

Analyzing and Modeling the CRM Chain—the Basis of SCM

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Abstract: This paper introduces the concept of CRM (customer relationship management) from the perspective of building Key Peoples (KPs) in the organization. The authors then analyze its relationships with SCM (Supply Chain Management) using a Markov chain model. Hence, we are able to quantify their variables, relationships and integration to obtain an optimal solution; study their behaviors and characteristics. Using various simple cases, we are also able to calculate and identify the effects on enterprise's supply chain, for example, the level of changes in process integration if the customers' downstream processes are changed or lost, moreover, the threshold values are also estimated under various hypothetical situations.

Keyword: Customer Relationship Chain Management, CRM, SCM, KP, Selling and Buying Model

INTRODUCTION

CRM (customer relationship management) and SCM (supply chain management) are currently the focus of many studies, and various authors attempt to link the two concepts together. But, in theory CRM system is a relatively hindered layer of an enterprise, i.e. a monolayered system; an enterprise cannot see the information behind its customers. Also, because the

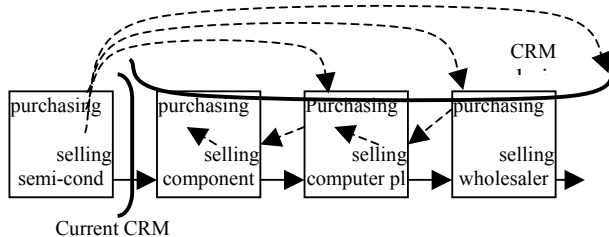


Fig. 1 “customer relationship chain”

system contains so much customer information, it is difficult for a plant to share such information with other plants. On the other hand, a supply chain also has its own personality: people who manage the business throughout the business lifetime, from its establishment to its dissolution. It is these Key Persons (KPs) who make the

decision to create, change, modify, integrate or terminate the properties and characteristics of the relationships in a supply chain. In fact, such perceptions can be shown by the state index and a diagram in Fig. 1. The next section describe some earlier works to model CRM using KPs.

Sheng Peng^[1] has proposed a sales system based on the customer as a “person” who can be analyzed psychologically. The principle is simple -- sale should sell to people. The sales enterprise should analyze the customer “person’s” characteristics, especially the customer's key person (KP), who has power or influence in decisions on purchases. In fact, the purchase of customers are closely related to the supplier's “selling point”--customer KP's “purchasing point”--customer KP's “selling point” in his own community--even the “purchasing point” of the customer's KP to that of the customer KP's “selling point.” Sheng also presents a three-state index number that can be used to describe a sales procedure. Chen, Ip, and Sheng^[2] demonstrated a comparison of this concept with the current CRM practices.

1. The Concept, Characteristics, and Its Application

Taking the customer “KP” as the aim of analysis, the base point of the thinking (and system) is to manage information across enterprises. If the enterprise has identified particular objective, the method of analysis is similar with any person in the organization. Such characteristics determine whether the system will be a single layer connecting information database in a customer relationship management system or not. If it is integrated with other planning systems, such a system will be used to manage customer relationships in the supply chain—a **Customer Relationship Chain Management (CRCM) System**.

A Singapore friend used to talk about the operations of his plant. Because competition was too severe, the quantity of products sold by the enterprise (a semiconductor plant, “S” in short) was steadily decreasing (see Fig. 1). Finally, a way was found to connect to the component plant's (C) downstream operations. The

management at the computer assembly plant (A) were persuaded to buy some products from plant C; then plant C was, in turn, persuaded to purchase plant A's products.

This is a "customer relationship chain" management problem (the problem of how to establish a supply chain). The most powerful "sales point" of the KP in plant C is the sales agreement from the sales department, because the purchasing KP in factory A makes certain that a fixed amount is purchased. Therefore the sales KP in the plant C may ask its purchasing department to purchase products from S plant, otherwise its enterprise will lose a fixed-sales contract. For same reason, plant C plant also faces the problem of a shrinking market. This is a relationship chain, led by S plant, composed of KPs

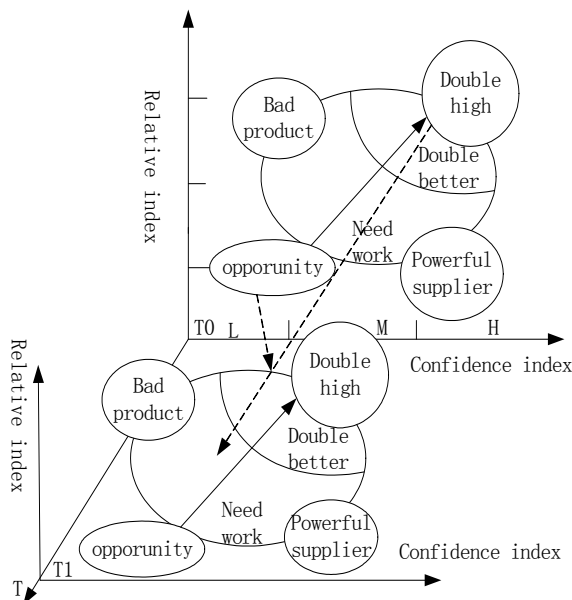


Fig. 2 Customer relationship varying on a supply from several other plants. Obviously, the KPs in the relationship chain relate to the creation and destruction of the chain, and support the chain's operations. They also monitor changes in its state.

The advantage of this approach is that it can improve integration and remove the obstacles to communication among different plants. Also, because its purpose is so clear and definite, the content of the information will not be voluminous. It can be shared with other enterprises in the supply chain, if necessary.

When we study this case study further, and assuming that we move the sales department of this semi-conductor factory using the concept of a virtual enterprise. It can be seen of composing the purchasing and selling KPs in each enterprise in the supply chain. It has a flat and even organizational structure, and is legal and reasonable. Thus, it appears to be the most attainable

and best result following the BPR (business process re-engineering) of the supply chain.

Moreover, the S plant does not need to be a pre-eminent business enterprise, because, in a similar condition themselves, most enterprises usually cannot afford to lost a supplier who whom they can make a fixed quantity of sale with a long term relationship.

When an enterprise wants to establish its supply chain, its immediate problem is how to establish a relationship with corresponding enterprises, who in those enterprises could help to establish a relationship; to determine the degree to which the relation should be developed, how to persuade others to agree to join when the enterprise is not a pre-eminent enterprise. Further questions include, for example, how to determine whether or not the supply chain can be maintained, if there are changes in management policy, where and who are involved in these changes. All of the above descriptions are questions about how to establish a supply chain and how to manage its operations. Even more difficult is that these problems are not always obvious before they emerge.

To analyze further, we need to find out if the majority of these companies in the supply chains have been established and managed in this way; on the other hand, we have not systematized a methodology, and found suitable way to evaluate and study them.

To better understand and quantify these characteristics, we can set some state index to describe the sales procedure^[1]:

Connection index (To customer): Has nothing to say (low), and only says the official words (middle), the conversation is valid (good), and no secrets are kept from each other (high);

Confidence index (To product): approval given on a case-by-case basis (low), approval given with appropriate examination (middle), approval given in big or important situations (high).

The connection index marks the degree to which a relationship has been established with a customer KP, and the confidence index marks the degree to which the customer KP approves of the selling points. These indexes establish a simplified selling process state space, and each such combination marks a selling state.

The Fig. 2 shows a state index change in a supply chain, at different times. The range from the "double high" at T0 to the "double middle" (taking the relation index and confidence index as an example) means that something bad is happening on the chain, and that the enterprise may analyze what is happening if the system can supply more information. If something wrong really does occur, the enterprise can subdivide the problem to see where it is at, such as: a key person, a purchasing standard, a buying point, a selling point, involving the

fulfillment of a promise, and so on, and to improve it. Another example, from the “double low” at T0 to the “double middle” at T1. If a new product is involved, this means that there is an opportunity for a new relationship (supply chain) to be established.

In order to develop the model, we merge the three-index set into one, and enlarge it. Take the conference index as an example: Confidence index (To product): not approve even on a case-by-case basis (very low), approve on a case-by-case basis (low), approve in medium situations (middle), approve in big or important situations (high).

2. The Mathematic Modeling

Taking an abstract of Fig. 1, we get Fig. 3. The number in Fig. 3 is not only shows the different location of plants, but also shows the degree of their relationship.

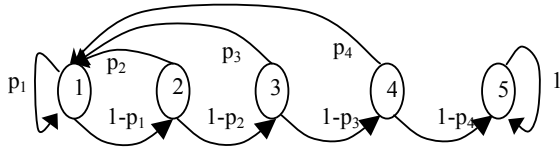


Fig. 3 Customer relationship chain and

degree. For example, class 1 plants are the S plant’s partner; they approve S’s product as their own product. Class 2 plants are general customers; they “approve in medium situations.” Class 3 plants are the customer’s customer; they know a little about the product and “approve on a case-by-case basis.” Class 4 plants know little about the product, they do “not approve even on a case-by-case basis.” Class 5 plants are plants with no connections. Here we marked the location number with the relation in Fig. 3, and divide the direct customers of S into two parts: classes 1 and 2. Therefore, the probability that the sale will be successful is different; the better the relationship, the higher the success rate. In fact, Fig. 3 should be a four-class plant with a five-state model; here, we just give a simple figure. The difference between the chain model and the relationship model, also with the same five states (between two plants) is that the rate of successful sales can be the same as in the chain case; for example, all in the state of being openly approved (see the front case). Therefore, the figure can be modeled by the Markov chain. From the above modeling procedures, it can be seen that we have established an order chain: If factory S can persuade any downstream enterprise, then all of the plants on the chain can form an order chain.

In fact, the work of applying the Markov chain to a CRM analysis has already begun. Bronnenberg^[3] tried to model and analyze consumer relationships using the Markov chain; Pfeifer and Carraway^[4] constructed several CRM models, computing and analyzing the

parameters they had been given. At the core is profit analysis. Jain and Singh^[5] conducted a rather complete survey of the area, describing its developments and future trends. What is different from Pfeifer’s view is that all states represent enterprises inside Fig. 3, and what similar is all positions in the chain can make successful deals, although, their probability of success will differ.

Initially, the relationship between the sales person and the customer can be at any position in the state of connecting; they will find it possible to make a deal at any position. Suppose that: The income is $N=40$ if that sale is successful, and that the cost M of the sale is 4. The probability of success for a one-time sale is p_i , and the profit is $N-M$, if the sale is successful; the profit will be $-M$, if the sale not successful, and the relationship goes back to earlier state. Its probability is $1-p_i$; obviously, $p_i < p_{i-1}$, $p_j = 1$, $i=1,2,\dots,j$. j is the number of a state. Suppose the sales cost is include before the sale is success or fail; when the relation goes into state 5, in this case this means that there is no connection between plant S and the customers. We can then get the following matrix and vectors: Matrix P is the one-step transition matrix, R is the reward vector, and V is the vector for expected net present value.

$$P = \begin{bmatrix} p_1 & 1-p_1 & 0 & 0 & 0 \\ p_2 & 0 & 1-p_2 & 0 & 0 \\ p_3 & 0 & 0 & 1-p_3 & 0 \\ p_4 & 0 & 0 & 0 & 1-p_4 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}; R = \begin{bmatrix} N-M \\ -M \\ -M \\ -M \\ 0 \end{bmatrix}; V = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ 0 \end{bmatrix}$$

The element of probability in the transition matrix (including in the result matrix P^2 , P^3 , P^4 , etc.) represents, to some extent, the corresponding relationship between the enterprise and the customer after one sale (or more sales). If required, we can set some threshold value or hypothesis test for those elements to be alerted for variations in the relationship before problems occur or the relationship collapses.

2.1 The Expected Income

In order to gain more practice, suppose that: the expected present value will be attenuated after each purchase connection; the attenuated factor is $d=0.2$; so the expected net present value after the j th purchase is (1):

$$V^j = \sum_{i=0}^{j-1} [(1+d)^{-i} P^i R + (1+d)^{-i-1} P^{i+1} R + \dots + (1+d)^{-j} P^j R]$$

If the infinite purchase case is considered, from (1), we have the expected net present value:

$$V = \lim_{j \rightarrow \infty} V^j = [I - (1+d)^{-1} P]^{-1} R \quad (2)$$

2.2 The Profit Analysis

2.2.1 The Profit Threshold Probability After One Purchase

Suppose in finite purchase case ($d=0$, $j=1$):

$$V^1 = \sum_{i=0}^1 P^i R = \begin{bmatrix} N + (p_1 N - 2M) \\ p_2 N - 2M \\ p_3 N - 2M \\ p_4 N - (1 + p_4)M \\ 0 \end{bmatrix} \quad (3)$$

If we want profits, we need $V^1_i \geq 0$; i.e., $p_i N - 2M \geq 0$.

Then the result is: $\bar{p}_i \geq 2M / N = 0.2$, where \bar{p}_i is the threshold probability. In this case, the salesperson could make a profit only when $p_i \geq \bar{p}_i$ ($i=2,3$).

If a salesperson plans to make a profit even in state 4, $v_4 \geq 0$, (p_4 is the least in the case of Fig. 1), from (3):

If N, M is Known: the threshold probability p_4 should be: $p_4 * N - (1 + p_4)M \geq 0$, then we have: $\bar{p}_4 \geq M / (N - M) = 0.11$, Therefore, no profit can be made on the sale when $p_4 \leq \bar{p}_4$.

If N, p_4 is known: the threshold cost $M \leq N * p_4 / (1 + p_4)$. And $M \leq N * p_4$ when p_4 is very small. The max profit is:

$$V^1_{\max} = \max \sum_1^4 v_i = \max(N + \sum_{i=1}^4 p_i N - (7 + p_4)M), (M > 0).$$

If the customer downstream effect is neglected, the chain will lost some profits and plant will lose the deal:

$$V^1_{\text{lost}} = \max\left(\sum_{i=2}^4 p_i N - (5 + p_4)M\right), \text{ when } V > 0.$$

2.2.2 The Threshold Probability And Profit Analysis To The Infinite Purchase Case

In cases where purchases are made many times, to simplify the analysis, suppose the infinite purchase case.

We can transfer equation (2) into:

$[I - (1 + d)^{-1} P] * V = R$; we then have:

$$\begin{bmatrix} (1 - \frac{p_1}{1+d})v_1 - (\frac{1-p_1}{1+d})v_2 \\ (\frac{-p_2}{1+d})v_1 + v_2 - (\frac{1-p_2}{1+d})v_3 \\ (\frac{-p_3}{1+d})v_1 + v_3 - (\frac{1-p_3}{1+d})v_4 \\ (\frac{-p_4}{1+d})v_1 + v_4 \\ 0 \end{bmatrix} = \begin{bmatrix} N - M \\ -M \\ -M \\ -M \\ 0 \end{bmatrix} \quad (4)$$

$$\text{then: } \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} v_1 \\ (\frac{p_2}{1+d})v_1 - M + (\frac{1-p_2}{1+d})v_3 \\ (\frac{p_3}{1+d})v_1 - M + (\frac{1-p_3}{1+d})v_4 \\ (\frac{p_4}{1+d})v_1 - M \end{bmatrix} \quad (5)$$

$$\text{then: } v_1 = \frac{N - (1 + q_1 + q_1 q_2 + q_1 q_2 q_3)M}{1 - p_1 - q_1 p_2 - q_1 q_2 p_3 - q_1 q_2 q_3 p_4}$$

$$\text{so: } v_4 = \frac{N * p_4 - M(1 + q_1 + q_1 q_2 + q_1 q_2 q_3) * p_4}{1 - p_1 - q_1 p_2 - q_1 q_2 p_3 - q_1 q_2 q_3 p_4} - M \quad (6)$$

Among them:

$$p_i = \frac{p_i}{1+d}; q_i = \frac{1-p_i}{1+d}; p_i + q_i = \frac{1}{1+d}; (i=1,2,3,4).$$

Because p_i is relatively independent, if we want to make profits in any state, this means that the prevent value in each state should be greater than zero. p_4 is the least. Taking p_4 as example, we can get:

$$\text{Threshold probability: } p_4 \geq \frac{M(1 - p_1 - q_1 p_2 - q_1 q_2 p_3)}{N - M(1 + q_1 + q_1 q_2)};$$

$$\text{Threshold cost: } M \leq \frac{N * p_4}{(1 + q_1 + q_1 q_2) * p_4 + (1 - p_1 - q_1 p_2 - q_1 q_2 p_3)};$$

Suppose: $p_1=0.3, p_2=0.2, p_3=0.15, M=4$; the threshold p_4 :

$$p_4 \geq \frac{0.547M}{40 - 2.375M} = 0.072;$$

If $p_4=0.05/1.2$, the threshold M : $M \leq \frac{N * p_4}{0.547 + 2.375 * p_4} = 2.58$.

Fig. 4 presents the relation between p_4 and M , when $v_4=0$. We can see that the larger the sale cost M is, the larger the p_4 is in order to obtain a positive profit. The area above the red line is the area of profits, and vice versa.

When $d=0$, then $p_i + q_i = 1, q_3 * q_4 = q_3(1 - p_4) = 1 - p_3 - q_3 p_4, 1 - p_1 - q_1 p_2 - q_1 q_2 p_3 - q_1 q_2 q_3 p_4 = q_1 q_2 q_3 q_4$.

$$v_1 = \frac{(N - M) - (q_1 + q_1 q_2 + q_1 q_2 q_3)M}{q_1 q_2 q_3 q_4};$$

$$v_4 = p_4 * \frac{(N - M) - M(q_1 + q_1 q_2 + q_1 q_2 q_3)}{q_1 q_2 q_3 q_4} - M$$

If: $p_1=p_2=p_3=p_4=p, 1 - q_i = 1 - p, d=0$; then:

$1 + q_1 + q_1 q_2 + q_1 q_2 q_3 = (1 - q^4) / p$, the result of (5) is:

$$v_1 = \frac{N}{q^4} - \frac{(1 - q^4)}{p q^4} M; v_4 = p * v_1 - M = \frac{p * N}{q^4} - \frac{M}{q^4};$$

also, we can get v_2, v_3 in this way. If p is small, $v_1 \gg v_4$.

If we turn to v_4 as the base, we obtain another result, as follows: $v_3 = p * v_1 - M + q * v_4 = (1 + q)v_4$;

$$v_4 = p * v_1 - M;$$

$$v_2 = p * v_1 - M + q * v_3 = (1 + q + q^2)(p * v_1 - M) = (1 + q + q^2)v_4$$

$$\text{then: } V = \begin{bmatrix} \frac{v_4}{p} + \frac{M}{p} & (1 + q + q^2)v_4 & (1 + q)v_4 & v_4 & 0 \end{bmatrix}^T$$

We then have the following result: $v_1 > v_2 > v_3 > v_4$, when p is small.

If information on the customer downstream information is neglected, the chain will be lost:

$$V^1_{\text{lost}} = v_2 + v_3 + v_4 = (3 + 2q + q^2)v_4$$

If v_4, p is large enough, the loss is big.

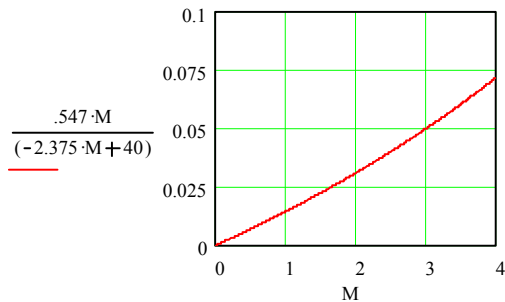


Fig. 4 the Relation between p4 and M

In general, besides promoting the success rate p_i and decreasing the sales cost M , the change in management will be helpful in increasing enterprise profits, but this is not the subject of our analysis in this paper.

3. Conclusion

We first introduced the concept of CRM, and discussed how it related to the concepts of SCM and their integration. We then modeled the relationship and analyze their relationship using a systematic mathematical model. Hence, we are able to quantify their variables and obtain an optimal solution. In today's fierce competition and buyer market, it is not very easy for an enterprise to understand and develop its supply chain. Our discussion and analysis provide an valuable approach to help enterprises improve their management, and that customer relationship management forms a very important base for SCM.

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