, 9, and 10).

$$ECV_{NC} = \sum_{j \in MC^A} (ecv_j) \quad (8)$$

where

$$ecv_j = K_j \times E_j \quad \text{if} \quad A_j \in \{2,3\} \quad j \in MC^A \quad (9)$$
$$ecv_j = 0 \quad \text{if} \quad A_j \in \{1\} \quad j \in MC^A \quad (10)$$

Comparison of the Offered and the Expected Customer Value

At this stage, the applicator wants to know if the value offered by the supplier meets his expected or desired value. In the VCM model, the applicator compares CV_{NC} and ECV_{NC} to make his decision to accept or reject the innovation as formu-

lated in (11). This decision is highly critical in non-cooperative VCM. The applicator accepts the innovation if the value offered by the supplier corresponds or exceeds his expected value. In this case, the applicator gains a favorable attitude toward the supplier innovation. Otherwise, the supplier innovation is rejected.

$$\textit{Acceptance:} \begin{cases} yes, if\ CV_{NC} \geq ECV_{NC} \\ no, if\ CV_{NC} < ECV_{NC} \end{cases} \quad (11)$$

Despite any rejection, the supplier has gone through a full VCM process at this stage. He has interacted with an applicator and has gained some learning (learning-by-doing). Actually, the supplier becomes more practiced and more efficient at doing what he is already doing (see Cohen and Levinthal, 1989). Therefore, he has improved his knowledge base and this shall be reflected in his kene set. The amount of knowledge and the expertise of the supplier are increased by one for the triples that have been used in the marketing concept. This, however, can only happen if there is still room for improvement, i.e. A and E are lower than 3.

Calculation of the Non-Cooperative Marketing Cost 2 ($Cost2_{NC}$)

In non-cooperative VCM, the second cost that a supplier spends is the cost to explain and demonstrate the value of his present innovation. This cost element depends on the supplier's marketing performance. Once again, the applicator could evaluate the innovation attributes only if the supplier has a deep knowledge in the relevant fields and if the supplier is able to transmit this knowledge appropriately to the applicator. In the case of supplier's inability, the value offered by the supplier will diverge widely from the value expected by the applicator. Consequently, the interaction process between the supplier and the applicator is characterized by communication problems and thus high costs.

Based on this argumentation the second cost factor in non-cooperative VCM is proportional to the difference of CV_{NC} and ECV_{NC} as depicted in (12). This implies that the bigger the difference between the offered and expected value, the higher the cost the supplier needs to spend in order to convince the applicator. The equation is scaled using a constant ($C2_{NC}$) to enable a comparison to other cost factors. More details on the cost calculation can be found in the Appendix.

$$Cost2_{NC} = (C2_{NC} \times |CV_{NC} - ECV_{NC}|) \quad (12)$$

Cooperative VCM

After having an overview of non-cooperative VCM, the different steps of cooperative VCM should be described. The special characteristic of this strategy is that the manufacturer is integrated at the beginning of the VCM process. Therefore, the supplier first selects one manufacturer randomly. The single process of cooperative VCM by a single supplier is shown in Figure 5.

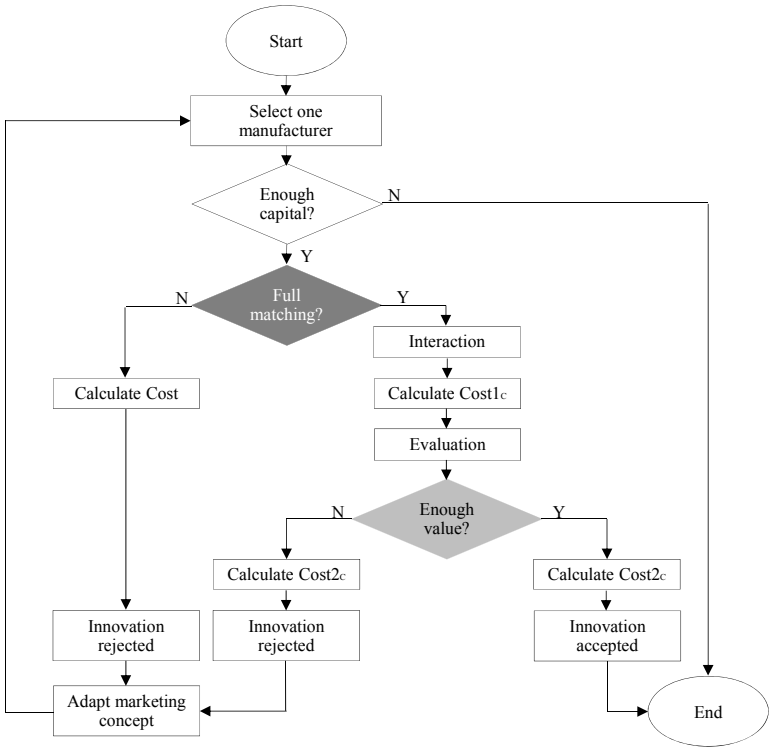

Fig. 5 Cooperative VCM process

Evaluation of the Marketing Objectives

At first, the supplier approaches a manufacturer to ask for support to implement his innovation. By early integration of the manufacturer, the supplier could take advantage of the manufacturer's knowledge. But the decision of the manufacturer to support the supplier's marketing attempt depends on his comparison of the objectives of the supplier and that of the applicator. Due to his position in the value chain, the manufacturer is well-informed on the present objectives of the supplier and the applicator. He only supports a supplier's attempt if both knowledge fields (Ks) used in the supplier's concept (MC^S) also occur in the applicator's concept (MC^A) (see Equation 13). Thus, he expects a perfect match.

$$Support: \begin{cases} yes, if\ K_1^S = K_1^A\ and\ K_2^S = K_2^A\ or\ K_1^S = K_2^A\ and\ K_2^S = K_1^A \\ no, if\ K_1^S \neq K_1^A\ and\ K_2^S \neq K_2^A\ or\ K_1^S \neq K_2^A\ and\ K_2^S \neq K_1^A \end{cases} \quad (13)$$

The manufacturer is characterized by an antagonistic attitude toward supplier innovations. He expects that the focal supplier innovation fully corresponds to the relevant applicator's needs. This implies that the applicator must require the innovation offered by the supplier. Only in this case, the manufacturer is willing to support the supplier's attempt to not place the business relationship with the appli-

cator at risk. But this threshold is hard to fulfill. If the applicator has one or two other items on his agenda, the manufacturer rejects the innovation. In this case, the manufacturer does not feel impelled to cooperate. In other words, the need uncertainty is too high. Consequently, the supplier has to start a new marketing attempt.

Interaction Process

After comparing the marketing objectives, the interaction process between the supplier, the manufacturer, and the applicator starts. First, the supplier and the manufacturer create a joint marketing message. To create this message, the supplier uses his marketing concept and the manufacturer tries to improve it (MC^{SM}) by replacing one or two of the supplier's triples with triples of his own kene set that have the same K with a higher A. This implicates that the manufacturer uses his knowledge base to reduce the distance between the supplier and the applicator.

In the model, the joint marketing concept then describes the source the supplier and the manufacturer use for their marketing attempt to jointly implement the innovation. Developing this marketing concept into a joint message ($joint\ M$) is a mapping procedure where the Ks and the As of the joint concept are used to compute an index number that represents the joint message (see Equation 14).

$$joint\ M = \sum_{i \in MC^{SM}} (K_i \times A_i) \quad (14)$$

As in the case of non-cooperative VCM, the marketing concept of the applicator is also used to generate his expected message (cf. Equation 3).

Calculation of the Cooperative Marketing Cost 1 ($Cost1_C$)

Similar to non-cooperative VCM, the first cost element that the supplier spends is the cost to address an applicator. The supplier cooperates with a manufacturer in order to transmit a joint message. The first cost factor in cooperative VCM is proportional to the difference of $joint\ M$ and EM as depicted in (15). The equation is scaled using a constant ($C1_C$) to enable a comparison to other cost factors. More details on the cost calculation can be found in the Appendix.

$$Cost1_C = (C1_C \times |joint\ M - EM|) \quad (15)$$

Evaluation process

As in non-cooperative VCM, the value of the innovation needs to be evaluated. However, the joint marketing concept (MC^{SM}) is used to describe the innovation to the applicator. As the manufacturer supports the supplier, the value as perceived by the applicator is contributed by both the supplier and the manufacturer as shown in (16), (17), and (18). The value of the innovation is proportional to the knowledge fields (K_j) and the expertise (E_j) used in the joint marketing concept (MC^{SM}). The limitation still holds: the amount of knowledge must be at least two ($A_j \in \{2,3\}$) so that the applicator could sense the value of the innovation.

$$CV_C = \sum_{j \in MC^{SM}} (cv_j) \quad (16)$$

where

$$cv_j = K_j \times E_j \quad \text{if} \quad A_j \in \{2,3\} \qquad j \in MC^{SM} \quad (17)$$
$$cv_j = 0 \quad \text{if} \quad A_j \in \{1\} \qquad j \in MC^{SM} \quad (18)$$

The customer value expected by the applicator (ECV_C) can be explained in the same way as in the case of non-cooperative VCM. The way it is calculated is also similar (cf. Equation 8, 9, and 10).

Comparison of the Offered and the Expected Customer Value

An innovation is accepted if the value offered by the supplier and the manufacturer (CV_C) is higher than or equal to the value expected by the applicator (ECV_C). Otherwise, the innovation is rejected. This evaluation process follows (19). It is the less critical step in cooperative VCM as the manufacturer supports the supplier during the whole interaction process. This implies that the supplier can profit from the manufacturer's experience in interacting with the applicator.

$$\textit{Acceptance:} \begin{cases} yes, if\ CV_C \geq ECV_C \\ no, if\ CV_C < ECV_C \end{cases} \quad (19)$$

Once again, at this stage, the supplier has performed a full VCM process and has interacted with other agents in the value chain. Therefore, the supplier's kene set is improved to reflect this learning process. The amount of knowledge and expertise of the triples used in the joint marketing concept are increased by one.

Calculation of the Cooperative Marketing Cost 2 ($Cost2_C$)

The second cost factor in cooperative VCM represents the cost needed to explain the value of the innovation to the applicator. Similar to the second cost factor in non-cooperative VCM, the cost is proportional to the difference between CV_C and ECV_C. The calculation of this cost factor follows (20). This equation is similar to other cost factor equations. The usage of the constant ($C2_C$) follows the same logic. More details on the cost calculation can be found in the Appendix.

$$Cost2_C = (C2_C \times |CV_C - ECV_C|) \quad (20)$$

Input and Output

Inputs are the environmental conditions that influence the output of the simulation. In the VCM model, there are several inputs whose values can be set by users. These inputs are listed in Table 5.

The marketing strategy (m) is selected by users to simulate cooperative VCM, non-cooperative VCM, or a mixture of both marketing strategies. The number of suppliers (N_S), the number of manufacturers (N_M), and the number of applicators

(N_A) can be adjusted to build different environments with different proportions of agent types. Some suppliers can be set to have more capital than the rest of the suppliers using the big supplier's ratio (b) input. This input is needed to create a more similar situation to the real world where there are some suppliers that are bigger than others. In addition, there is an innovation rate (r) input where the user can set the number of supplier innovations or the number of active suppliers in the model. A supplier is active if he has an innovation and tries to promote it. At last, users can set the initial marketing capital (c) owned by the suppliers.

Table. 5 List of inputs

Symbol	Description	Value
m	VCM strategy	(coop., non-coop., random)
N_S	Number of suppliers	$0 \leq N_S \leq 100$
N_M	Number of manufacturers	$0 \leq N_M \leq 100$
N_A	Number of applicators	$0 \leq N_A \leq 100$
b	Big supplier's ratio	$0 \leq b \leq 50\%$
r	Innovation rate (number of active suppliers)	$0 \leq r \leq 50\%$
c	Marketing capital	$0 \leq c \leq 50$

The outputs are the outcomes that are obtained after running the simulation model. In order to achieve the objective of this model, there are a number of outputs that need to be analyzed as listed in Table 6. The marketing success (S) is the result of the marketing attempt whether the innovation is accepted and implemented or rejected. The implementation time (IT) describes the total number of attempts by the supplier to implement his present innovation. It thus describes the duration of the implementation process. Finally, the marketing costs are to be recorded as the spent as total implementation costs (IC).

Table. 6 List of outputs

Symbol	Description	Value
S	Marketing success	(acceptance, rejection)
IT	Implementation time	$n \in Z$
IC	Implementation costs	$Sum \in R$

Multi-Agent Features

The main process in the model has been described. It serves as a generic VCM process. In the real business environment, there is always more complexity. One aspect that should be included in the model is the competition between agents. To reproduce the competition aspect, some additional features are added. These features basically enable the agents to adapt and learn during the marketing process. These will also bring more complexity in the agent's interactions.

The first feature is the supplier's preference in selecting a (potential) business partner. Once a supplier is successful in addressing an agent (i.e. manufacturer or applicator), he will remember that and will try to target this agent again. This procedure is based on the *SKIN model* where previously good experience with former contacts militates in favor of renewing a partnership (see Ahrweiler et al., 2004).

Schulze (2012) also suggests that a firm should select a partner that it is familiar with in order to get optimal results in collaboration.

Applicators also have their preference. It is possible that more than one supplier target an applicator and try to promote their innovations. In these cases, the applicator would definitely like to listen to the offers of the different suppliers and try to find which one is most suitable to his needs. Therefore, applicators are given the ability to listen and speak to a maximum of three suppliers. Each supplier goes through the same VCM process, but the final selection is based on the customer value offered by the supplier. In fact, the supplier innovation that offers the highest customer value will be accepted by the applicator. Regarding the *SKIN model*, the user selects the product with the cheapest price (see Ahrweiler et al., 2004).

Appendix

Calculation of the Non-Cooperative Marketing Cost 1 ($Cost1_{NC}$)

- Max. $Cost1_{NC} = 15$
- Condition: $K \geq 3$
- Supplier's message: $K_1^S \times A_1^S + K_2^S \times A_2^S$
  (min: $3 \times 1 + 3 \times 1 = 6$; max: $6 \times 3 + 6 \times 3 = 36$)
- Applicator's message: $K_1^A \times A_1^A + K_2^A \times A_2^A$
  (min: $3 \times 1 + 3 \times 1 = 6$; max: $6 \times 3 + 6 \times 3 = 36$)
- $\Delta M_{min} = 0, \Delta M_{max} = 30 \rightarrow C1_{NC} = 15/30$

Calculation of the Non-Cooperative Marketing Cost 2 ($Cost2_{NC}$)

- Max. $Cost2_{NC} = 15$
- Condition: $K \geq 3 \; and \; A \geq 2$
- Offered customer value: $K_1^S \times E_1^S + K_2^S \times E_2^S$
  (min: 0 if $A < 2$; max: $6 \times 3 + 6 \times 3 = 36$)
- Expected value: $K_1^A \times E_1^A + K_2^A \times E_2^A$
  (min: $0 \; if \; A < 2$; max: $6 \times 3 + 6 \times 3 = 36$)
- $\Delta CV_{min} = 0, \Delta CV_{max} = 36 \rightarrow C2_{NC} = 15/36$

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