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A Decision Model for Information Systems Outsourcing: Using a Multicriteria Method

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ABSTRACT

An ever-increasing trend in today's firms is to exploit outsourcing for those information systems (IS) functions deemed to be outside the company's core competence. Given the multi-attribute nature of IS outsourcing decision, this paper argues that five factors, including, strategy, economics, risk, environment and quality, should be considered for IS outsourcing decisions, and proposes the use of analytic hierarchy process (AHP) and improved ELECTREIII as aids in making IS outsourcing decisions. The AHP is used to analyze the structure of the outsourcing problem and determine weights of the criteria, and the improved ELECTREIII method is used for final ranking. It shows by means of an application that the hybrid method is very well suited as a decision-making tool for the IS outsourcing decision. Finally, potential issues for future research are presented.

Keywords: *Information systems outsourcing, Multiple criteria analysis, AHP, ELECTREIII*

1. Introduction

Information systems (IS) outsourcing can be defined as "a significant contribution by external vendors in the physical and/or human resources associated with the entire or specific components of the IS infrastructure in the user organization"[1]. IS outsourcing is a growing phenomenon in a wide variety of industries. According to the Gartner Group, overall spending in information technology (IT) outsourcing reached $ 177 billion in 2003, and it is predicted to rise to $ 236 billion in 2007(Oh, 2005). Yet in many cases, outsourced IS projects have failed. For example, in one study, IS managers reported only a 33% satisfaction with outsourced IS services, as compared with a satisfaction rate of 70%-80% for outsourced non-IS services [2]. Wrong IS outsourcing decision is one of critical reasons which cause the high IS outsourcing failure [3]. Therefore, the scientific IS outsourcing decision process is very important to increase the success rate of outsourcing. The problem of how to scientifically make the IS outsourcing decisions tends to be an important issue facing organizations in today's rapidly changing business environment [4].

Business practitioners recognize that IS outsourcing is one of the many tools in their toolkit to design and manage their business and potentially has a place in most strategic plans. Although there is a wealth of academic literature examining outsourcing, it generally addresses the decision whether or not to outsource: the go/no go choice. There is little academic literature that address the IS outsourcing decision in a quantitative way. This paper will apply a hybrid of analytic hierarchy process (AHP) and improved ELECTRE III methods to the "IS outsourcing decision" in an effort to demonstrate one quantitative approach to this complex decision.

The remainder of this paper is organized into five sections. Section 2 presents a brief literature review of the existing decision models related to the IS outsourcing decision. Section 3 will briefly describe the two proposed methodologies. In section 4 we argue five factors proposed as the principal criteria for outsourcing decision. In Section 5 a description of proposed methodology is followed by an application. In Section 6, we present our conclusions and future research.

2. Literature Review

A number of decision frameworks appear in academic literature to support the outsourcing decision-making process. Lacity, Willcocks and Feeny (1996) argued that deciding the outsourcing of IT activities just by strategic or commodities was fallacious and senior executives might mistakenly classify all IS activities as commodities. Therefore, they presented a 2x2 decision matrix guiding the selection of outsourcing candidates based on the business, economic, and technical factors[5].

Venkatraman (1997) viewed information technology as a portfolio of IS elements that were cost centers, service centers, investment centers and profit centers (which are collectively referred to as an IS "value centers"). His focus on "four independent sources of value from IS resource" is useful for identifying IS elements that might be considered for outsourcing [6].

Yang and Huang (2000) argued that five factors, including management, strategy, economics, technology and quality, should be considered for outsourcing decision, then they used the analytic hierarchy process (AHP) method to help users in structuring the outsourcing problems[7].

Roy and Aubert (2002) presented an IT outsourcing decision model based on the resource theory[8]. Hsu *et al* (2004) analyzed the IS outsourcing decision problems by case-based reasoning (CBR) method[9]. Aubert *et al* [2004] proposed an IT outsourcing decision model relied on transaction costs and incomplete contracts theories[10].

According to the above-mentioned literature, researchers put so many outsourcing decision strategies and determinants to practitioners, but current practice remains in the stage of conceptual discussion as to how to outsource the IS activities. Furthermore, only the AHP method offers a quantitative magnitude for judgment among these strategies and determinants. But AHP approach has the disadvantage that the number of pairwise comparisons to be made, may become very large (more specifically: n(n-1)/2). Another critical disadvantage of the AHP method is that compensation between good scores on some criteria and bad scores on other criteria can occur. Other strategies or determinants, for instance, decision matrix, transaction cost or CBR method, are too narrow to help the practitioners determine if their systems could be outsourced or to examine the priorities among many potential IS outsourcing projects. Ineffective outsourcing activities, derived from improper strategy or method, would lead to loss core competencies and capabilities, exposure to unexpected risk and business failures.

Facing the problem of how to decide the priority of those IS which have been decided to outsource, we propose a hybrid multi-criteria decision method for the IS outsourcing decision making. We shall use the AHP method to analyze the structure of the outsourcing problem and determine the weights of criteria, and use the improved ELECTRE III method for final ranking. The purpose of this work is to offer a quantitative decision model that can help practitioners set priority and reap the most benefits from outsourcing.

3. The AHP and Electre III Method

3.1. The AHP Method

The AHP, developed by Saaty (1980)[11], is a technique for considering data or information about a decision in a systematic manner [12]. The AHP mainly addresses how to solve decision problems with uncertainty and with multiple criteria characteristics. It is based on three principles: first, constructing the hierarchy; second, priority setting, and third, logical consistency.

3.1.1. Construction the hierarchy

A complex decision problem, centered round measuring contributions to an over objective or focus, is structured and decomposed into sub-problems (sub-objectives, criteria, alternatives, etc), within hierarchy.

3.1.2. Priority setting

The relative "priority" given to each element in the hierarchy is determined by comparing pairwise the contribution of each element at a lower level in terms of the criteria (or elements) with a causal relationship exists. In AHP multiple paired comparisons are based on a standardized comparison scale of nine levels (see Table 1, Saaty 1980).

Table 1. Scale of Relative Importance

Intensity of importance	Definition
1	Equal importance
2	Weak
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, very strong
9	Extreme importance

Let $C = \{C_j \mid j = 1, 2, \cdots, n\}$ be the set of criteria. The result of the pairwise comparison on n criteria can be summarized in a $(n \times n)$ evaluation matrix A in which every element a_{ij} is the quotient of weights of the criteria, as shown in (1).

$$A = (a_{ij}), (i, j = 1, \cdots, n) \tag{1}$$

The relative priorities are given by the right eigenvector (w) corresponding to the largest eigenvector ($\lambda_{\max}$), as shown in (2).

$$Aw = \lambda_{\max} w \tag{2}$$

In case the pairwise comparisons are completely consistent, the matrix A has rank 1 and $\lambda_{\max} = n$. In that case, weights can be obtained by normalizing any of the rows or columns of matrix A.

The procedure described above is repeated for all subsystems in the hierarchy. In order to synthesize the various priority vectors, these vectors are weighted with the global priority of the parent criteria and synthesized. This process starts at the top of the hierarchy. As a result, the overall relative priority to be given to the lowest level elements is obtained. These overall, relative priorities indicate the degree to which the alternatives contribute to the focus. These priorities represent a synthesis of the local priorities, and reflect an evaluation process that permits to integrate the perspectives of the various stakeholders involved [13].

3.1.3. Consistency check

A measure of consistency of the given pairwise comparison is needed. The consistency is defined by the relation between the entries of A: $a_{ij} \cdot a_{jk} = a_{ik}$. The "consistency index" (CI) is given by (3).

$$\mathrm{CI} = (\lambda_{\max} - n)/(n-1) \tag{3}$$

The final consistency ratio (CR), on the basis of which one can conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the consistency index (CI) and the random consistency index (RI), as indicated in (4). The number 0.1 is the accepted upper limit for CR. If the final consistency ratio exceeds the number, the evaluation procedure has to be repeated to improve consistency. The measurement of consistency can be used to evaluate the consistency of decision makers as well as the consistency of all the hierarchy.

$$\mathrm{CR}=\mathrm{CI}/\mathrm{RI} \tag{4}$$

3.2. The ELECTRE III Method

3.2.1. The normal ELECTRE III method

ELECTREIII method is a non-compensatory, MCDM technique. It uses various mathematical functions to indicate the degree of dominance of one alternative or group of alternatives over the remaining ones. It also facilitates comparisons between alternative schemes by assigning weights to decision criteria. The outranking relationships between alternatives are constructed and exploited eventually.

A discrete multiple criteria decision making problem is usually formulated by a set of alternatives $X=\{x_1,x_2,\cdots;x_n\}$, a set of criteria $C=\{c_1,c_2,\cdots,c_m\}$ and a set of functions $G=\{g_1,g_2,\cdots,g_m\}$. The real-valued functions defined on the set X so that $g_l(x_j)$ represents the performance of the alternative x_j on the criterion c_l . Without loss of generality we assume that all the objective functions are to be maximized.

A *pseudo-criterion* is a preference model including three different thresholds: a preference threshold $p_l(g_l(x_j))$, an indifference threshold $q_l(g_l(x_j))$ and a veto threshold $v_l(g_l(x_j))$ for each criterion $C=\{c_1,c_2,\cdots,c_m\}$. These thresholds may be constants, linear or affine functions of $g_l(x_j)$ in the form [14].

$$p_l(g_l(x_j)) = \alpha_{p,l} + \beta_{p,l} g_l(x_j)$$

and $q_l(g_l(x_j)) = \alpha_{q,l} + \beta_{q,l} g_l(x_j)$

For every criterion c_l , the preference and indifference threshold model is as follows. x_i is preferred to x_j if

$g_l(x_i) \succ g_l(x_j) + p_l(g_l(x_j))$

x_i is weakly preferred to x_j if

$g_l(x_j) + q_l(g_l(x_j)) \prec g_l(x_i) \le g_l(x_j) + p_l(g_l(x_j))$, and x_i is indifferent to x_j if

$g_l(x_j) + q_l(g_l(x_j)) \ge g_l(x_i)$ and

$g_l(x_i) + q_l(g_l(x_i)) \ge g_l(x_j)$

Where $p_l(g_l(x_j))$ and $q_l(g_l(x_j))$ are preference and indifference thresholds, respectively and $p_l(g_l(x_j)) \succ q_l(g_l(x_j)) \succ 0$. Weak preference is supposed to describe the decision maker's hesitation between indifference and preference.

In ELECTRE III method, one considers an outranking degree $S(x_i, x_j)$ describing the outranking credibility of x_i over x_j taking its values between 0 and 1. The value of $S(x_i, x_j)$ is defined based on so-called concordance and discordance indices. A concordance index $C(x_i, x_j)$ is computed for each pair of alternatives (x_i, x_j) by

$$C(x_i, x_j) = \frac{1}{w}\sum_{l=1}^{m} w_l c_l(x_i, x_j) \tag{5}$$

Where $w_l (l = 1, \cdots, m)$ is the weight of each criterion, and

$$w = \sum_{l=1}^{m} w_l \tag{6}$$

$$c_l(x_i, x_j) = \begin{cases} 1 & g_l(x_i) + q_l(g_l(x_i)) \ge g_l(x_j) \\ 0 & g_l(x_i) + p_l(g_l(x_i)) \le g_l(x_j) \\ \dfrac{p_l(g_l(x_i)) + g_l(x_i) - g_l(x_j)}{p_l(g_l(x_i)) - q_l(g_l(x_i))} & \text{otherwise} \end{cases} \tag{7}$$

A discordance index $d_l(x_i, x_j)$ is defined for each criterion c_l by

$$d_l(x_i, x_j) = \begin{cases} 1 & g_l(x_i) + v_l(g_l(x_i)) \le g_l(x_j) \\ 0 & g_l(x_i) + p_l(g_l(x_i)) \ge g_l(x_j) \\ \dfrac{g_l(x_j) - g_l(x_i) - p_l(g_l(x_i))}{v_l(g_l(x_i)) - p_l(g_l(x_i))} & \text{otherwise} \end{cases} \tag{8}$$

where $p_l(g_l(x_i))$ is the preference threshold value and $v_l(g_l(x_i))$ is the veto threshold value of each c_l and $v_l(g_l(x_i)) \succ p_l(g_l(x_i))$.

Finally, the degree of outranking is defined by

$$S(x_i,x_j)=\begin{cases} C(x_i,x_j) & d_l(x_i,x_j)\le C(x_i,x_j) \quad \forall l \\ C(x_i,x_j)\bullet \prod_{l\in J(x_i,x_j)} \dfrac{1-d_l(x_i,x_j)}{1-C(x_i,x_j)} & J(x_i,x_j) \end{cases} \tag{9}$$

where $J(x_i,x_j)$ is the set of criteria for which $d_l(x_i,x_j)\succ C(x_i,x_j)$. The complete set of outranking degree is assembled as shown in the following credibility matrix $\boldsymbol{S}$.

$$\boldsymbol{S}=\begin{bmatrix} S(x_1,x_1) & S(x_1,x_2) & \cdots & S(x_1,x_n) \\ S(x_2,x_1) & S(x_2,x_2) & \cdots & S(x_2,x_n) \\ \vdots & \vdots & \vdots & \vdots \\ S(x_n,x_1) & S(x_n,x_2) & \cdots & S(x_n,x_n) \end{bmatrix} \tag{10}$$

The ranking of the decision alternatives in ELECTRE III is carried out by a distillation procedure, where the alternatives are ranked based on their qualification from the best to the worst (descending distillation process) and from the worst to the best (ascending distillation process).The final partial order of the alternatives is built based on these two complete orders. The descending distillation process is as follows.

Let $\lambda=\max_{x_i,x_j\in X} S(x_i,x_j)$. Determine a "credibility value" such that only values of $S(x_i,x_j)$ that are sufficiently close to λ are considered; that is, $\lambda-s(\lambda)$. Thus if $\lambda=1$, let $s(\lambda)=0.15$. Define the matrix $\boldsymbol{T}$ as:

$$\boldsymbol{T}(x_i,x_j)=\begin{cases} 1 & \text{if} \quad S(x_i,x_j)\succ \lambda-s(\lambda) \\ 0 & \text{otherwise} \end{cases} \tag{11}$$

Further, define the qualification of each alternative – $Q(x_i)$ – as the number of alternatives that are outranked by x_i minus the number of alternatives which outrank x_i. $Q(x_i)$ is simply the row minus the column sum of the matrix $\boldsymbol{T}$. The set of alternatives having the largest qualification is the first distillate of D_1. If D_1 contains only one alternative, repeat the previous procedure with $X\setminus D_1$. Otherwise, apply the same procedure inside D_1. If distillate D_2 contains only one alternative, the procedure is started in $D_1\setminus D_2$ (unless the set is empty); otherwise it is applied within D_2, and so on until D_1 is used up. The procedure is then repeated starting with $X\setminus D_1$. The outcome is the first preorder.

The ascending distillation is carried out in a similar fashion except that alternatives with the smallest (rather than the largest) qualification are retained first.

3.2.2. An improved ranking method for ELECTRE III

The normal ranking of ELECTRE III requires an additional threshold to be introduced. The weakness of this handing is that the ranking of the alternatives depends on the size of this threshold for which there exists no "correct" value. Additionally, the final ranking is not complete.

Aiming at the ranking problems in ELECTRE III, we present a new ranking method by introducing three definitions — concordance credibility degree, discordance credibility degree and net credibility degree, into ELECTRE III method.

Definitions

The concordance credibility degree is defined by

$$\Phi^+(x_i)=\sum_{x_j\in X} S(x_i,x_j), \quad \forall x_i\in X \tag{12}$$

The concordance credibility degree is the measure of the outranking character of x_i (how x_i dominates all the other alternatives of X)

The discordance credibility degree is defined by

$$\Phi^-(x_i)=\sum_{x_j\in X} S(x_j,x_i), \quad \forall x_i\in X \tag{13}$$

The discordance credibility degree gives the outranked character of x_i (how x_i is dominated by all the other alternatives of X)

The net credibility degree is defined by

$$\Phi(x_i)=\Phi^+(x_i)-\Phi^-(x_i), \quad \forall x_i\in X \tag{14}$$

The net credibility degree represents a value function, where a higher value reflects a higher attractiveness of alternative x_i.

Final ranking

All the alternatives can be completely ranked by the net credibility degree.

An application

This application is based on a real-life case study where the ELECTRE III method was use to help choose route for Dublin port motorway [15].

The first credibility matrix in [15] is as follows:

$$S_1 = \begin{bmatrix} & \text{B2/B3} & \text{B4} & \text{B6} & \text{B5/7it} & \text{B5/7bt} & \text{B5/7ht} & \text{B8} \\ \text{B2/B3} & - & 0.625 & 0.75 & 0.875 & 0.875 & 0.875 & 0.875 \\ \text{B4} & 0.875 & - & 1 & 1 & 1 & 0.875 & 0.875 \\ \text{B6} & 0.875 & 1 & - & 1 & 1 & 0.875 & 0.875 \\ \text{B5/7it} & 0.875 & 0.875 & 0.875 & - & 0.875 & 0.875 & 0.875 \\ \text{B5/7bt} & 0.875 & 1 & 1 & 1 & - & 0.875 & 0.875 \\ \text{B5/7ht} & 0.75 & 0.875 & 0.875 & 0.875 & 0.875 & - & 1 \\ \text{B8} & 0.688 & 0 & 0 & 0 & 0 & 0 & - \end{bmatrix}$$

The final ranking based on the normal method is as follows [15]:

$$\{\text{B4,B6,B5/7bt}\} \rightarrow \{\text{B2/B3,B5/7hb}\} \rightarrow \{\text{B5/7it,B8}\}$$

With S_1 and (12)-(14) leads to the final values of concordance credibility degree, discordance credibility degree and net credibility degree of alternatives in Table 2.

Table 2. Degrees of alternatives (S_1)

	Φ^+	Φ^-	Φ
B2/B3	4.875	4.938	– 0.063
B4	5.625	4.375	1.25
B6	5.625	4.5	1.125
B5/7it	5.25	4.75	0.5
B5/7bt	5.625	4.625	1
B5/7ht	5.25	4.375	0.875
B8	0.688	5.375	– 4.687

The final ranking based on the new method is as follows:

$$\text{B4} \rightarrow \text{B6} \rightarrow \text{B5/7bt} \rightarrow \text{B5/7ht} \rightarrow \text{B5/7it}$$
$$\text{B5/7it} \rightarrow \text{B2/B3} \rightarrow \text{B8}$$

The second credibility matrix in [15] is as follows:

$$S_2 = \begin{bmatrix} & \text{B2/B3} & \text{B4} & \text{B6} & \text{B5/7it} & \text{B5/7bt} & \text{B5/7ht} & \text{B8} \\ \text{B2/B3} & - & 0.45 & 0.61 & 0.81 & 0.81 & & \\ \text{B4} & 0.93 & - & 1 & 1 & 1 & 0.93 & 0.93 \\ \text{B6} & 0.93 & 1 & - & 1 & 1 & 0.93 & 0.93 \\ \text{B5/7it} & 0.93 & 0.97 & 0.97 & - & 0.97 & 0.93 & 0.93 \\ \text{B5/7bt} & 0.93 & 1 & 1 & 1 & - & 0.93 & 0.93 \\ \text{B5/7ht} & 0.75 & 0.82 & 0.82 & 0.82 & 0.82 & - & 1 \\ \text{B8} & 0.69 & 0 & 0 & 0 & 0 & 0 & - \end{bmatrix}$$

The final ranking based on the normal method is as follows [15]:

$$\{\text{B4,B6,B5/7it,B5/7bt}\} \rightarrow \text{B5/7ht} \rightarrow \text{B2/B3} \rightarrow \text{B8}$$

With S_2 and (12)-(14) leads to the final values of concordance credibility degree, discordance credibility degree and net credibility degree of alternatives in Table 3.

The final ranking based on the new method is as follows:

$$\text{B4} \rightarrow \text{B6} \rightarrow \text{B5/7bt} \rightarrow \text{B5/7it} \rightarrow \text{B5/7ht}$$
$$\text{B5/7ht} \rightarrow \text{B2/B3} \rightarrow \text{B8}$$

From above comparison, the final ranking based on the new method is complete ranking, while the normal is partial ranking.

Table 3. Degrees of alternatives (S_2)

	Φ^+	Φ^-	Φ
B2/B3	4.29	5.16	– 0.87
B4	5.79	4.24	1.55
B6	5.79	4.4	1.39
B5/7it	5.7	4.63	1.07
B5/7bt	5.79	4.6	1.19
B5/7ht	5.03	4.53	0.5
B8	0.69	5.52	– 4.83

The normal ranking method of ELECTRE III suffers from the complicated ranking process, which requires an additional threshold to be introduced. The weakness of this handing is that the ranking of the alternatives depends on the size of this threshold for which there exists no "correct" value. Additionally, the normal ranking method also suffers from incomplete ranking result. Aiming at the ranking problems in ELECTRE III, the present research develops a new ranking method. Compare to the normal ranking method, the new ranking method is simple and ranking result is complete.

4. Performance Criteria

There have been a lot of attempts to find out all factors of outsourcing decision, but the problem has not been theoretically solved. The choice of factors has been selected in agreement with a group of experts and managers. Another group might have selected a somewhat different set of factors. Firms should select all factors which can affect organizations benefit as possible as they can. A careful examination of factors used before concludes that five dimensions, strategy, economics, risk, environment and quality, should be included.

4.1. Strategy

For strategy, firms need to focus on their core activities and outsource noncore activities. IS outsourcing allows management to focus available IS talent on important and strategic IT applications rather than the mundane and routine activities. The internal operations and outsourced operations should then work in unions striving to optimize flexibility and responsiveness to customer and internal needs, and minimize unnecessary paperwork and bureaucracy. In addition, the firms can make strategic alliance with vendors to make up the shortage of resources; resources include new technologies and professional workers. From strategic alliances, the firm even can develop and market new products. Other strategic consideration includes sharing risks and accelerating the time of product to market [5][7][16][17][18][19].

4.2. Economics

For economics, the major consideration of a firm is to reduce costs of information systems. Because the vendors have a better management skill as well as higher productivity per employee, the costs can be reduced. Meanwhile, Because of the scale of economics vendors have invested in the hardware, software and human resources, the cost can be reduced. Another consideration of economics is financial flexibility. Because of outsourcing, the facilities and employee would be transferred to the vendor side, which transform fixed costs into variable costs, resulting in increasing financial flexibility [7][9][20][21].

4.3. Risk

For risk, it is rare to experience opportunities in organizational life where the managerial actions taken to produce benefits are not associated with potential risks either. This is most certainly the case with IS outsourcing. The most prominent risks in outsourcing are information security concerns and loss of management control. Khalfan [2004] noted theses two factors were coupled with hidden costs in outsourcing [22].

If a labor union exists, a firm should first explore its negative effect before deciding to outsource, since outsourcing is accompanied with some possibility of layoffs. Companies often have to deal with low employee morale as a result of outsourcing, and low employee morale in turn affects productivity. It has been noted that often a large proportion of IT staff are laid off as a consequence of an outsourcing contract. This can cause a lot of disturbance in the client company.

Other risks that have to be dealt with include: loss of core competence, loss of internal technical knowledge, loss of flexibility, damaging the firm's innovative capability, increasing information services management complexity, etc [23][24]. As being the factors with benefits, these risks factors should not be ignored in outsourcing activities [25] [26].

4.4. Environment

Quinn and Hilmer [1994] indicated that environment factors such as market maturity, market depth, and the number of suppliers influences the level of outsourcing [16]. There are times when contestability explains market maturity; a contestable market means that while only a few firms can immediately provide the service now, many other firms are intending to provide the service if the price paid by the firm exceeds the average cost of vendors. In addition, the decision to outsource may be induced by imitative behavior among firms [27]. For example, Kodak's outsourcing decision made many other firms begin to consider IS outsourcing as a viable alternative [28].

4.5. Quality

For quality, because vendors may have access to more technological environments, have more qualified or more motivated personnel, provide a greater breadth of services, and simply be more committed than internal staff to making the alliance with the customer work well, outsourcing can improve the quality and services of the internal IS department. Therefore, good quality of service and good relationship are the significant success factors of outsourcing [7] [25[29].

5. An Application

Based on IS outsourcing decision problem presented in Section 1, an example is used to illustrate how the combined AHP and improved ELECTREIII model support decision maker on the IS outsourcing decision making.

5.1. The Problem Faced

A bookstore wants to outsource parts of IT functions, they think about the management and cost issues and want to know how to decide which systems should be outsourced first.

The candidate systems for outsourcing are facilities management (P1), development of internet homepage (P2), maintenance of the customer relationship management information system (P3), development of the supplier relationship management information system (P4), development and maintenance of the online transaction processing system (P5).

The leader of the task force is the vice president, while members include IS department manager, a senior engineer, business department manager, finance department manager, planning department manager and five professional consultants. The vice president convened a meeting to discuss this problem. After some discussion, they employ the hybrid of AHP and ELECTRE III methods in the decision process.

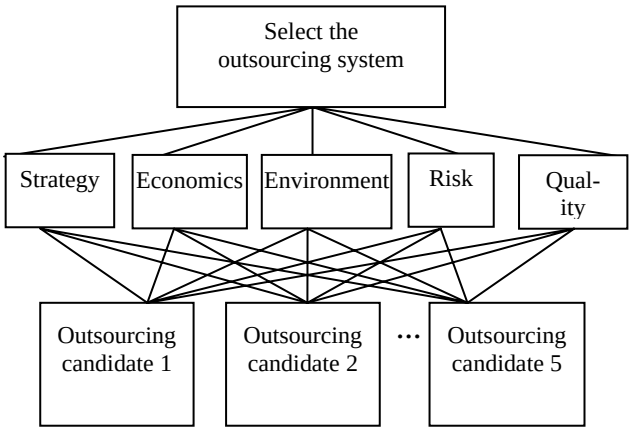

Figure 1. The Hierarchy Structure of the Problem

5.2. Structure of the Problem

After some debate, according to the AHP method, the

task force depicts a hierarchy structure as shown in Figure 1.

5.3. Determination of the Weights

Following the computing method described in the AHP, experts began to compare the factors of the structure. After that, they got the square matrix as shown in Table 4.

Table 4. The Square Matrix. (C1- Strategy; C2- Economics; C3- Environment;C4- Risk;C5- Quality)

	C1	C2	C3	C4	C5
C1	1	3	4	2	4
C2	1/3	1	1	1/3	1
C3	1/4	1	1	1/3	1
C4	1/2	3	3	1	3
C5	1/4	1	1	1/3	1

According to (1)-(4), we got

$\lambda_{\max} = 5.0394$

$RI = 1.12$

$CR = 0.0088 < 0.1$

$w = (0.41, 0.11, 0.10, 0.28, 0.10)$

5.4. Evaluation of Alternatives

All outsourcing candidates were evaluated by experts. According to the criteria of strategy, environment, risk and quality, a qualitative impact value is used, expressed on a qualitative scale (judgment on a series of ordered semantic values; each semantic value included in the set {very weak, weak, common, good, very good} is associated with a numerical value {1, 3, 5, 7, 9}, that is used for the calculations.). The economics indicator is evaluated by the following formula:

Saving costs / Costs of in house development and maintenance (%).A 5×5 matrix was produced, as shown in table 5.

Table 5. Evaluation Matrix (C1- Strategy; C2- Economics; C3- Environment;C4- Risk;C5- Quality)

Criteria	C1	C2	C3	C4	C5
Max/Min	Max	Max	Max	Min	Max
Weight	0.41	0.11	0.10	0.28	0.10
P1	9	15	9	1	9
P2	7	12	7	3	7
P3	3	8	3	7	3
P4	7	15	5	5	7
P5	7	10	7	7	5

5.5. Final Ranking

Before using the ELECTRE III method to calculate the indices, for each criterion's thresholds is defined (see table 6).

Table 6. The Thresholds of Each Criterion

	q	*p*	*v*
Strategy	2	3	8
Economics	2	4	8
Environment	2	3	4
Risk	2	3	7
Quality	2	3	6

According to (5)-(9), we get the outranking degree matrix $\boldsymbol{S}$:

$$\boldsymbol{S} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 0.94 & 1 & 1 & 0.94 & 1 \\ 0 & 0 & 1 & 0.15 & 0 \\ 0 & 1 & 1 & 1 & 1 \\ 0.26 & 0.72 & 1 & 0.89 & 1 \end{bmatrix}$$

According to (12)-(14), we got the values of leaving, entering and net flows and the complete ranking of alternatives in table 7 and in figure 2.

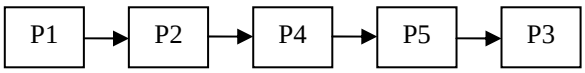

Figure 2. Final Ranking

The priorities for outsourcing the five IS are in the following order: facilities management (P1), development of internet homepage (P2), development of the supplier relationship management information system (P4), development and maintenance of the online transaction processing system (P5), maintenance of the customer relationship management information system (P3). If the bookstore want to outsource two IS activities first, we know that the facilities management and development of internet homepage would be outsourced.

Table 7. Values of Leaving, Entering and Net Flows

	Φ^+	Φ^-	Φ
P1	4	1.20	2.80
P2	3.88	2.72	1.16
P3	0.15	4	-3.85
P4	3	2.98	-0.02
P5	2.87	3	-0.13

6. Conclusions and Future Researches

IS outsourcing is emerging as a flexible and powerful

management approach chosen by managers to achieve a wide range of tactical and strategic goals. Outsourcing firms benefit from cost savings, strategic fitness, improved management effectiveness, technology upgrade, and the service quality of IS. Moreover, one needs an operational decision model that can offer systematic steps and quantitative results to increase the precision of decision-making.

This study suggests a decision model for IS outsourcing adoption for management, and shows how it may be applied in a real decision process for IS outsourcing. This research also argues that firms need to consider more dimensions, including economics, strategy, risk, environment and quality factors. Meanwhile, we offer a decision model, which developed by AHP and improved ELECTRE III methods, to help the practitioners make better decisions. Our approach allows to deal with IS outsourcing project selection involving several conflicting performance criteria (qualitative as well quantitative). The proposed decision model can help practitioners analyze factors and attributes easily. Because it is a quantitative process, the practitioners can make better decisions and obtain better results from outsourcing.

While it has successfully developed the decision model for IS outsourcing, and with most research efforts, this study is not without limitations. First, the case study just based on a small firm. Second, the AHP and ELECTRE III methods also have their own limitations; such as, in order to get more professional results, the use of more advance form of AHP method would be desirable. In addition, the determinants in the decision model are not complete. Further studies need to include additional possible factors through a more extensive literature review and empirically investigation.

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Extended TOPSISs for Belief Group Decision Making

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ABSTRACT

Multiple attribute decision analysis (MADA) problems in the situation of belief group decision making (BGDM) are a special class of decision problems, where the attribute evaluations of each decision maker (DM) are represented by belief functions. In order to solve these special problems, in this paper, TOPSIS (technique for order preference by similarity to ideal solution) model is extended by three approaches, by which group preferences are aggregated in different manners. Corresponding to the three approaches, three extended TOPSIS models, the pre-model, post-model, and inter-model, are developed and their procedures are elaborated step by step. Aggregating group preferences in the three extended models respectively depends on Dempster's rule or its modifications, some social choice functions, and some mean approaches. Furthermore, a numerical example clearly illustrates the procedures of the three extended models for BGDM.

***Keywords*:** *basic belief assignment, belief group decision making, belief preferences aggregation, TOPSIS*

1. Introduction

Recently, the uncertain multiple attribute decision analysis (MADA) problems with a group of decision makers (DMs) have been widely studied in the literature, in which the attribute evaluations are unknown, vague, partial known, or imprecise. The representative solution is to construct a fuzzy TOPSIS (technique for order preference by similarity to ideal solution), a classical modified approach for uncertain MADA problems, to choose the best one from a set of alternatives [2-4, 18, 20, 30].

However, compared with the Dempster-Shafer theory (DST) [5,23], the operators of fuzzy set theory (FST) to aggregate group preferences, which are usually the arithmetical mean, the geometric mean, or their modifications, are less adaptable and available. Hence, this paper uses the DST to describe uncertain MADA problems; that is to say, it uses basic belief assignments (bbas) to represent uncertain attribute evaluations.

In practice, due to the one-to-one correspondence between the bba and the belief function [23], the bba is usually either elicited from experts, or constructed from observation data. To transform qualitative experts' opinions into bbas, some methods have been proposed by Wong and Lingras [31], Bryson and Mobolurin [1], and Yaghlane et al. [34]. Using the bba to represent uncertain group attribute evaluations, one correspondingly converts the group decision making (GDM) to the belief group decision making (BGDM).

To solve MADA problems in the situation of BGDM, the original TOPSIS [15] is extended by three approaches described in [25]. Their operators to aggregate group preferences are respectively the pre-operation, post-opera- tion, and inter-operation.

Based on Yang's rule and utility based equivalent transformation of the assessments on different frames of discernment [35], the evaluations on different attributes related to different frames can be unified to become the ones on a common frame. Furthermore, the positive and negative preference vectors of DM, the positive ideal solution of belief (PISB), and the negative ideal solution of belief (NISB) are constructed. The preference vectors avoid the possible paradoxes between the calculating ranks of alternatives and the fact of DM's preference, and the PISB and NISB are used to determine the ranks of alternatives. The detailed extended models are explained step by step in Section 3.

The rest of this paper is organized as follows. In Section 2, the related foundations are reviewed. Section 3 discusses three extended models in accord with three approaches to aggregating group preferences, the pre-operation, post-operation, and inter-operation, in order to make solutions to BGDM. A numerical example is given in Section 4 to illustrate the procedures of three extended models and their differences. At last, Section 5 concludes this paper.

2. Review of Related Foundations

2.1. Basics of bba

In a specific application domain, the DST first defines Ω, called the frame of discernment, containing N exhaustive and exclusive hypotheses. Let 2^{Ω} denote the power set composed of 2^N propositions of A such that $A \subseteq \Omega$.

Definition 1. Let Ω denote a frame of discernment, and S be a piece of arbitrary evidence source (ES) on Ω. Thus, the bba of ES is defined by m: $2^{\Omega} \rightarrow [0, 1]$. This function

verifies the following properties [5, 23]:

$$\sum_{A\subseteq\Omega} m(A) = 1. \quad (1)$$

In Shafer's original definition, m is called basic probability assignment (bpa) [23] with condition $m(\varnothing) = 0$. However, since transferrable belief model (TBM) was proposed as a model of uncertainty [28], condition $m(\varnothing) = 0$ has been omitted. Subsets A of Ω such that $m(A) > 0$ are called focal elements of m.

Definition 2. Let a power set on Ω be defined as $2^{\Omega} = (B_1, B_2, \ldots, B_r)$, where $r = |2^{\Omega}|$, the cardinality of 2^{Ω}. Suppose bba_i $(1 \leqslant i \leqslant n)$ represents the distribution on 2^{Ω}, thus $bba_i = (x_{i1}, x_{i2}, \ldots, x_{ir})$ satisfies:

$$x_{ij} \geqslant 0,\ 0 \leqslant j \leqslant r\text{-}1, \quad (2)$$

$$\sum_{j=0}^{r-1} x_{ij} = 1,\ i = 1, 2, \ldots, n. \quad (3)$$

Given $A \subseteq \Omega$, the mass $m(A)$ represents the belief that supports A, and that, due to lack of the information and knowledge, does not support any strict subset of A.

Let m_1 and m_2 be two bbas defined on Ω. Satisfying the closed world assumption, the normalized Dempster's rule of combination is defined as [5,23]

$$(m_1 \otimes m_2)(A) = k * \sum_{B,C\subseteq\Omega, B\cap C=A} m_1(B) m_2(C), \quad (4)$$

$$\text{where } K^{-1} = 1 - \sum_{B,C\subseteq\Omega, B\cap C=\varnothing} m_1(B) m_2(C), \quad (5)$$

$$(m_1 \otimes m_2)(\varnothing) = 0. \quad (6)$$

Here, $\sum_{B,C\subseteq\Omega, B\cap C=\varnothing} m_1(B) m_2(C)$ is the mass of the combined belief allocated to the empty-set before normalization. Dempster's rule is meaningful and can be applied only when $\sum_{B,C\subseteq\Omega, B\cap C=\varnothing} m_1(B) m_2(C) \neq 1$.

2.2. Basics of TOPSIS

2.2.1. MADM.

MADM problems are a class of decision problems simply denoted by

$$\begin{array}{cccccc} & C_1 & C_2 & \cdots & C_n \\ A_1 & v_{11} & v_{12} & \cdots & v_{1n} \\ A_2 & v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_m & v_{m1} & v_{m2} & \cdots & v_{mn} \end{array}, \quad (7)$$

where A_i $(1 \leqslant i \leqslant m)$ denotes the ith alternative, C_j $(1 \leqslant j \leqslant n)$ denotes the jth attribute, and v_{ij} $(1 \leqslant i \leqslant m,\ 1 \leqslant j \leqslant n)$ denotes the assessment of DM to the attribute C_j of alternative A_i.

Suppose $W = (w_1, w_2, \ldots, w_n)$ such that $\sum_{j=1}^{n} w_j = 1$ is a weight vector, where w_j denotes the weight of C_j.

MADM problem solving includes:

(a) Construct the attribute set of system assessment and correlate system performance and objective;

(b) Confirm the available alternative set for implementing the objective;

(c) Evaluate all alternatives according to the attribute set and give v_{ij} $(1 \leqslant i \leqslant m,\ 1 \leqslant j \leqslant n)$.

(d) Apply normalized analysis methodologies to MADM problems;

(e) Make choice of the best alternative;

(f) Collect new information and start with a new decision procedure for MADM problems if the resulting alternative can not be accepted.

Steps (a) and (e) orient to DM, but others to applications. In Step (d), DM expresses his/her preference according to the relative importance of every attribute, for example, setting w_j.

2.2.2. TOPSIS

The TOPSIS is an important practical technique to solve MADA problems originating from the concept of a displaced ideal point from which the compromise solution has the shortest distance [36]. In the view of Hwang and Yoon [15], the rating of alternative depends on the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS) or nadir. Compared with the Analytic Hierarchy Process (AHP) [22], the TOPSIS fits the cases with a large number of attributes and alternatives.

In [15], Hwang and Yoon partition attributes into three classes: benefit ones, cost ones and non-monotonic ones. The different classes of attributes correspond to different normalization methods in order to fit different real-world situations, i.e. the vector normalization, the linear normalization, and the non-monotonic normalization.

Practically, the TOPSIS and its extensions are used to solve many theoretical and real-world problems, such as decision making with fuzzy data [16] or interval data [17], decision support analysis for material selection of metallic bipolar plates [24], evaluating initial training aircraft under a fuzzy environment [29], or inter-company comparison [6].

A general flow of TOPSIS involves:

1) Normalize decision matrix $V = (v_{ij})_{m\times n}$.

The decision matrix V is transformed to a normalized matrix R by $r_{ij} = \dfrac{v_{ij}}{\sqrt{\sum_{k-1}^{m} v_{kj}^2}}$ $(1 \leqslant i \leqslant m,\ 1 \leqslant j \leqslant n)$, where r_{ij} is the normalized one of v_{ij}.

2) Calculate weighted decision matrix $Z = (z_{ij})_{m\times n}$.

The normalized matrix R is transformed to a weighted decision matrix Z such that $z_{ij}=w_j \cdot r_{ij}$ $(1\leqslant i\leqslant m,\ 1\leqslant j\leqslant n)$, where w_j denotes the weight of C_j such that $\sum_{j=1}^{n} w_j = 1$.

3) Determine PIS and NIS.

The PIS and NIS are respectively

$A^+ = \{ z_1^+, z_2^+, \ldots, z_n^+ \} = \{ (\max_j z_{ij} \mid j\in\Omega_b), (\min_j z_{ij} \mid j\in\Omega_c) \}$,

$A^- = \{ z_1^-, z_2^-, \ldots, z_n^- \} = \{ (\min_j z_{ij} \mid j\in\Omega_b), (\max_j z_{ij} \mid j\in\Omega_c) \}$,

where Ω_b and Ω_c are benefit attribute set and cost attribute set, respectively.

4) Compute the separation measures of each alternative from the PIS and NIS.

The separation measures of each alternative from the PIS and NIS are respectively

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (z_{ij} - z_j^+)^2}\ , \ i=1, 2, \ldots, m,$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (z_{ij} - z_j^-)^2}\ , \ i=1, 2, \ldots, m.$$

5) Calculate the closeness coefficient of each alternative.

The closeness of each alternative can be defined as

$$RC_i = \frac{D_i^-}{D_i^+ + D_i^-}\ , \quad i=1, 2, \ldots, m.$$

6) Rank the preference order.

The alternative set denoted by A_i $(1\leqslant i\leqslant m)$ is ranked by means of RC_i, which indicates what the best alternative is.

2.3. Discussion

The original TOPSIS has the ability to effectively solve general MADM problems for one DM, which can easily extended to deal with the situation of GDM.

In the work of Shih et al. [25], they constructed an internal extended model of TOPSIS for GDM, in which the steps were updated involving the decision matrix normalization, distance measures, and aggregation operators. One can obviously realize that the internal model never fits external extensions of TOPSIS associated with the pre-operation and post-operation. Furthermore, it is not suitable for the internal extension of TOPSIS in this study, where uncertain group evaluations are represented by bbas.

In Section 3, three extended models for BGDM, recently researched by Fu etc. in [10-12], are elaborated step by step, corresponding to the pre-operation, post-operation, and inter-operation.

3. Solutions to Belief Group Decision Making

According to the classes of group preference aggregation proposed by Shih et al. [25], we extend the original TOPSIS to be available for BGDM situation by three approaches, corresponding to the pre-operation, post-operation, and inter-operation. Three extended TOPSIS models are respectively named as pre-model, post-model, and inter-model. The detailed procedures of the three models are interpreted as follows.

3.1. Pre-model

The pre-model is composed of the following steps.

Step 1: Construct initial group belief decision matrices (BDMs).

The initial BDM of each DM can be defined as follows:

$$\begin{array}{c|cccc} & C_1 & C_2 & \cdots & C_n \\ A_1 & y_{11}^t & y_{12}^t & \cdots & y_{1n}^t \\ A_2 & y_{21}^t & y_{22}^t & \cdots & y_{2n}^t \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_m & y_{m1}^t & y_{m2}^t & \cdots & y_{mn}^t \end{array} \tag{8}$$

where A_i $(1\leqslant i\leqslant m)$ denotes the ith alternative, C_j $(1\leqslant j\leqslant n)$ denotes the jth attribute, and y_{ij}^t $(1\leqslant i\leqslant m,\ 1\leqslant j\leqslant n,\ 1\leqslant t\leqslant T)$ denotes the belief assessment of DM t to the attribute C_j of alternative A_i. Let Ω_j $(1\leqslant j\leqslant n)$ be the frame of discernment used to generate the assessments on the attribute C_j. In terms of Definition 2, we have $y_{ij}^t = B_{i\Omega_j}^t = (b_{i1}^t, b_{i2}^t, \ldots, b_{ir_j}^t)$, where $r_j = |2^{\Omega_j}|$.

Convenient to decide the PISB and NISB, the distribution of power set on Ω_j is specified in Definition 3.

Definition3. Let Ω_j be the frame of discernment used to generate the assessments on the attribute C_j $(1\leqslant j\leqslant n)$, and $2^{\Omega_j} = (B_1, B_2, \ldots, B_{r_j})$ be the distribution of an arbitrary power set on Ω_j, where $r_j = |2^{\Omega_j}|$. Suppose the cardinality of B_k is increasing along the increase of k. Furthermore, we assume $B_1 = \varnothing$ (empty-set), B_2 and B_3 respectively correspond to the single positive ideal element (SPIE) and the single negative ideal element (SNIE) of Ω_j.

The original TOPSIS requires a uniform dimension for the assessments on every quantitative attribute. The three extensions of TOPSIS for BGDM situation are also constrained by this requirement. That is to say, the various frames, Ω_j $(1\leqslant j\leqslant n)$, have to be transformed to a unified frame Ω_C so that every attribute can be assessed in a uniform, consistent and compatible manner.

The transformation from Ω_j $(1\leqslant j\leqslant n)$ to Ω_C is stipulated

as Proposition 1.

Proposition1. Let Ω_j be the frame of discernment used to generate the assessments on the attribute C_j ($1 \leqslant j \leqslant n$). The assessments on Ω_j can be equivalently and rationally transformed to the ones on a common frame of discernment Ω_C.

In fact, Proposition 1 is clearly correct since two techniques, a rule based one and a utility based one, are investigated to accomplish the transformation in Proposition 1 [35].

From Proposition 1, y_{ij}^t in Eq (8) can be transformed to a distribution on Ω_C. Therefore, the belief attribute evaluations of each DM to each alternative are unified in the set of distributions on Ω_C. In the following, we suppose y_{ij}^t denotes a distribution on Ω_C.

Step 2: Aggregate group BDMs to form a total BDM.

From Step 1, we know the BDM of each DM as defined in Eq (8). With the normalized Dempster's rule of combination [5, 23], group BDMs are combined to form a total BDM. Let the total BDM be defined in the following:

$$\begin{array}{cccccc} & C_1 & C_2 & \cdots & C_n \\ A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{array} \tag{9}$$

where $x_{ij} = B_{i\Omega_j} = (b_{i1}, b_{i2}, \ldots, b_{ir_C})$, $r_C = |2^{\Omega_C}|$, $1 \leqslant i \leqslant m$, $1 \leqslant j \leqslant n$. Given any element x_{ij} in the total BDM, we have $x_{ij} = \overset{T}{\underset{t=1}{\otimes}} y_{ij}^t$, where the operator $\otimes$ denotes the normalized Dempster's rule of combination as specified in Eqs (4) to (6). Here, we suppose all experts have the same importance.

Step 3: Normalize the total BDM.

Different from the original TOPSIS, x_{ij} is not a real number but a normalized distribution on Ω_C, the Step can be omitted.

Step 4: Assign a total weight vector W to the attribute set.

Let W^t denote the weight vector of each DM assigned to the attribute set. We have $W^t = (w_1^t, w_2^t, \ldots, w_n^t)$, $1 \leqslant t \leqslant T$, $\sum_{j=1}^n w_j^t = 1$. The total weight vector W can be defined as the arithmetical mean of all W^t ($1 \leqslant t \leqslant T$), which is $W = (w_1, w_2, \ldots, w_n)$ such that

$$w_j = \frac{1}{T}\sum_{t=1}^{T} w_j^t,\ 1 \leqslant j \leqslant n. \tag{10}$$

Step 5: Determine the total PISB and NISB.

Before determining the total PISB and NISB, first of all we define the PISB and NISB in Definition 4, owing to the distribution specification in Definition 3.

Definition4. Based on the specification in Definition 3, given the attribute C_j ($1 \leqslant j \leqslant n$), no matter whether it is the benefit attribute or the cost attribute, its PISB and NISB are respectively

$$(0,1,\overbrace{0,\ldots,0}^{r_C-2})_{1\times r_C} \quad \text{and} \quad (0,0,1,\overbrace{0,\ldots,0}^{r_C-3})_{1\times r_C}.$$

According to Definition 4, by combining the PISB and NISB of each attribute, we achieve the total PISB and NISB of total BDM.

Step 6: Calculate the separation measures of each alternative from the total PISB and NISB.

From Step 5, the total PISB and NISB can be respectively denoted by

$$S^+_{1\times(n\ \ r_C)} = (\overbrace{0,1,0,\ldots,0}^{r_C},\ \cdots,\ \overbrace{0,1,0,\ldots,0}^{r_C})$$

and $S^-_{1\times(n\ \ r_C)} = (\overbrace{0,0,1,0,\ldots,0}^{r_C},\ \cdots,\ \overbrace{0,0,1,0,\ldots,0}^{r_C})$.

Furthermore, in order to precisely reflect the preference of each DM and the physical implication of each subset of the distribution on 2^{Ω_C} when calculating the separation measures of each alternative from the PISB and NISB, we define the positive preference vector (PPV) ($\beta_1^{t+}, \ldots, \beta_k^{t+}, \ldots, \beta_{r_C}^{t+}$) and the negative preference vector (NPV) ($\beta_1^{t-}, \ldots, \beta_k^{t-}, \ldots, \beta_{r_C}^{t-}$) of each DM for the distribution on 2^{Ω_C} where $\sum_{k=1}^{r_C} \beta_k^{t+} = 1$, $\sum_{k=1}^{r_C} \beta_k^{t-} = 1$, $r_C = |2^{\Omega_C}|$. Through ordered comparison of any two different subsets of the distribution on 2^{Ω_C} the PPV and NPV of DM can be achieved. We postulate $\beta_k^{t+} > 0$, $\beta_k^{t-} > 0$, if k>1, and $\beta_k^{t+} = \beta_k^{t-} = 0$, if k=1, so as to keep all available information. Let the positive group preference vector (PGPV) and negative group preference vector (NGPV) respectively be ($\beta_1^+, \ldots, \beta_k^+, \ldots, \beta_{r_C}^+$) and ($\beta_1^-, \ldots, \beta_k^-, \ldots, \beta_{r_C}^-$) such that $\sum_{k=1}^{r_C} \beta_k^+ = 1$, $\sum_{k=1}^{r_C} \beta_k^- = 1$, we thus have

$$\beta_k^+ = \frac{1}{T}\sum_{t=1}^{T} \beta_k^{t+}, \tag{11}$$

$$\beta_k^- = \frac{1}{T}\sum_{t=1}^{T}\beta_k^{t-} . \quad (12)$$

The PPV and NPV can effectively avoid the possible paradoxes between calculating results and the fact of DM's preference as well as physical implications of worlds in Ω_C.

Hence, the separation measures of each alternative from the total PISB and NISB are expressed as

$$D_i^+ = \sqrt{\sum_{j=1}^{n} w_j \sum_{k=1}^{r_C} \beta_k^+ (b_{ik} - S^+_{1((j-1)\quad r_C+k})^2} \quad (13)$$

and

$$D_i^- = \sqrt{\sum_{j=1}^{n} w_j \sum_{k=1}^{r_C} \beta_k^- (b_{ik} - S^-_{1((j-1)\quad r_C+k})^2} \quad (14)$$

where $1\leqslant i\leqslant m$, $r_C = |\,2^{\Omega_C}\,|$, with the approach of Euclidian distance [9].

Step 7: Compute the closeness coefficient E_i^* of each alternative for group.

The closeness coefficient of each alternative can be defined as

$$E_i^* = D_i^- /(D_i^- + D_i^+)\ (1\leqslant i\leqslant m). \quad (15)$$

The larger the value of E_i^*, the better the alternative.

Step 8: Rank the preference order.

In terms of E_i^*, a set of alternatives will be ranked in an incremental order representing group preferences.

3.2. Post-model

The post-model is partially the same as the pre-model. After the procedure of original TOPSIS, the rank of each alternative representing group preferences is determined, aided by one of social choice functions [14], such as the Borda function in this paper.

Step 1: Construct initial group BDMs.

The Step is the same as Step 1 of pre-model.

Step 2: Normalize the BDM of each DM.

Same as Step 3 of pre-model, the Step can be omitted.

Step 3: Assign the weight vector W^t to the attribute set for each DM.

We suppose W^t denotes the weight vector of DM t assigned to the attribute set, where $W^t = (w_1^t, w_2^t, \ldots, w_n^t)$, $1\leq t\leq T$, $\sum_{j=1}^{n} w_j^t = 1$.

Step 4: Determine the PISB and NISB of each DM.

As specified in Definition 3, the PISB and NISB of each DM are respectively denoted by

$$S^{t+}_{1\times(n\quad r_C)} = (\overbrace{0,1,0,\ldots,0}^{r_C},\ \cdots,\ \overbrace{0,1,0,\ldots,0}^{r_C})$$

and

$$S^{t-}_{1\times(n\quad r_C)} = (\overbrace{0,0,1,0,\ldots,0}^{r_C},\ \cdots,\ \overbrace{0,0,1,0,\ldots,0}^{r_C}),$$ where $1\leq t\leq T$.

Step 5: Calculate the separation measures of each alternative from the PISB and NISB of each DM.

Similar to Step 6 of pre-model, the separation measures of each alternative from the PISB and NISB for each DM are expressed as

$$D_i^{t+} = \sqrt{\sum_{j=1}^{n} w_j^t \sum_{k=1}^{r_C} \beta_k^{t+} (b_{ik} - S^{t+}_{1((j-1)\quad r_C+k})^2} \quad (16)$$

and

$$D_i^{t-} = \sqrt{\sum_{j=1}^{n} w_j^t \sum_{k=1}^{r_C} \beta_k^{t-} (b_{ik} - S^{t-}_{1((j-1)\quad r_C+k})^2} \quad (17)$$

where $(b_{i1}, b_{i2}, \ldots, b_{ir_C}) = y_{ij}^t$, $1\leq i\leq m$, $1\leq t\leq T$, $r_C = |\,2^{\Omega_C}\,|$.

Step 6: Compute the closeness coefficient E_i^{t*} of each alternative for each DM.

The closeness coefficient of each alternative for each DM can be defined as

$$E_i^{t*} = D_i^{t-} /(D_i^{t-} + D_i^{t+}), \quad (18)$$

where $1\leq i\leq m$, $1\leq t\leq T$.

Step 7: Rank the preference order of each DM.

In terms of E_i^{t*}, a set of alternatives will be ranked in an incremental order representing the preference of each DM, where $1\leq t\leq T$.

Step 8: Give the Borda score of each alternative according to the preference order of each DM.

Suppose the preference order of DM t is $B_1^t \succ \ldots \succ B_i^t \succ \ldots \succ B_m^t$, where B_i^t ($1\leq i\leq m$) is the same as A_j^t ($1\leq j\leq m$). The Borda score of B_1^t is $m-1$, the ones of B_2^t and B_m^t are respectively $m-1$ and 0, and the rest may be deduced by analogy.

Step 9: Aggregate the Borda score of each alternative given by each DM.

Let the Borda score vectors of each alternative representing the preference of DM t and group preferences be respectively $(S_1^t,\ldots,S_i^t,\ldots,S_m^t)$ and $(S_1,\ldots,S_i,\ldots,S_m)$. We have

$$S_i = \sum_{t=1}^{T} S_i^t,\ 1\le i\le m. \tag{19}$$

Step 10: Rank the preference order for group.

According to $(S_1,\ldots,S_i,\ldots,S_m)$, we rank the preference order of a set of alternatives for group.

3.3. Inter-model

The inter-model is similar to the internal TOPSIS model of Shih et al. [25]. It combines the individual separation measures of each alternative from the PISB and NISB to form group measures within the TOPSIS procedure.

The first five Steps of inter-model are the same as Steps 1 to 5 of post-model.

Step 6: Combine the individual measures of each alternative from the PISB and NISB to form group measures.

From Step 5 of post-model, we achieve the individual measures of each alternative from the PISB and NISB, which are respectively D_i^{t+} and D_i^{t-} ($1\le i\le m$, $1\le t\le T$). Thus, the group measures of each alternative are respectively

$$D_i^{+} = \bigoplus_{t=1}^{T} D_i^{t+} \tag{20}$$

and

$$D_i^{-} = \bigoplus_{t=1}^{T} D_i^{t-}. \tag{21}$$

The operator $\oplus$ can be the arithmetical mean, the geometric mean, or their modifications. In this paper, the arithmetical mean is our choice.

Steps 7 and 8 are the same as Steps 7 and 8 of pre-model.

As mentioned above, three extended models are similar to each other in many Steps. The main differences lie in the aggregation of group preferences.

In the pre-model, thanks to two strategies of Dempster's rule modification (e.g. [8, 19, 26-27, 32-33]) and source modification (e.g. [7, 13, 21]) aiming at combining conflicting beliefs, the preference conflicts between different DMs can be effectively dealt with. In the post-model, some social choice functions [14] can be selected to guarantee group preferences aggregation is rational and available in different applications. In the inter-model, the arithmetical mean, the geometric mean, or their modifications are used to aggregate the individual separation measures of each alternative from the PISB and NISB.

In practice, how to select the appropriate extended model depends on how to select the appropriate approach to aggregating group preferences, which is the most suitable one for real-world problems.

4. Numerical Example

To clearly illustrate the procedures of three extended models, a numerical example is shown as follows.

From Tables 1 to 3, one can know initial group BDMs, and the preference vectors and weight vector of each DM. There are two attributes, three alternatives, and three DMs in this example. Two attributes C_1 and C_2 are the benefit one and the cost one, respectively. Suppose Ω_1= {good, common}, Ω_2= {small, big, common}, Ω_C= {first, second, third}, according to Proposition 1, the assessments on Ω_1 and Ω_2 can be equivalently transformed to the ones on Ω_C. In terms of Definition 3, the power set on Ω_C is {{$\varnothing$}, {first}, {third}, {second}, {first, third}, {first, second}, {second, third}, {first, second, third}}.

As specified in Definition 4, the PISB and NISB are respectively (0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0) and (0,0,1,0, 0,0,0,0,0,0,1,0,0,0,0,0). The decision procedures of three extended models will be presented as follows.

In the pre-model, group belief evaluations are firstly combined to form the total BDM displayed in Table 4, with the normalized Dempster's rule of combination.

Afterwards, according to Eq (10), the total weight vector W= (0.6, 0.4) is generated from the weight vectors in Table 3. Based on the data in Table 2, the PGPV and NGPV are computed respectively as (0,0.03,0.207,0.092, 0.207,0.05,0.207,0.207) and (0,0.384,0.055,0.163,0.055, 0.233,0.055,0.055), in terms of Eqs (11) and (12).

With the above results, the total separation measures and the closeness coefficient of each alternative are obtained in Table 5, according to Eqs (13) to (15).

From Table 5, the preference order of three alternatives is known to be $A_1 \succ A_3 \succ A_2$, where the notation "$\succ$" means "**prior**".

In the post-model, first of all the individual separation measures and the closeness coefficient of each alternative are computed in Table 6.

The Borda score and rank of each alternative for group are generated from the data in Table 6 and shown in Table 7.

According to Table 7, three alternatives are ranked by the preference order $A_1 \succ A_2 = A_3$.

In the inter-model, the separation measures and closeness coefficient of each alternative for group are achieved in Table 8, on the basis of the data in Table 6.

Three alternatives are ranked with the preference order $A_1 \succ A_2 \succ A_3$ according to Table 8.

The three preference orders corresponding to three extended models are pair-wise different. The mediator and the requirements of a real application decide which order is the best one and which extended model should be applied. Especially, if the mediator only wants to know the best alternative, it is unnecessary to differentiate the three orders.

Table 1. Initial group BDMs

		C1	*C2*
A1	*DM1*	(0,0.6,0,0,0,0.4,0,0)	(0,0.3,0.2,0,0,0.5,0,0)
	DM2	(0,0.5,0,0.2,0,0.3,0,0)	(0,0.5,0.2,0,0,0,0.3,0)
	DM3	(0,0.4,0,0.2,0,0.4,0,0)	(0,0.4,0,0.4,0,0.2,0,0)
A2	*DM1*	(0,0.2,0,0.5,0,0,0.3,0)	(0,0.6,0.2,0,0,0.2,0,0)
	DM2	(0,0.3,0,0.5,0,0.2,0,0)	(0,0.4,0.1,0,0,0,0.5,0)
	DM3	(0,0.4,0,0.3,0,0.3,0,0)	(0,0.5,0.3,0,0,0.2,0,0)
A3	*DM1*	(0,0.2,0,0.8,0,0,0,0)	(0,0.2,0.4,0,0,0,0.4,0)
	DM2	(0,0.7,0,0,0,0.3,0,0)	(0,0.4,0.2,0.4,0,0,0,0)
	DM3	(0,0.6,0,0.1,0,0.3,0,0)	(0,0.2,0.6,0,0,0.2,0,0)

Table 2. The preference vectors of each DM

	$(\beta_1^+,\ldots,\beta_8^+)$	$(\beta_1^-,\ldots,\beta_8^-)$
DM1	(0,0.04,0.2,0.1,0.2,0.06,0.2,0.2)	(0,0.4,0.05,0.15,0.05,0.25,0.05,0.05)
DM2	(0,0.03,0.2,0.12,0.2,0.05,0.2,0.2)	(0,0.3,0.09,0.14,0.09,0.2,0.09,0.09)
DM3	(0,0.02,0.22,0.06,0.22,0.04,0.22,0.22)	(0,0.45,0.025,0.2,0.025,0.25,0.025,0.025)

Table 3. The weight vector of each DM

	w_1	w_2
DM1	0.5	0.5
DM2	0.7	0.3
DM3	0.6	0.4

Table 4. The total group BDM

	C_1	C_2
A1	(0,0.83,0,0.1,0,0.07,0,0)	(0,0.73,0,0.27,0,0,0,0)
A2	(0,0.17,0,0.83,0,0,0,0)	(0,0.8,0.13,0.07,0,0,0,0)
A3	(0,0.65,0,0.35,0,0,0,0)	(0,0.2,0,0.8,0,0,0,0)

Table 5. The separation measures and closeness coefficient of each alternative in the pre-model

	D+	*D-*	*E*= D-/(D-+ D+)*	*rank*
A1	0.06911	0.54954	0.8883	1
A2	0.2291	0.4715	0.673	3
A3	0.2005	0.46065	0.6967	2

Table 6. The separation measures and the closeness coefficient of each alternative in the post-model

		S+	*S-*	*E**
A1	*DM1*	0.17117	0.42691	0.7138
	DM2	0.14768	0.41741	0.7387
	DM3	0.13023	0.37762	0.7436
A2	*DM1*	0.19925	0.38341	0.658
	DM2	0.227	0.39373	0.6343
	DM3	0.14241	0.36932	0.7217
A3	*DM1*	0.29933	0.31937	0.5162
	DM2	0.12822	0.46573	0.7841
	DM3	0.20465	0.37376	0.6462

Table 7. The Borda score and rank of each alternative

	Borda score	*rank*
A1	5	1
A2	2	2
A3	2	2

Table 8. The separation measures and closeness coefficient of each alternative in the inter-model

	D+	*D-*	*E*= D-/(D-+ D+)*	*rank*
A1	0.14969	0.40731	0.7313	1
A2	0.18955	0.38215	0.6684	2
A3	0.21073	0.38629	0.647	3

5. Conclusions

Through representing the uncertain attribute evaluations of a group of DMs to alternatives by bbas, the common GDM is extended to the BGDM. To solve the MADA problems in the situation of BGDM, we develop three extended TOPSIS models, the pre-model, post-model, and inter-model, associated with three approaches to aggregating group preferences, the pre-operation, post-operation, and inter-operation.

For the BGDM, three extended models are elaborated step by step, based on the equivalent transformation of the assessments on different frames of discernment, the PISB and NISB, and the PPV and NPV of each DM. Furthermore, a numerical example clearly illustrates the procedures of three extended models.

The reliability of experts may be an important factor to influence our method. If a group of experts have different reliability, their bbas may be discounted [23] before used in the three models. The discounting approach is introduced in the original work of Shafer [23]. In practical applications, how to decide the reliability of experts may be a problem difficult to solve [19].

The computational complexity may be a problem for our method is on the power set of a frame of discernment. In fact, the numerical examples in Section 4 are solved by the program made by Microsoft Visual C++ 6.0 within several seconds. By testing randomly selected data, we find that when $|\Omega|<13$, the solutions can be obtained within several seconds. Note that for the MADA problems in the situation of BGDM, $|\Omega|<13$ is generally enough to provide the satisfactory service for experts. If $|\Omega|$ is too large, experts will have difficulties to make decisions. Therefore, the computational complexity of our method can be effectively solved by the computer program and the real constraints of experts' decision making.

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Research on Supply Chain Inventory Optimization and Benefit Coordination with Controllable Lead Time

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ABSTRACT

In this paper, we propose two supply chain inventory models with controllable lead time, the first is proposed under centralized decision mode and the other is proposed under decentralized decision mode. The solution procedures are also suggested to get the optimal solutions. In addition, taking individual rationality into consideration, Shapely value method and MCRS method are used to coordinate the benefits of the vendor and the buyer. Numerical example is given to illustrate the results of the proposed models.

Keywords: *Supply Chain Inventory Model, Controllable Lead Time, Shapely Value, MCRS Method*

1. Introduction

Time-based competition (TBC) has been one of the most popular competitive modes and time management is becoming more and more important in this increasing intense competitive environment [1]. In most of traditional economic order quantity literatures, lead time is viewed as a constant or a stochastic variable by either using deterministic or probabilistic models, that is, lead time is assumed to be not subject to control [2,3]. However, this may not be realistic. As pointed out by Tersine [4], lead time usually is consisted of five components: order preparation time, order transmit time, vendor's lead time, delivery time and setup time. In many practical cases, lead time can be reduced by an added crashing cost, that is, it is controllable. The benefit of reducing lead time, such as lower safety stock, decrease stock out loss, enhance customer service level, and obtain the competitive advantages has been clearly evidenced by successful experience of using Just-In-Time (JIT) production. Lead time reduction has been viewed to be an effective way to realize the quick response of the whole supply chain and one of the most important sources of competitive advantage [1].

Liao & Shyu (1991) [5] first put forward a continuous review model where order quantity is predetermined and lead time is the only decision variable. Ben-Daya & Raouf (1994) [6] extended Liao & Shyu's model (1991) by viewing both lead time and order quantity as decision variables. Ouyang *et al.* (1996) [7] further took the assumption that the shortage could be divided into a mixture of backorders and lost sales. Ouyang&Wu (1998) [8] viewed that the demand of lead time can be any known and free cumulative distribution, and proposed procedures to get the optimal lead time and order quantity under different situations. Moon&Choi (1998) [9] extended Ouyang *et al.*'s model (1996) by considering the reorder point to be another decision variable. Ouyang&Chang (2000) [10] improved Ouyang *et al.*'s model (1996) by further assuming the backorder rate is not a determined constant, but be dependent on the length of lead time. All of these above models only took the optimal policy decisions for the buyer into consideration. However, the growing focus on supply chain management for this increasing intense competitive environment calls for a more efficient management of inventories across the whole supply chain through more coordination and cooperation. In recent paper, Pan & Yang (2002) [11] extended Goyal's model (1988) [12] by assuming lead time as a controllable variable and gained a lower joint expected cost and shorter lead time of the entire supply chain compared to that of Goyal's model. Ouyang *et al.* (2004) [13] improved Pan & Yang's model (2002) by further assuming the reorder point as the other decision variable and shortages is permitted, optimizing ordering quantity, lead time, reorder point and the number of lots simultaneously in an integrated supply chain inventory model.

In this paper, we consider the single vendor single buyer inventory problem. As known to all, a supply chain can be viewed as a network which is consisted of series of suppliers, manufacturers, retailers, and customers, through the physical flow, information flow and financial flow. It is beginning with the raw materials producing by a supplier and ending with the product consumption by customers. A node in the supply chain network represents a physical site, a sub-network, or an operation process, and links represent physical flow. However, all supply chain network (SCN) can be divided into several one-to-one supply models consists of single vendor and single buyer under certain conditions. This kind of one-to-one supply model is the basis of supply chain network analysis. Hence, we only take the two-echelon

supply chain consists of single vendor and single buyer situation into consideration in this paper. We relax the assumption that long-term strategic partnerships between vendor and buyer were well established and they could bargaining and cooperate with each other to obtain an optimal integrated joint policy under centralized decision mode in both Pan & Yang model (2002) [11] and Ouyang *et al*. model (2004) [13]. We assume the vendor and the buyer representing different benefit entities and take their individual rationalities into consideration, develop two effective benefit sharing models to coordinate benefit between vendor and buyer and realize the Pareto dominance of the entire supply chain system. Solution procedures are suggested for solving the proposed models and numerical examples are provided to illustrate the results.

This paper is organized as follows. In the section 2, two different inventory models with controllable lead time are proposed, one is proposed under centralized decision mode, and other is proposed under decentralized decision mode. The solution procedures are also suggested to get the optimal solutions. In the section 3, a numerical example is provided to illustrate the results of the proposed models. Shapley value method and MCRS method are used to coordinate the benefits of the vendor and the buyer in section 4 and section 5 contains some concluding remarks and future research.

2. Model Construction

2.1. Notations and Assumptions

To develop the proposed models, the following notations are used.

D = Average demand per year;
P = Vendor's production rate. ($P > D$);
A = Buyer's ordering cost per order;
h_r = Buyer's unit holding cost per year;
S = Vendor's setup cost per set-up;
h_s = Vendor's unit holding cost per year;
Q = Order quantity of the buyer **(Decision variable)**;
L = Length of lead time **(Decision variable)**;
γ = Unit shortage cost.

The following assumptions are made for both models in this paper:

1. A two-echelon supply chain consists of single vendor and single buyer is considered.
2. Inventory is continuously reviewed and replenishments are made whenever the inventory level falls to the reorder point r .
3. The reorder point r =expected demand during lead time + safety stock. The demand X during lead time L is assumed to be normally distributed with mean uL and standard deviation $\delta\sqrt{L}$. That is, $r = uL + k\delta\sqrt{L}$ where k is the safety factor.
4. The vendor manufactures the product in lots of size mQ with a finite production rate P ($P > D$) and ship in quantity Q to the buyer over m lots.
5. The lead time has n mutually independent components. The i th component has a minimum duration a_i and normal duration b_i , buyer's crashing cost per unit time c_i and vendor's crashing cost per unit time d_i . Furthermore, for convenience, we arrange c_i and d_i such that $c_1 \le c_2 \le .... \le c_n$, $d_1 \le d_2 \le .... \le d_n$. Then, it is clear that the reduction of lead time should be first on component 1 (because it has the minimum unit crashing cost), and then component 2, and so on.
6. If we let $L_0 = \sum_{j=1}^{n} b_j$ and L_i be the length of lead time with components 1,2,....i crashed to their minimum duration, then L_i is expressed as

$$L_i = \sum_{j=1}^{i} a_j + \sum_{j=i+1}^{n} b_j = \sum_{j=1}^{n} b_j - \sum_{j=1}^{i} (b_j - a_j) = L_0 - \sum_{j=1}^{i} (b_j - a_j)$$

$i = 1,2,....n$.

2.2. Buyer's inventory cost model

Based on the above notations and assumptions, the total expected annual cost for the buyer is given by:

TEC_r = **ordering cost** + **holding cost** + **lead time crashing cost** + **shortage cost**

Since A is the ordering cost per order, the expected ordering cost per year is given by DA/Q .

The average on-hand inventory for the buyer is $I_r = \frac{Q}{2} + k\delta\sqrt{L}$ and the expected holding cost per year for the buyer is $h_r(\frac{Q}{2} + k\delta\sqrt{L})$.

The buyer's lead time crashing cost $R(L)$ for a given $L \in [L_i, L_{i-1}]$ is given by

$R(L) = c_i(L_{i-1} - L) + \sum_{j=1}^{i-1} c_j(b_j - a_j)$, hence the expected annual lead time crashing cost for the buyer is $DR(L)/Q$.

The expected shortage of each order cycle is $E(X - r)^+ = \int_{ROP}^{+\infty} (X - r)dF(x) = \delta\sqrt{L}\Psi(k)$, where $\Psi(k) = \phi(k) - k[1 - \Phi(k)]$, and ϕ , Φ are the standard normal distribution and cumulative distribution function, respectively [14]. The expected shortage cost per year is $D\gamma\delta\sqrt{L}\Psi(k)/Q$.

Therefore, the total expected annual cost for buyer is given by

$$TEC_r(Q,L)=\frac{DA}{Q}+h_r(\frac{Q}{2}+k\delta\sqrt{L})+\frac{D}{Q}R(L)+\frac{D\gamma}{Q}\delta\sqrt{L}\Psi(k) \quad (1)$$

2.3. Vendor's inventory cost model

For the vendor's inventory model, its total expected annual cost can be represented by:

TEC_v = **set-up cost + holding cost + lead time crashing cost**

Since S is the vendor's set-up cost per set-up, and the production quantity in a lot will be Q, the expected set-up cost per year is given by DS/Q.

The vendor's average inventory can be evaluated as $QD/2P$. Hence, the vendor's expected holding cost per year is $h_sQD/2P$.

The vendor's lead time crashing cost $M(L)$ for a given $L\in[L_i,L_{i-1}]$ is given by

$M(L)=d_i(L_{i-1}-L)+\sum_{j=1}^{i-1}d_j(b_j-a_j)$, hence the expected annual lead time crashing cost for the vendor is $DM(L)/Q$.

It follows that the total expected annual cost for the vendor is:

$$TEC_S=\frac{D}{Q}S+h_s\frac{Q}{2}(\frac{D}{P})+\frac{D}{Q}M(L) \quad (2)$$

2.4. Inventory model under centralized mode

To provide a benchmark, we first analyze the supply chain system where a central controller makes all decisions to minimize the total expected cost of the whole supply chain. In this case, the vendor and the buyer negotiate to decide lead time and order quantity together. The integrated inventory of supply chain under centralized mode is given by

$$TEC_{sc}(Q,L)=\frac{D}{Q}(A+S+R(L)+M(L))+h_r(\frac{Q}{2}+k\delta\sqrt{L})+\frac{D\gamma}{Q}\delta\sqrt{L}\Psi(k)+h_s\frac{Q}{2}(\frac{D}{P}) \quad (3)$$

Taking the partial derivatives of $TEC_{sc}(Q,L)$ with respect to Q, L in each time interval $[L_i,L_{i-1}]$, and equating them to zero, we obtain

$$\frac{\partial TEC_{sc}(Q,L)}{\partial Q}=-\frac{D}{Q^2}(A+S+R(L)+\gamma\delta\sqrt{L}\Psi(k)+M(L))+\frac{h_r}{2}+\frac{h_sD}{2P}=0 \quad (4)$$

$$\frac{\partial TEC_{sc}(Q,L)}{\partial L}=\frac{D}{Q}(\frac{\gamma\delta L^{-\frac{1}{2}}\Psi(k)}{2}-c_i-d_i)+\frac{h_rk\delta L^{-\frac{1}{2}}}{2}=0 \quad (5)$$

Hence, for fixed $L\in[L_i,L_{i-1}]$, $TEC_{sc}(Q,L)$ is convex in Q, since

$$\frac{\partial TEC_{sc}(Q,L)}{\partial Q^2}=\frac{2D}{Q^3}(A+S+R(L)+M(L)+\gamma\delta\sqrt{L}\Psi(k))>0 \quad (6)$$

However, for fixed Q, $TEC_{sc}(Q,L)$ is concave in $L\in[L_i,L_{i-1}]$, because

$$\frac{\partial TEC_{sc}(Q,L)}{\partial L^2}=-\frac{D}{Q}\frac{\gamma\delta L^{-\frac{3}{2}}\Psi(k)}{4}-\frac{h_rk\delta L^{-\frac{3}{2}}}{4}<0 \quad (7)$$

Therefore, for fixed Q, the minimum expected annual cost of the entire supply chain will occur at the end points of the interval $[L_i,L_{i-1}]$. From Eq. (4), we have

$$Q^*=\sqrt{\frac{2PD(A+S+R(L)+M(L)+\gamma\delta\sqrt{L}\Psi(k))}{h_rP+h_sD}} \quad (8)$$

We have proved that the total expected annual cost $TEC_{sc}(Q,L)$ is convex in Q and easily obtain the analytic expression of the optimal order quantity under centralized mode. However, we assume the lead time crashing cost to be a piecewise linear function and have proved that the total expected annual cost $TEC_{sc}(Q,L)$ is concave in $L\in[L_i,L_{i-1}]$ and the minimum $TEC_{sc}(Q,L)$ will occur at the end points of the interval $[L_i,L_{i-1}]$. So we cannot obtain the analytic expression of the optimal lead time directly. Hence we can develop the following heuristic algorithm 1 to get the optimal values of Q, L under centralized mode. We can compare the total expected annual cost of each end point of $[L_i,L_{i-1}]$ and set the lead time and order quantity that minimizing total expected annual cost to be the optimal lead time and order quantity decisions.

Algorithm 1

Step1: For each $L_i,(i=0,1,...,n)$, compute Q_i using Eq. (8).

Step2: For each (L_i,Q_i), compute the expected annual cost of the entire supply chain $TEC_{sc}(Q_i,L_i)$, $i=0,1,2,...,n$.

Step3: Set $TEC_{sc}(Q^*,L^*)=\min_{i=0,1,2,..,n}TEC_{sc}(Q_i,L_i)$, then (Q^*,L^*) is a set of optimal solutions under centralized mode.

2.5. Inventory model under decentralized mode

Under decentralized mode, the buyer and the vendor do not cooperate with each other, they will determine their own optimal policy separately. That is, the buyer will choose optimal order quantity and lead time to maximum his own benefit. Hence, taking the partial derivatives of $TEC_r(Q,L)$ in Eq. (1) with respect to Q and L in each time interval $[L_i, L_{i-1}]$, and equating them to zero, we obtain

$$\frac{\partial TEC_r(Q,L)}{\partial Q} = -\frac{D}{Q^2}(A + R(L) + \gamma\delta\sqrt{L}\Psi(k)) + \frac{h_r}{2} = 0 \quad (9)$$

$$\frac{\partial TEC_r(Q,L)}{\partial L} = \frac{D}{Q}(\frac{\gamma\delta L^{-\frac{1}{2}}\Psi(k)}{2} - c_i) + \frac{h_r k\delta L^{-\frac{1}{2}}}{2} = 0 \quad (10)$$

Hence, for fixed $L \in [L_i, L_{i-1}]$, $TEC_r(Q,L)$ is convex in Q, since

$$\frac{\partial TEC_r{}^2(Q,L)}{\partial Q^2} = \frac{2D}{Q^3}(A + R(L) + \gamma\delta\sqrt{L}\Psi(k)) > 0 \quad (11)$$

However, for fixed Q, $TEC_r(Q,L)$ is concave in $L \in [L_i, L_{i-1}]$, because

$$\frac{\partial TEC_r{}^2(Q,L)}{\partial L^2} = -\frac{\gamma\delta L^{-\frac{3}{2}}\Psi(k)D}{4Q} - \frac{h_r k\delta L^{-\frac{3}{2}}}{4} < 0 \quad (12)$$

Therefore, for fixed Q, the buyer's minimum expected annual cost will occur at the end points of the interval $[L_i, L_{i-1}]$. From Eq. (9), we have

$$Q^{**} = \sqrt{\frac{2D(A + R(L) + \gamma\delta\sqrt{L}\Psi(k))}{h_r}} \quad (13)$$

In the same way of the situation of centralized mode, we proved that the buyer's expected annual cost $TEC_r(Q,L)$ is convex in Q and easily obtain the analytic expression of the optimal order quantity under decentralized mode. However, we assume the lead time crashing cost to be a piecewise linear function and proved that the buyer's expected annual cost $TEC_r(Q,L)$ is concave in $L \in [L_i, L_{i-1}]$ and the minimum $TEC_r(Q,L)$ will occur at the end points of the interval $[L_i, L_{i-1}]$. So we cannot obtain the analytic expression of the optimal lead time directly. Hence we can develop the following heuristic algorithm 2 similar to algorithm 1 to get the optimal values of Q, L under decentralized mode.

Algorithm 2

Step1: For each $L_i, (i = 0,1,...,n)$, compute Q_i using Eq. (13).

Step2: For each (L_i, Q_i), compute the buyer's expected annual cost $TEC_r(Q_i, L_i)$, $i = 0,1,2,...,n$.

Step3: Set $TEC_r(Q^{**}, L^{**}) = \min_{i=0,1,2,...,n} TEC_r(Q_i, L_i)$, then (Q^{**}, L^{**}) is a set of optimal solutions under decentralized mode. And the vendor's and buyer's expected cost under decentralized mode is $TEC_s(Q^{**}, L^{**}), TEC_r(Q^{**}, L^{**})$, respectively.

3. Numerical Example

Consider an inventory system with the following characteristics: $D = 600 unit/year$, $P = 2500 unit/year$, $h_r = \$20/unit/year$, $A = \$200/order$, $\delta = 7 unit/week$, $\gamma = \$60/unit$, $h_s = \$40/unit/year$, $S = \$250/set\text{-}up$, $k = 2$. The lead time has three components with the data shown in Table 1.

Table 1. Lead time data (*i*: Component of lead time; a_i: Minimum duration with crashing; b_i: Normal duration; c_i: Buyer's crashing cost per unit time; d_i: Vendor's crashing cost per unit time)

i	b_i(days)	a_i (days)	c_i(\$/day)	d_i(\$/day)
1	20	6	0.4	0
2	20	6	1.2	2.0
3	16	9	5.0	3.0

The results under the centralized decision mode are summarized in Table 2 and the results under the decentralized decision mode are summarized in Table 3.

Table 2. Summary of the results under centralized decision mode (*x*: Expected cost of supply chain; *y*: Both parties' expected cost without coordination; y_1: Vendor; y_2: Buyer)

i	L	$R(L_i)$	$M(L_i)$	Q_i	x	y	
						y_1	y_2
0	8	0	0	136	4832	1754	3078
1	6	5.6	0	137	4745*	1752	2993
2	4	22.4	28	139	4804	1851	2953
3	3	57.4	49	144	4954	1913	3041

Table 3. Summary of the results under decentralized decision mode (*r*: Inventory cost of supply chain; *s*: Vendor's expected cost; *t*: Buyer's expected cost)

i	L_i	$R(L_i)$	Q_i	r	s	t
0	8	0	112	4910	1876	3034
1	6	5.6	113	4819	1868	2951
2	4	22.4	117	4890	1985	2905*
3	3	57.4	126	5029	2031	2998

From Table 2, the optimal inventory policy under cen-

tralized mode can be easily obtained. The optimal lead time $L^* = 6 weeks$, optimal order quantity $Q^* = 137 units$. The minimum expected annual cost of the entire supply chain is $TEC_{sc} = \$4745$, and the vendor's and buyer's expected costs are \$1752 and \$2993, respectively.

From Table 3, the optimal inventory policy under decentralized mode can be easily obtained. The optimal lead time $L^{**} = 4 weeks$, optimal order quantity $Q^{**} = 117 units$. The buyer's minimum expected cost is \$2905, and the vendor's expected cost is \$1985, then the inventory cost of the entire supply chain is \$4890.

Obviously, the expected annual cost of the entire supply chain under decentralized decision mode is higher than that of centralized decision mode. However, the buyer's expected cost under centralized mode is higher than that of decentralized mode. Hence, taking individual rationality into consideration, we need to design mechanisms that can induce both the vendor and the buyer to cooperate and make decisions to minimum the expected annual cost of the entire supply chain. In the following, we develop two kinds of benefit sharing methods, the first one is based on Shapley value method and the other is based on MCRS method (Minimum Costs-Remaining Savings) to coordinate the benefits of the vendor and the buyer. These two benefit sharing methods can not only meet both vendor and buyer's individual rationality, but also realize Pareto dominance of the entire supply chain.

4. Supply Chain Benefit Allocation Model

The benefit allocation methods to make benefit sharing of multiple-person cooperation game usually include Shapely value method, core method, CGA (Cost Gap Allocation) method and MCRS (Minimum Costs-Remaining Savings) method. Here we adopt Shapley value method and MCRS method to allocate benefits of supply chain.

4.1. Shapley value method

The Shapley value is one of the most popular benefit allocation solutions for the cooperative games. By using Shapley value method, we can suggest an allocation criterion to the benefits obtained from the cooperation among the players who have cooperated to form a coalition [15]. The Shapley value method gave out a formula for providing a standard to measure the contribution of each player makes to the benefits of a cartel within a cooperative game [16].

Assuming the number of players taking part into a coalition to be specified and is denoted by n. The marginal savings which each player contributes to a coalition depends on the size of that coalition. Let $|T|$ represents the set of players in a coalition before player i's joining. The saving derived from the inclusion of the i th player in a coalition of size $|N|$ has been given out by the Shapley value method.

For given cooperative game v of n person, there exists single Shapley value $\varphi(v) = (\varphi_1(v), \varphi_2(v), ..., \varphi_n(v))$, and

$$\varphi_i[v] = \sum_{T \subseteq N, i \in T} \frac{(|T|-1)!(n-|T|)!}{n!} \cdot [v(T) - v(T \setminus i)], \forall i \in N$$

where v is the characteristic function defined in the subset of N, $|T|$ represents numbers of element in coalition T, and $n = |N|$. $v(T \setminus i)$ is the savings of player i joining the coalition of T, $v(T)$ is the savings of the coalition of T.

For the case of this paper, only one coalition is possible, for there is only one buyer and one vendor. The benefit of buyer and vendor under decentralized mode is $-TEC_r(Q^{**}, L^{**}), -TEC_s(Q^{**}, L^{**})$ respectively. The benefit of the entire supply chain under centralized mode is $-TEC_{sc}(Q^*, L^*)$. According to Shapley value we can get the benefit of vendor and buyer under centralized mode, that is

$$\varphi_s[v] = \frac{(-TEC_{sc}(Q^*, L^*) + TEC_r(Q^{**}, L^{**})) + (-TEC_s(Q^{**}, L^{**})}{2} \tag{14}$$

$$\varphi_r[v] = \frac{(-TEC_{sc}(Q^*, L^*) + TEC_s(Q^{**}, L^{**})) + (-TEC_r(Q^{**}, L^{**})}{2} \tag{15}$$

Now we use Eq.（14）and（15）to coordinate the benefit of the vendor and the buyer of this example. Under decentralized decision mode, the expected costs of the buyer and the vendor are $TEC_r(Q^{**}, L^{**}) = \$2905$, $TEC_s(Q^{**}, L^{**}) = \$1985$, respectively. Under centralized decision mode, the expected annual cost of the entire supply chain is $TEC_{sc}(Q^*, L^*) = \$4745$. So by using Eq.（14）and （15）, we can get the benefit of the vendor and the buyer under centralized decision mode, they are $\varphi_s[v] = -\$1913, \varphi_r[v] = -\$2832$, respectively. That is, under centralized mode and with benefit coordination, the vendor's expected cost will be *\$1913* and the buyer's expected cost will be *\$2832*. From table 2, we can see, under centralized mode and without benefit coordination, the vendor's expected cost is *\$1752* and the buyer's expected cost is *\$2993*. That is, only if the vendor transfers *\$1913-\$1752=\$161* to the buyer, and the buyer's expected cost changes to *\$2993-\$161=\$2832*. Then both the vendor's and the buyer's cost will be improved comparing to that of decentralized mode and they will cooperate and make decisions under centralized mode to minimize the expected annual cost of the entire supply chain. Hence the benefit allocation model based on Shapley value method can not only meet both vendor and buyer's individual rationality, but also realize Pareto dominance of

the entire supply chain.

4.2. MCRS method

MCRS method（Minimum Costs-Remaining Savings）is another kind of acknowledged method to allocation benefit of multiple-person cooperation game. It can also be used to coordinate the benefit of each player of supply chain.

Taking the numerical example of this paper for example, we set TEC_r^* , TEC_s^* to be the expected annual cost of the buyer and the vendor under centralized decision mode, respectively. According to allocation model of MCRS method, the expected cost of players is given by:

$$TEC_k^* = TEC_{k\min} + \frac{TEC_{k\max} - TEC_{k\min}}{\sum_{k=s,r}(TEC_{k\max} - TEC_{k\min})}[TEC_{sc}(Q^*, L^*) - \sum_{k=s,r} TEC_{k\min}] \quad (16)$$

where $k=s,r$. TEC_{kmin} , $TEC_{k\ \min}$ can be obtained by linear programming:

$$\max or \min TEC_k^* \quad s.t. \begin{cases} TEC_r(Q^{**}, L^{**}) \ge TEC_k^* \\ TEC_s(Q^{**}, L^{**}) \ge TEC_k^* \\ TEC_k^* + TEC_k^* = TEC_{sc}(Q^*, L^*) \end{cases} \quad (17)$$

From table 2 and table 3, We obtain $TEC_r(Q^{**}, L^{**}) = \$2905$, $TEC_s(Q^{**}, L^{**}) = \$1985$, $TEC_{sc}(Q^*, L^*)$ =\$4745. By Eq.（13）we can get the optimal solution $TEC_{r\max}^* = \$2905$, $TEC_{r\min}^* = \$2759$, and $TEC_{s\min}^* = \$1840$, $TEC_{s\max}^* = \$1985$. Hence using Eq.(17) we can get allocation solution :

$$TEC_r^* = 2759 + \frac{(2905-2759)}{(2905-2759)+(1985-1840)} * [4745-4599] = \$2832 \quad (18)$$

$$TEC_s^* = 1840 + \frac{(2905-2759)}{(2905-2759)+(1985-1840)} * [4745-4599] = \$1913 \quad (19)$$

Hence, we can see the results are consistent with that of Shapley value. MCRS method can also make reasonable allocation of benefits derived from the cooperation between the vendor and the buyer according to their contribution to the coalition.

5. Conclusions

In this increasing intense competitive world, more and more companies have recognized the importance of the response time to customer and also have used time management as an important mean of gaining competitive advantage in the global marketplace. Lead time is an important element in any inventory system. In many practical situations, lead time can be controllable by an added crashing cost. In this paper, the supply chain inventory optimization with controllable lead time under centralized mode and decentralized mode are proposed. The solution procedures to get the optimal solutions are also suggested. At last, the benefit allocation models based on Shapley value method and MCRS method are developed to coordinate the benefit of the vendor and the buyer. The results of numerical example show that shortening lead time reasonably can reduce inventory cost and the benefit allocation models developed in this paper are effective. In real situations, the supply chain network is more complex than that of two-echelon supply chain consists of single vendor and single buyer discussed in this paper. When we take all the players of the supply chain network into consideration, things will be more complicated and the results may be different. Furthermore, only the benefit allocation of one-to-one problem is discussed in this paper. When we extend the problem to the entire supply chain network, there will be existed many more complex relationships, such as one-to-multi, multi-to-multi relationships and so on. How to deal with the cooperation and benefit allocation of n persons with individual difference and competition under these circumstances will be the points of further research. The supply chain inventory optimization problem with controllable lead time under fuzzy circumstance and asymmetric information situation can be the points of further research.

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Value Delivery Systems under the Instantaneous Competition

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ABSTRACT

In this paper, the necessary conditions and the components of the operation of value delivery under the instantaneous competition system are analyzed; the every node enterprise to make clear that the function of each of them in value creation and increase is discussed. The processes and model of a value delivery system are discussed in this paper, and the processes content and model are presented, we firstly discuss the operational flowchart and classification of the value delivery under the instantaneous competition environment. Secondly, we analyze the tactics of the instantaneous competition in supply chain system and the marketing system, both of which compose the whole value delivery system. Thirdly, we analyze some factors that must be controlled in value delivery system. Finally, we set up a multi-objective optimization model, which is a mixed-integer nonlinear programming problem. And a case study illustrates our conclusions.

Keywords: *Value delivery system, Instantaneous competition, Multi-objective optimization*

1. Introduction

The essence of time-based competition involves compressing time in every phase of the product development and delivery cycle, which becomes one of the most important strategies for enterprises development in nowadays. The competition mode is called instantaneous competition in this paper. Enterprises take quick respond to the demands of customers and rapid introduction of new products as the main strategic target and possess competitive cost and service quality at the same time, so they have to reduce the process time of service (involved product) planning and developing, producing, selling and transporting. Under the globalization environment, in which product life cycle becomes shorter and demand forecast is harder, the instantaneous competition between enterprises is very necessary. Value delivery system (VDS) is one of the most important processes, which includes the whole supply chain system and the marketing network of the service. The operational objective of VDS is to maximize the value that deliver to customer and realize the profit of member companies in system which obtained by participation in value creation. According to the different functions, a VDS can be divided into two portions: one is the supply chain system, and the other is the marketing system, which will be discussed separately later. However, we must consider the influence on service or band value both from the strategy selection in supply chain system and from the implement effect of marketing policy synthetically.

Research on VDS under the instantaneous competition is to control the service stream, stock and cost to maximize the value that delivered from the system to customers, and considering the influence of product lifecycle on the product demand and price simultaneity. It is because that demand and price of the product are always the main factors to weigh whether a product possess advantages in competition or not. And under the instantaneous competition, these factors are also sensitive to time, each of which change dramatically in different process of product's lifecycle. So, in this paper, we will forecast the product's demand and price at some periods by using some forecasting model in marketing and the results will be involved to compute how the value is in the VDS, which is the criterion to consider the advantage that the company. With the global economy development, a remarkable phenomenon shows that the VDS exists to create value for customers by supplying demand products and services. VDS and its abilities are at the heart of every firm and, more than anything else, determine whether the firm survives in the marketplace or disappear into bankruptcy or reengineered. VDS may cover many forms as illustrated by these two cases [8] as follows: (1) Facing increased competition and customers who are smarter, more demanding, and less brand-loyal, McDonald's is reevaluating the way it makes some of the items on its menu. For example, it is considering a switch to a hamburger bun that does not require toasting. In trial tests, customers seemed to prefer the new bun's taste and texture. Furthermore, not toasting buns should translate into substantial cost savings due to reduced preparation time and the elimination of commercial toasting

equipment [6]. (2) It is not well known that the Kmart and Wal-Mart chains both date back to 1962. By 1987 Kmart was clearly dominating the discount chain race, with almost twice as many stores and sales of $25 - $63 billion to Wal-Mart's $15.96 billion. However, for the retail year that ended in January 1991, Wal-Mart had overtaken Kmart, with sales of $32.6 billion to Kmart's sales of $29.7 billion. Interestingly, although Wal-Mart had taken the lead in sales in 1991, it still had fewer stores-1721 to Kmart's 2330. By the 1997 retail year, Wal-Mart had clearly established itself as the dominant discount chain, with sales of $106.1 billion to Kmart's $31.4 billion. For the period from 1987 to 1995 Kmart's market share declined from 34.5 percent to 22.7 percent, while Wal-Mart's increased from 20.1 percent to 41.6 percent. What accounts for this reversal in fortunes? Kmart's response to the competition from Wal-Mart was to build on its marketing and merchandising strengths and invest heavily in national television campaigns using high-profile spokespeople such as Jaclyn Smith. Wal-Mart took an entirely different approach and invested millions of dollars in VDS for the products it sells in an effort to lower costs. For example, Wal-Mart developed a company-wide computer system to link information from cash registers to firms in its supply chain, thus greatly facilitating inventory management. The integration of the system and the distribution system meant that customers would rarely encounter out-of-stock items and to reach the quick response. Further, the use of scanners at the checkout stations eliminated the need for price checks. By Kmart's own admission, its employees were seriously lacking the skills needed to plan and control inventory effectively [5]. These brief examples highlight the diversity and importance of VDS. Great many societal changes inevitably involve in VDS. There is great pressure among competing nations to increaseglobal productivity. Businesses are on a national crusade to improve quality and speed of their offerings in both products and services. As we will see, increasing productivity of the firm and value-added to customers are primary objectives of the VDS.

Technological change is an important consideration. Technologies such as e-mail, laptops, personal digital assistants, e-commerce, are profoundly affecting business and are fundamentally changing the nature of today's work. Many banks are shifting their focus from building new branch locations to using the Web as a way to develop new customer relationships and transaction processes. Banks rely on technology to carry out more routine activities as well, such as transferring funds instantly across cities, states, and oceans. Other industries also rely increasingly on technology for efficient, effective and secure processes, e.g., RFID used to control logistics activities, electronic data interchange and integrated information system of the same server of database and planning system.

Since the early nineteen 70s, many literatures represented how to shorten manufacturing process time in supply chain operation, such as Vinson, C.E (1972) [16] discussed costs of ignored lead time uncertainties in inventory phase. Das, C. (1975) [4] given a static analysis to lead time effect on inventory. Szwarc, W. (1971) [14] paid attention on time management in transportation. Stalk, G. Jr, published a milestone article named ad "Time-the next source of competitive advantage" in 1998, he first put forward the word of "time-based competition", the paper is early discussed under the instantaneous competition (IC) in details, not only analyzed the evolving process of competitive pattern, also discussed the importance of time by way of competitive advantage's core resource and described the essence of those such as instantaneous manufacture, instantaneous sale, instantaneous distribution, instantaneous innovation and strategy etc. Stalk, G. Jr and Hout, T.M., (1990) [13] expatiated the instantaneous competition in-depth, analyzed its relationships among business, financing, customer and innovation, pointed out using least time, lowest cost to supply maximal value is a successful business pattern, besides, the instantaneous competition needs supply new products which satisfying customer's demand rapidly and having competitive quality and cost. Certainly, the instantaneous competition has an important strategic meaning, since it can reach the following objective: adding the enterprise productivity; increasing product price elasticity; lowering the enterprise risk; enlarging the market possession. Gattorna John (2003) [9] based on financing explained compressed time strategy result in value, with eye on the customer service, customer response, balance in supply and demand, inventory. In China, research on the instantaneous competition emphasized its strategy combining with supply chain. From operational viewpoint, Yanhui Li and Shihua Ma (2005) [18] designed a distribution system to minimize the total responding time other than the delivery cost in the instantaneous competition environment and the multiobjective non-linear programming model for the instantaneous competition distribution system was constructed with certain assumptions as premises. [11] Based on analysis of the insufficient plan pattern which is widely used, a new plan pattern, predict-order pattern in supply chain was proposed for the instantaneous competition. Predict-order pattern aimed to shorten multi-stage response time, and made node enterprises in supply chain link up business information and determine plans in advance. Yuxing Han and Xiaowei Liu (2004) [19] considered the instantaneous competition environment, analyzed safety stock management of supply chain companies involving cost optimization and time optimization, and set up a safe stock management system based on lead time through analyzing the relations between safe stock and lead time. Qiufang Fu and Shihua Ma (2005) [10] studied instant customerization supply chain management pattern based on IC. Xiao Zhou *et al.*

distributed the quick-responded logistics pattern should be improved lies in the logistics of manufactures and their downstream enterprises, illustrated four kinds of logistics patterns that have great significance to shortening the response time of the final customers, which are the directly-sale pattern based on the manufactures, the retailer-supported wholesale logistics, the synthesized-wholesale logistics patterns which supporting districts retailer, and the alliance pattern of producing and retailing, and have their own adaptive environment, which depending on the operation character and the industrial character of SC. Thus it can be seen, most of literatures studied the instantaneous competition is based on supply chain management, and that A.Lockamy III (1993) [1] analyzed the lead time management based on product delivery system, set up a conceptive model to manage how to reducing lead time for manufacturer VDS, and depending on 6 world-wide manufacturers. We can know this article is early to refer delivery system based on the instantaneous competition.

In this paper, the necessary conditions and the components of the operation of a VDS under the instantaneous competition are analyzed; the every node enterprises in a VDS to make clear that the function of each of them in the value creation and addition are discussed. We firstly discuss the operational frame and classification of the VDS under the IC. Secondly, we analyze the tactics of the instantaneous competition in supply chain system and the marketing system, both of which compose the whole VDS. Thirdly, we analyze some factors that must be controlled in a VDS. Finally, we set up a multi-objective optimization model, which is a mixed-integer nonlinear programming problem. And a case study illustrates our conclusions.

2. The Missing Elements and Process Models in the VDS

The term operation is often applied loosely in business, and can mean anything from a firm's facility, to a VDS, to a process, to an activity, to a formal functional organization of people. Recall that a VDS's definition, clearly, some of these processes are officially part of the operations functions, but there are likely other processes in a VDS that fall under other functional areas within the organization and within other organizations in the supply chain. For instance, we may view General Motors' Cadillac line as a VDS that includes assembly processes as well as processes in marketing, R&D, engineering and finance within its organization. Examples within GM include: (1) Marketing processes that introduce to customers the new season's Cadillac configuration; (2) Design processes responsible for engineering detailed features for that configuration; (3) Assembly and test processes within operations, and (4) Sales processes responsible for finished good distribution, demand forecasting and promotions.

Unfortunately, most firms manage processes Depart-mentally, without recognition and concern for the entire VDS. James Harrington (1991) [7] explained the history and reasons for broken processes so prevalent in businesses today. A VDS and its associated processes were first developed out of a need to provide a family of products or services. In most companies, these needs arose when the business was young and growing. They were developed quickly to meet an immediate need to marshal a small internal population to serve a small customer target base.

After that meager beginning, the processes were Neglected and ignored. They were not updated to keep pace with the business environment. No one took the time to review and refine them. As business grew, disparate new products and services value-added, but most likely provided by the same processes. Responsibility for these processes was divided among many departments, and additional checks and balances were instituted as small empires grew. Little pools of bureaucracy began to develop. Two, three, or even four replaced one signature. Bureaucracy became the rule rather than the exception. Patches were put on top of patches. No one really understood what was going on, so no one could audit business processes within VDS to ensure that they were operating correctly. Along the way, the focus on the external customer was lost. The firm became more inwardly focused, and people did not really understand the impact of their activities on external customers.

Consequently, many business processes became in-effective, out of date, overly complicated, burdened with bureaucracy, labor intensive, time consuming, and irritating to management and employees alike. While most firms accepted these processes as a necessary evil, they have turned out to be millstones around the organization' neck that increasingly hamper its ability to compete. James Harrington (1991) [7] represented that between 40 and 70 percent of all white-collar support effort in manufacturing adding no value to customers. Eliminating white-collar errors and bureaucracy can cut overhead costs by as much as 50 percent, make a firm a leader in its field, and greatly improve response time, quality and cost of products to customers.

It is no wonder that in practice, important decisions made by a firm bear little or no relationship to their stated or official business strategy-even if the firm regularly conducts what it considers a rigorous strategic planning exercise. One important reason is that firms tend to seek strategies that are uniform in nature. This offers apparent clarity in the form of consistent strategic statements that are easy to express, explain, and address. A desired level of uniformity has inherent attractions no matter what the company's scale. It is not surprising then that typical expressions of corporate strategy include such general terms as low cost, differentiation, balanced scorecard, and

4 critical success factors. The use of general terms such as these blur rather than focus the firm on differences in markets that are increasingly characterized by difference, not similarity, and it brings conflicting demands on the operations function.

Unless strategy statements translate into actions and result in incremental or radical improvement in the VDS, they are of little value. Markets are characterized by increasing difference. Companies replace annually some 10 percent of existing sales revenue with "better" margin business [15]. The key to understanding markets, therefore, lies in being able to identify and integrate this new business into a new VDS. Because the needs of the market segments differ, decision priorities likely differ by market segment and VDS. A clear and accurate understanding of a company's markets arises from facts, data and ongoing discussions of strategic options involving all functions and process stakeholders within VDS. Firms must stop thinking functionally, and start thinking about markets served, and the VDS and associated processes that need improvement. World-class firms continuously strive to provide superior products and services to their target customers. Now, we will discuss the business process improvement steps. The general approach advocated in this paper is called business process improvement. It provides an objective method for segmenting markets, uncovering customer needs and developing a means to profitably satisfy those needs through the creation or improvement of critical processes. Business process improvement embodies the following principles: (1) Linking improvement efforts to the needs of target customers, ensuring constancy of purpose; (2) Working on a manageable number of projects, emphasizing improvements to critical processes within value streams with the greatest potential for improvement and profit; (3) Using facts, not speculation, based largely on data collected or logically inferred from customers and other stakeholders for selection and direction of improvement projects; (4) Pro-actively considering creation and improvement, as well as correction.

Business process improvement efforts may well involve and impact people within every functional department in the VDS. It is therefore time consuming and ongoing. A business process improvement initiative should be directed to a specific target market, its VDS and critical processes etc. It involves three basic steps:

(A) Determine the process intent

Process intent is a clear statement of what the VDS is intended to do-create value of customers, of course, but specifically who is the customer, what type of value is needed, and by how much additional value [14]. Unmet needs continually arise between what customers require and what the firm currently delivers, and these needs may be expressed in general terms, e.g., missing or inferior aspects of the bundle of products/services that comprise the offering, a price too high relative to perceived value in the marketplace, or some shortcoming concerning response time in delivering the offering. If the firm expects loyalty from its customers, these needs must somehow be satisfied by the firm's VDS and associated business processes. Thus, to improve the VDS, it is essential to first understand exactly who the customers are (target market profiles) and what they need. Expressed needs or latent needs of customers may be uncovered in various ways. It is important to understand not only the unmet customer needs but also the importance of each need, since the firm should focus its limited resources on satisfying the most important ones.

(B) Develop the process model

A process model is a detailed statement of how work should be divided in the VDS to satisfy the process intent (the process model would be best labeled the "VDS model"). In fact, there are no universally optimal ways to organize work, but there is one way to organize work to satisfy the particular process intent. Unmet customer needs can be satisfied through development or improvement of one or more processes within the VDS. Critical processes in the VDS must be identified and understood. If critical processes already exist they should be dissected to uncover opportunities for improvement. Regardless of whether or not a process currently exists, it is important to benchmark other firms with similar processes that are considered world-class to discover their best practices. With this analysis, a process model which best conforms to the process intent may then be constructed.

(C) Establish the learning and improvement system

The abovementioned covers how to establish continual learning and improvement within the "process model". Learning and improvement involves three sides: (1) Organization and management of change. The process model analysis conducted in (B) above should yield a set of actionable, prioritized recommendations as to how to profitably achieve the "ideal-state" in the VDS. Implementation of these business process improvements requires effective organization and management. (2) Feedback and control. This entails monitoring progress of the business process improvement endeavor against the performance targets, and taking corrective action if necessary. Feedback and control should occur during implementation and after implementation during execution. (3) Standardization. It is important to document standard work practices established in business process improvement efforts and communicate the knowledge gained to other parts of the business. Furthermore, business process improvement on one aspect of the business may have been unsuccessful, yet the firm may have gained if the lessons can be shared elsewhere.

Process intent (is commonly known in marketing circles as a value proposition) is a clear statement of what the VDS is intended to do, a strategic direction for the firm's management and employees as well as position statement for target customers on the role of the VDS. According to Terry Hill (2000) [15], clear process intent rarely occurs in practice, and unclear process intent causes confusion for customers, managers and employees. Many companies mistakenly assume that particular products or services compete in the same way in different markets, thus, failing to recognize how business is won.

In today's competitive markets, customers and potential customers demand increased value from the firm's offerings. Unmet needs are gaps that arise between what customers require and what the firm delivers. If the firm expects loyalty from its customers, these needs must somehow be satisfied by its VDS. To improve the VDS, it is essential to first understand exactly who the target customers are, what they need, how much they are willing to pay to satisfy this need, and what the impact will be on sales and profits. A firm must understand the importance of each need and focus its limited resources on fulfilling the most important ones. There must be a means to translate needs as customers express them into company language. That is, the *external process intent* must be translated into the *internal process intent*. Internal process intent relies on performance characteristics, design specifications and performance measures, and performance targets to describe the unmet needs in terms the company can measure. Figure 1 illustrates those steps involved in preparing the process intent.

A process model is a detailed statement of how work should be divided to satisfy the process intent. Figure 2 represents a logical set of steps in developing a process model. The first is to construct a process map that identifies major processes within a VDS. Second, critical processes are identified whose creation or improvement would enable us to satisfy the process intent. Processes should be dissected and analyzed to uncover opportunities for improvement. We do this using a lean audit and process benchmarking. A lean audit looks internally at existing processes, while process benchmarking looks externally at existing processes or ones that need to be created. In addition to a statement of the process model, it is also important to establish within the process model a set of actionable, prioritized recommendations as to how to achieve the process intent in a profitable manner and stay there.

3. VDS under IC

A VDS under IC has quite sensitive to time. Mostly, the meaning represents as follows: The market demand change along with product's life cycle, such demand change can be described by the product's life cycle curve; With the market demand changing, product's price will fluctuate in time progress, which will directly influence the revenue of a VDS and members in the system; The marketing strategy can alter product demand, usually add product value and improve product delivery efficiency.

In market economy, a VDS is enclosed customer, is based on a supply chain and a marketing system. Namely, it is a complex system that responding market demand rapidly, its objective is to create maximal value for customers and node enterprises of the system. Different product types correspond to different VDSs. When product is sensitive to time, whether it is functional product or innovative product, often needs to utilize the IC strategy in a VDS. Moreover, some requirements are necessary for a VDS under IC, such as all nodes linkage effect, operational effect, response ability and value-added ability etc. When the functional product is sensitive to time, its market demand and price are all influenced by itself lifecycle and seasonal demand markedly, such as milk, fresh vegetable, etc. To furthest achieve the product value, meet market demand, the VDS must adopt IC strategy, as soon as possible shorten lead time and process time of all nodes to guarantee product delivered to customer in the determinate time window and in optimal status.

Innovative product usually is sensitive to time, the reason includes: At the initial period of product introducing, the firstcomer can become monopoly absolutely, results in node enterprises in a VDS can gain the excess profit. For example, to newly SARS bacterin introduced to market, one branch price is 30 to 50 times higher than its costs. In fact, this is why enterprise "get rid of the stale and bring forth the fresh" continually; To winning time advantage, enterprise must take the lead in technology, its product standard and technical criterion are strongest likely first impressions, it evolves the correlative industry cognized uniform standard, compels aftercomer must accept the standard, then becomes the follower of lead enterprise. And that, the uniform standard will settle the lead enterprise in the steady core position among their industries, then virtually would improves their competitive ability; In a supply chain, member enterprises want win time advantage early can still setup their supply network and sale network, take the lead in taking possession of resource advantage, develop well sale channel, in this way, result in stronger support in organizing production and sale; From marketing viewpoint, early introduced market product which its first impressions are strongest. In competition of subsequent alike product, generally, customer is apt to select the brand-loyal product, since by long time chastened in market, such product is more mature, and the relative service is more perfect.

When a VDS is under IC, then all members of the system should recognize IC as the accordant value proposition, i.e., strategy of nodes is regarded as their

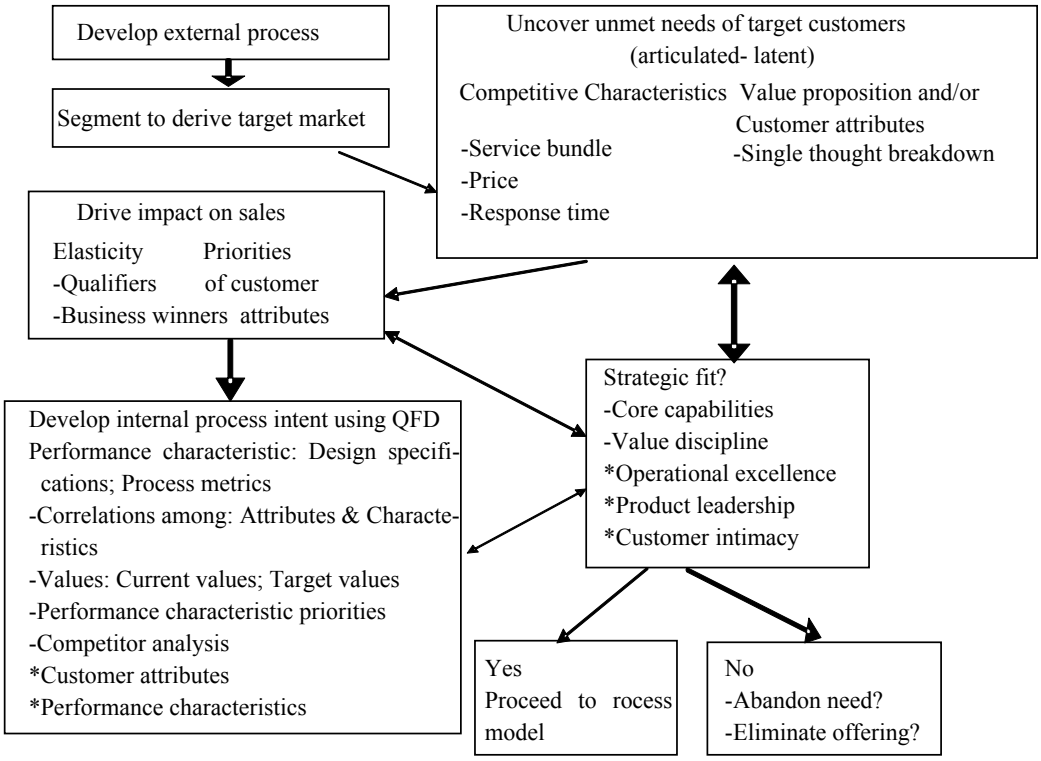

Figure 1. Preparation of process intent

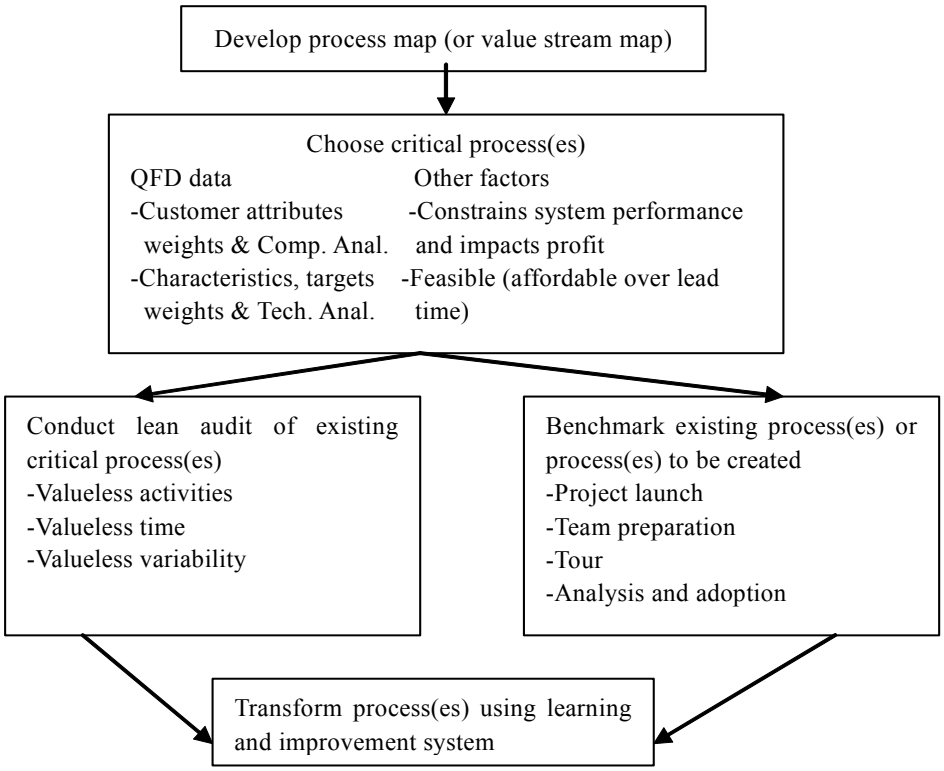

Figure 2. Development of process model

active rule must be under IC. Otherwise, time competitive advantage created by the upper stream enterprises, can be weakened by other nodes, which counteract even delay the product value realization time, then result in aftereffect would be not only wasteful, but also lose the market opportunity due to missing competitive advantage. Therefore, setup the accordant value proposition actually means that the strategic disposer and layout in members of the supply chain come down in one continuous line. This can reach from the following: (i) Philosophy of IC is rapid response to customer's demand. Enterprises under IC must optimize their process, adjust operation joined border upon nodes, and respond to the uncertain market demand agilely by shortened lead time. However, implementing IC is not simply shortening the process time among nodes. Moreover, the whole system must consider IC costs in node enterprises, utilizes the scientific layout and the detailed analysis to determine the relative strategies, tactics and scale of reducing process time for any nodes. (ii) All members in the system must have enough production capacity. Nowadays, since product is often sensitive to time, business opporunity is fleeting. So, members of the system must be likely to production sufficient product to fill market. In this competitive rule, whose operational time is shorter and sold product is greater, who will becomes a winner in competition market. (iii) IC needs integrate the enterprise's abilities. G. Jr. Stalk and Alan M. Webber (1993) [13] ever described IC existed latent risks, and Von Braun, Christoph-Friedrich (1997) [20] expounded the speed trap resulted in the negative effect on IC. No reason, endless reducing time will result in increasing cost largely, and virtually quicken regenerate product speed, shorten product lifecycle, instead go against profit gained by product value realization.

4. Operational Flowchat of the VDS under IC

Generally, the dominance built based on IC can actualize as follows: Time competitive strategy is driven by customer demand, i.e., according to customer demand fluctuation, enterprise rapidly adjusts its actions such as design, production, sale, etc., to meet customer demand at best times and largest released value; Time competitive strategy oriented in technological innovation, i.e., enterprise via the rapid innovation mechanism, deduces new product introducing time, takes possession of market at best times and maximal output, such pattern behaves obviously in updating speed industries such as IT and mobile telephone; Time competitive strategy oriented in marketing. One side because product lifecycle is more and more shorter, which needs enterprise to quicken product sale speed and decrease depreciating losses, on the other hand, enterprise improves product sale speed result in circulative speed decreased, warehouse stock costs reduced, members' turnover speed increased and gained higher revenue in a VDS. Therefore, different node enterprises in the VDS undertake the different tasks under IC, and they need to implement the different strategies. Commonly, considering the operational characteristics of nodes, the VDS under IC is divided into 4 modules, i.e., instantaneous design, instantaneous manufacturing, instantaneous sale, instantaneous service. The operational flowchart of the VDS under IC is illustrated in Figure 3.

The instantaneous design indicates via reduced product design period, improved the transform speed from concept to real product, based on technological innovation, to reach product competitive advantage, which can be realized from the following: In the different phases ofnew product development process, enterprise needs control and reduce the interstitial time among processes, as the possible as shortens time, such as time covered in redeployment, combination and process of the setup team, etc; The different types of product development organization will effect on time reduced, for example, some of organizations invite other members to participate in the R&D projects, such as supplier, the relative technological personnel in production department, seller in final market so many as retailer, improve the knowledge sharing between the design department and others; Enterprise must makes use of the computer auxiliary technology.

Product design process would result in value creating process, but its contribution to value creation occasionally limits in conception, yet no scale value realization or value-added. The instantaneous manufacturing mostly utilizes the competitive strategy based on customer

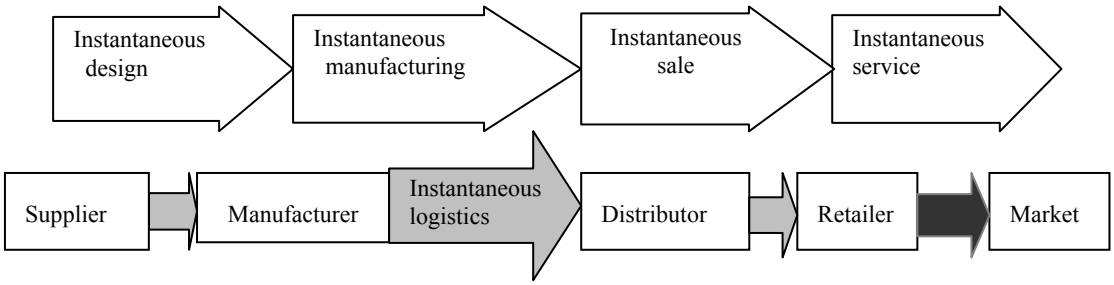

Figure 3. The operational flowchart of VDS based on IC

demand. According to the different product types, the detailed operational measures are incomplete similarity. For instance, the fun-ctional product always use JIT production pattern, the innovative product is suitable the rapid responsive operational pattern, and that the virtual operation provides more flexibility and more agility for the VDS. The instantaneous sale indicates decrease product no value-added time in circulation to the best to enterprise' abilities, such as stock time, distribution time, etc., the same as the instantaneous service, enterprise must follow out the time competitive strategy based on sale. If product can not deliver to customer in time, or does not sold and become finished goods stock, then JIT production will lose its significance. The instantaneous sale objective not only leads up market, enterprise becomes a leader in market, but also increases turnover speed, then deduces the period involving in product transforming profit to create more value. Herein, enterprise needs reengineer channel, makes the sale channel is so flat that enterprise and consumer are easy communication directly, and improves factor control and radicalization to the distribution channel. Nowadays, along with computer network and information technology development rapidly, market has already entered E-business times, online transaction is on popularization, in this way will result in both sides sale information transfer promptly and reduce the process time of product sale at greatest degree. The instantaneous service means that response to customer service demand rapidly, i.e., supports knowledge transfer and technology be used in the fore-and-aft product sale widely. Enterprise responds to customer service in the customer's forbearing time, can maximize customer value, then can keep customer loyalty and realize the product brand value. The instantaneous logistics mainly means that decreasing the needless waiting time and process time among nodes. In the VDS based on IC, enterprise should introduce the new operational pattern such as third party logistics, fourth party logistics, to improve the linkage effect among enterprises and increase product competitive advantage. In addition, to some products, enterprise in order to win the time advantage, can introduce the merge-in-transit strategy or postpone logistics strategy to change process from the tradition non value-added process to value-added process.

In fact, build inventory in anticipation of demand makes life so much easier for manufacturers, despite all the troubles that inventory management gives them. It is a luxury that many service enterprises envy. Management of a service enterprise often has to guess what demand will be and then establish its capacity, within fairly narrow limits, to meet that demand. If demand falls below projections, the enterprise suffers the pain of having to pay an excessive investment in capacity (e.g., facilities, or equipment). If demand exceeds the projections, then the enterprise loses revenue and contribution to profit. It can be a tricky business. A restaurant for example, must have sufficient capacity upon first opening, or risk a loss of goodwill, a deathnell for new sites. Generally, there are two ways to resolve these problems: adjust supply or adjust demand. We will discuss the two ways in detail. Firstly, let us consider supply management issues.

Under IC, a chief consideration for the management of supply chain within a VDS is to make sure there is enough capacity at the peak to response to customer demand rapidly. For many businesses, the peak period is a critical one for the financial health of the company. Retailers at holiday are not the only ones for whom the results of the peak times toll either joy or gloom. Accountants experience a busy season in the spring. Florists have six holidays that are critical. Other businesses face busy times on selected days of the week or at selected hours of the day such as lunch breaks and after 6 P.M. It is mandatory to prepare well for the peak, whenever it occurs. The supply of capacity in services may be adjusted in three general ways: shifting resources, changing resources levels, and changing the structure of the system.

Shifting resources: Shifting resources is most effective when there exists a scheduling problem, not a capacity problem, i.e., there is sufficient capacity overall, but it does not match the seasonal demand pattern. One way to deal with a scheduling problem is to shift the schedule of existing resources to cover peak loads to meet customer demand quickly. To the extent that the demand for services can be forecast or managed, the staff-start times and breaks can be adjusted accordingly. Of course, staff schedules must conform to work rules of unions, company policy, day-care considerations, etc. Another way to deal with a scheduling problem is to schedule the most productive employee. For this reason, fast-food restaurants schedule their best crews for their peak hours each week and renew services schedule their best workers at bottleneck activities during their peaks to deliver their value rapidly.

Changing resource levels: When there is a capacity problem, to win the IC advantage, changing resource levels becomes a viable option. To increase capacity usually involves adding resources (such as space, equipment, materials, or worker). In many services, the most controllable resource is worker. Worker may be acquired by hiring full-time or part-time workers, or by using overtime. Some services are constrained at peak times not by worker but by space or equipment. Here is where short-term rentals or borrowing can help. For example, airlines during peaks have been adopted to rent additional planes. The same is true for trucking firms or for warehousing operations, particularly if the peak is not expected to last very long. A decision to acquire resources implies deliberately investing in more capacity at the peak than is necessary for other times. Of concern, naturally, is

paying for the resources. There are two ways to justify such excess: (1) Margins earned at the peak. Peak times may be so lucrative or the costs of setup excess capacity may be so cheap that it pays for the service to exist with excess capacity for the rest of the time. At it turns out, many service organizations are judged by customers on their ability to handle peak loads. Concern halls, amusement parks, golf courses and gymnasium are classic examples; (2) Countercyclical service. Some service facilities have multiple uses. Ski resorts that double as summer resorts are this examples, their size is dictated by the ski peak, but funded in part with summer resort revenues. The economic justifications behind these two scenarios are complicated. The duration of the peak, the prices that can be charged, the costs of maintaining the facility, the costs of operating it, and the off-peak demand and prices must all be considered.

System restructuring: Whatever the system capacity, it is important to use it to the fullest under IC. There are several ways to restructure a VDS based on IC: perform activities concurrently, combine activities, standardize service pathways, untangle work flows in the layout, create cells, perform triage, provide support, and educate customers. (a) Perform activities concurrently: Sometimes, improvements in the rapid response to customers can be made if different resources perform tasks concurrently. For example, a credit card check may be performed concurrently while customer-mailing information and the order are processed. Even in cases where the same amount of work needs to be done, performing activities in parallel can shorten the customer's flow time. (b) Combine activities. Opportunities to combine similar or sequential activities may also be encountered. By consolidating multiple activities into one and performing the activity by one set of resources, the system may benefit from shorter processing times and queue times. Using the example above, combining activities of credit card checks, gathering mailing information and order processing allow one worker to perform them in series without delay in-between. In the case of concurrent activities, different workers would perform them in parallel. © Standardize service paths. Some customers, types of customers or customer orders may follow different paths through the same set of activities. These paths are called patient pathways in healthcare, service paths in other services, and part routings in manufacturing. The system can become much more orderly and efficient by rearranging some pathways so they all follow the same route, and increase the IC advantage. (d) Untangle work flows in the layout. Once the paths are standardized, we may discover opportunities to change the layout within the process so that customers or orders flow in the same direction through the resources. Logical and physical flowcharts often are effective in identifying tangled workflows. For instance, logical flowcharts may reveal similar pathways for different types of customers, when a physical flowchart may show how they are processed within conflicting, tangled flows. By changing resources around, businesses may be able to untangle these flows, then reducing travel time for customers, orders and workers, i.e., improving enterprise IC ability. (e) Create cells. Here cells mean that a natural extension of linearizing pathways and untangling workflows. A cell includes a set of resources that is dedicated to similar customers, customer types or customer orders. Within the dedicated cells, workers and equipment are co-located within close proximity, and customers follow the same or similar workflows. Cells may decrease the variation of work arriving at any particular cell and permit similar customers to be served more rapidly than they otherwise would. Reductions in processing time and variability are possible because of increased homogeneity of work and added learning by workers. Generally, the staff within a cell should be cross-trained as much as possible to facilitate efficient processing and flexibility. It is important to note, however, that resources dedicated within cells, are usually unavailable to "help out" on work across cells. Therefore, learning within cells must be large enough to offset the loss of pooling across cells. (f) Triage. Triage mechanisms can serve to route customers, customer types or customer orders to appropriate cells. Triage mechanisms are widespread at present, especially "touchtone triage," where we are asked to press "1" stands for one need, and "2 if our needs are something else. Triage, from the French word for "sorting" was originally a medical concept where a triage specialist decides whether a doctor or a nurse treats a patient. (g) Provide support. Workers need proper support to perform their jobs. A nurse may be more efficient if the right information, supplies, and assistance are provided at the right place and time. Additionally, circulating performance data, such as the number of patients treated, may in certain circumstances provide feedback and incentive to improve mean service time, service variability and conformance-to-standards. (h) Educate customers. Another mechanism that can effectively increase capacity and rapid responding time is to educate customers as to how to follow desired behavior. For example, a message may inform a caller when waiting on the telephone to have her order number and mailing address ready when a representative answers. An airline might benefit by informing people in line at the ticket counter to have a picture ID ready for security purposes. (i) Customer participation. Still another mechanism that can increase capacity and responding time is to persuade customers to do things for themselves. Hence, restaurants, during their peaks, may schedule a buffet service. In so doing they relinquish control over the portions provided people, but they can save substantially on the wait staff and kitchen help than they would otherwise require.

Next, we will discuss the management of demand appeared in a VDS based on IC. The key to demand

management will alter the behavior of customers, shift the timing of demand, so that the peak is "shaved", and the off-peak times, with their excess capacities, are fed more. Sometimes, this can be done directly, and other times it has to be done indirectly.

• Direct management of demand

The direct management of demand involves the following ways. (1) Deny service. It is often better not to accept business than to surprise customers with long waits. In the absence of input from the company, customers may decide to leave the system. In queuing terminology, a customer who encounters a long line may decide to leave (balk) before entering the line, or to leave (renege) after some time in line. Some service businesses encourage balking by designing waiting rooms or queue structures that allow only a certain number of customers in the system. (2) Reservations. For many services especially those with high intrinsic value for the customer, demand can be managed by introducing a reservation system. Customers make reservations for travel on airplanes and trains, particularly when supply is likely to be constrained. Sometimes, reservations do more than simply ensure full utilization of the service. They segment demand, then squeezing more revenue out of the customer who hope a better seat at a game, concert or plane, and generally, better or quicker service. Reservations also act to regulate the arrival of demand and to decrease its variability. As is the case with service time variability, a reduction in load variability can increase effective capacity and IC advantage. Reservation systems cost money to install and operate but they are effective and usually regarded by customers as fair, particularly if the queue is managed by a first come, first served rule or by a rationing scheme whereby those who pay more are served first. Reservation systems do require early, non-spontaneous action by customers, and thus they are not well-suited to all kinds of services. Certainly, reservation systems exist side-by-side with first come, fist served non-reservation systems, for instance, hotels, transportation, restaurants etc. This nearly always occurs with services that have enough excess capacity to accommodate walk-in business. Customers here also recognize that those who have planned ahead should be rewarded more than those acting on impulse, if capacity suddenly becomes constrained. (3) Yield management. Closely allied to reservation systems is yield management. Airlines have done much to perfect this technique. The objective of yield management is to maximize the revenue that a service can realistically expect. This is accomplished by offering "blocks" of the service, with differing restrictions on them, at a variety of price points. As reservations roll in, one can adjust the size of the chunks of service offered t each price with the goal of full utilization and maximum revenue. For example, airlines offer a variety of prices for seats with different restrictions. The lowest fares are limited in number and require the passenger to book significantly in advance, to stay a minimum amount for time at the destination, and to forfeit a considerable sum of money if the customer later desires a schedule change. Higher fares carry fewer restrictions and offer the most flexibility. Trying to maximize revenue in such situations, given the uncertainty of demand and the absolutely fixed capacity of the service, is an interesting dynamic problem. It is amenable to mathematical programming solutions. Economic solutions that equate the expected marginal revenues across the fare classes have also been studied. Most airlines and hotels, for instance, create a "threshold curve" based on historical demand patterns over time. If demand runs significantly higher than it has historically, then one or more low fare classes are closed and demand is forced into the higher fare classes. If demand runs significantly behind, then the lower fare classes are left open or expanded. Yield management, of course, requires an absolutely accurate and timely control system so that sellers have the best, most current data about the status of demand and knowledge about which fare classes are still open and which are either full or closed. It is no wonder that yield management is essentially a product of the information age. (4) Triage. Triage affects demand as well as supply. In the military, triage usually refers to battlefield conditions where the severity of patient medical needs is assessed and priorities for treatment are decided. Therefore, some cases are taken on immediately, others wait, and still others are treated in a partial way. For example, triage mechanisms in combination with reservation systems permit airlines, to handle first-class and business-class travelers more expeditiously than coach or tourist class travelers who have paid considerably lower fares.

• Indirect management of demand

Indirect management of demand includes persuading customers who might ordinarily want service during peak times to shift their demand to nonpeak times when there is capacity or delay time to handle them. The indirect management of demand focuses on the pricing and service policies that companies can use as inducements to customers. The detailed analysis is as follows. (1) Pricing policies. Customers understand price. As long as demand curves slope downward, lowering price is an incentive for getting customers to buy more of what you have to offer, and raising price will choke off demand. Raising prices for peak times and lowering prices for nonpeak times can work wonders for smoothing demand on the service process. Electric utilities offer electricity for lower prices if the peak days are avoided. Telephone company offers cut rates in the evening and night hours. (2) Promotions. Non-price service policies to shift demand are less straightforward and often not as effective ad pricing policies. They are frequently used in conjunction with pricing policies. For instance, not only does the hotel offer rooms at decreased rates on the weekend, but they may throw in a free breakfast or a swim place in the hotel.

(3) Alter customer expectations. Another non-price mechanism has to do with a firm's ability to influence customer expectations about timing. Simple signs, telephone messages or mailings that convey or future response times and the reasons for potential delays sometimes are enough to convince customers to wait. Others may come back when they expect the system to be less busy. And still others will go elsewhere or find substitute services. Even in these cases of lost contribution, it is better to inform customers ahead of time of the delays than to suffer the bad will of angry customers.

In a word, the suitable patterns of demand management and supply management will result in many ways benefit in the VDS based on IC, such as the maximum profit, the rapid response to satisfying customers, more value-added, etc.

5. The VDS Models Based on IC

Based on abovementioned, the VD involves the supply system and the marketing system. The supply system is base of the VDS, which form the value entity to respond to the change demand; and that the marketing system extends supply chain, not only searches and forecasts the demand information, but also needs adjust the marketing strategy and the sale environment to improve product value and sale quantities, then gains the maximum revenue of the VDS.

To sensitive time, the IC is a dominating strategy in the VDS. Therefore, to study such system, time factor must be taken into account the two systems (supply system and marketing system), and integrates such two systems, furthest develops market demand, so as to meet customer's demand, and maximize revenue. In this way, the following models consider two ways: (1) Build the model based on the marketing system. Using by the lifecycle curve of product, approximately forecast demand, and apply the advertising model and customer service model to adjust and triage the demand change, then based on the pricing model to find the pricing strategy. (2) Setup model based on supply system. To optimize the product flow and the operational time in system, do best maximize value in the VDS, and compare with different strategies to make decision.

A general supply chain that consists of three different levels of enterprises is considered and showed in Figure 4 [Chen *et al*., 2003] [2]: the first level enterprise is retailer or market from which the products are sold to customer under the conditions subject to a given low bound of customer service; the second level enterprise is distribution center (DC) or warehouse using different type of transport capacity to deliver products from manufacturer side to retailer side; and the third level enterprise is manufacturer that batch-manufactures one product at one period. The fixed manufacture/idle costs are also employed: on one hand, if the production line is changed over to manufacture another product, manufacture cost would be remained fixed; on the other hand, if the production line is set up to manufacture one specific product but actually is idle, the idle cost, also fixed. Furthermore, the manufacturer has options of manufacturing in regular time or overtime to satisfy the customer demand. To simplify the problem here, we do not consider the problem of purchase and inventory of the raw materials in manufacturers nor incorporate the purchasing cost into manufacturing cost. The research region of this paper, therefore, is from manufacturer to customer, like the dash line region showed in Figure 4. And the other assumptions are similar to [2] and the crucial difference was considered as follows: (1) Additional considering the resources supply, the whole supply chain extends from supply to the final market; (2) In sale way, involves service costs, to describe the value-added of a VDS.

Assume that s ($s \in S$) is a supplier, m ($m \in M$) is a plant, d ($d \in D$) is a distributor, r ($r \in R$) is a retailer, c ($c \in C$) is a customer, i ($i \in I$) is a product, j ($j \in J$) is a resource, t ($t \in T$) is a operational period.

Let FCS_{rt}^{i} denotes the service fixed cost when retailer r supply i product to c customer;

D_s denotes the maximum output of s supplier;

D_m denotes the maximum output of m plant;

D_r denotes the maximum capacity of r retailer;

FHC_{rt}^{i} denotes the fixed operational cost for r retailer;

FMQ_{s}^{j} denotes the average output of j resource manufactured by s supplier;

FMQ_{m}^{i} denotes the average output of i product manufactured by m manufacturer;

FMQ_{d}^{i} denotes the average magnitude of i product delivered by d distributor;

FMQ_{r}^{i} denotes the average magnitude of i product sold by r retailer;

FTC_{sm} denotes the fixed transportation costs when s supplier delivers resources to m plant;

FTC_{md} denotes the fixed transportation costs when m manufacturer delivers product to d distributor;

FTC_{dr} denotes the fixed transportation costs when d distributor deliver product to r retailer;

I_{*t}^{i} denotes the inventory level at period t, $* \in \{s, m, d, r\}$;

$MITC_{d}$ denotes the maximum input of d distributor;

TCL_{sm}^{j} denotes the maximum output when s supplier supply j material to m manufacturer;

TCL_{md}^{i} denotes the maximum output when m plant supply i product to d distributor;

TIC_{*t} denotes the whole inventory cost of s supplier, m

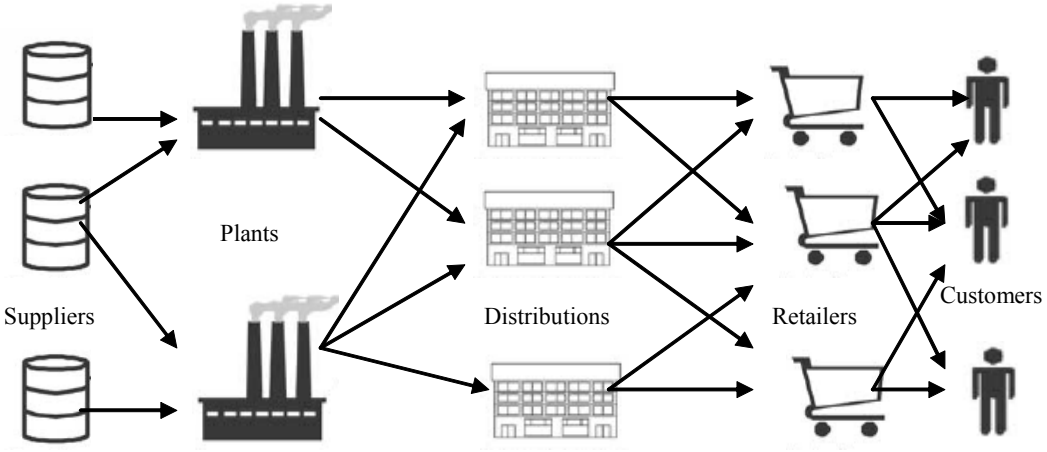

Figure 4. The supply system in the VDS MODEL

is a plant, d is a distributor, r is a retailer, $* \in \{s, m, d, r\}$, where $TIC_{*t} = \sum_{\forall i \in I} UIC_{*}^{i} I_{*t}^{i}, * \in \{s, m, d, r\}$;

μ^{j} denotes j material used in unit production;

UIC_{*t}^{i} denotes the unit inventory cost, where $* \in \{s, m, d, r\}$;

UMC_{m}^{i} denotes the unit production cost when m manufacturer make i product averagely;

UMC_{s}^{j} denotes the unit production cost when s supplier manufactures j material averagely;

UMT_{m}^{i} denotes the unit production period based on m manufacturer makes i product averagely.

Some variables satisfy as follows:

o_{st}^{j} is a bivariate function, when s supplier invests the excess j material, $o_{st}^{j} = 1$, otherwise $o_{st}^{j} = 0$;

o_{mt}^{i} is a bivariate function, when m manufacturer overtime manufactures i product, $o_{mt}^{i} = 1$, otherwise $o_{mt}^{i} = 0$;

o_{dt}^{i} is a bivariate function, when d distributor via excess investment to delivery i product, $o_{dt}^{i} = 1$, otherwise $o_{dt}^{i} = 0$;

o_{rt}^{i} is a bivariate function, when r retailer via excess investment to sale i product, $o_{rt}^{i} = 1$, otherwise $o_{rt}^{i} = 0$;

$\tau_{*t}^{i,1}$ denotes the production or operational time in unit product at any period, where $* \in \{s, m, d, r\}$;

$\tau_{*t}^{i,2}$ denotes the logistics time spending on all nodes, where $* \in \{sm, md, dr\}$;

τ_{SC}^{i} denotes the lead time spending on service of supplied i product;

OMQ_{st}^{j} denotes the j material magnitude of s supplier overrun the average output, where

$$OMQ_{st}^{j} = \sum_{m \in M_s} SQ_{smt}^{j} + I_{st}^{j} - I_{s,t-1}^{j} - FMQ_{s}^{j};$$

OMQ_{mt}^{i} denotes the output of i product overrun average output by m manufacturer, where

$$OMQ_{mt}^{i} = \sum_{d \in D_m} SQ_{mdt}^{i} + I_{mt}^{i} - I_{m,t-1}^{i} - FMQ_{m}^{i};$$

PS_{st} is the sale revenue of s supplier, where

$$PS_{st} = \sum_{\forall m \in M_s} \sum_{\forall j \in J} USP_{sm}^{j} SQ_{smt}^{j};$$

PS_{mt} is the sale revenue of m manufacturer, where

$$PS_{mt} = \sum_{\forall d \in D_m} \sum_{\forall i \in I} USP_{md}^{i} SQ_{mdt}^{i};$$

PS_{dt} is the sale revenue of d distributor, where

$$PS_{dt} = \sum_{\forall r \in R_d} \sum_{\forall i \in I} USP_{dr}^{i} SQ_{drt}^{i};$$

PS_{rt} is the sale revenue of r retailer, where

$$PS_{rt} = \sum_{\forall c \in C_r} \sum_{\forall i \in I} USP_{rc}^{i} SQ_{rct}^{i};$$

SQ_{smt}^{j} is the magnitudes of j material delivered by s supplier to m manufacturer;

SQ_{mdt}^{i} is the magnitudes of i product delivered by m manufacturer to d distributor;

SQ_{drt}^{i} is the magnitudes of i product sold by d distributor to r retailer;

SQ_{rct}^{i} is the magnitudes of i product sold by r retailer to c customer;

TCS_{t}^{i} is the overall relative service cost for i product at t period;

$TCS_t^i = \sum_{\forall c \in C^i} \left[FCS_c^i + UCS_{ct}^i(\tau_{sc}^i, SQ_{ct}^i) SQ_{ct}^i \right]$, where $UCS_{ct}^i(\tau_{sc}^i, SQ_{ct}^i)$ denotes the relationship among the service cost of unit product and the lead time of unit product, generally, when τ_{SC}^i is more smaller, the service cost of unit product is more higher, and more product are delivered to market, more higher the relative service cost is;

THC_{dt} is the fixed operational cost of d distributor at t period, where

$$THC_{dt}^i = \sum_{d \in D_l} \sum_{m \in M_d} (FHC_{dt}^i + (SQ_{md}^i + SQ_{dr}^i) UHC_{dt}^i(SQ_{md}^i, SQ_{dr}^i, \tau_{dt}^{i,1}))$$

THC_{rt} is the fixed operational cost of r retailer at t period, where

$$THC_{rt}^i = \sum_{r \in R^l} \sum_{d \in D_r} (FHC_{rt}^i + (SQ_{dr}^i + SQ_{rc}^i) UHC_{rt}^i(SQ_{dr}^i, SQ_{rc}^i, \tau_{rt}^{i,1}))$$

TLT_{*t}^i is the i product lead time among every node enterprises, $TLT_{*t}^i = TLT_{*t}^{i,1} + TLT_{*t}^{i,2}$, where $* \in \{sm, md, dr, rc\}$;

$TLT_{*t}^{i,1}$ is the production lead time among every periods, where $* \in \{sm, md, dr, rc\}$;

$TLT_{*t}^{i,2}$ is the exterior logistics time among every nodes, where $* \in \{sm, md, dr, rc\}$;

$TLT_{smt}^{j,1} = \tau_s^{j,1}(SQ_{smt}^j - I_{s,t-1}^j) + \tau_{sm}^{j,2}$;

$TLT_{mdt}^{i,1} = \tau_m^{i,1}(SQ_{mdt}^i - I_{m,t-1}^i) + \tau_{md}^{i,2}$;

$TLT_{drt}^{i,1} = \tau_d^{i,1}(SQ_{drt}^i - I_{d,t-1}^i) + \tau_{dr}^{i,2}$;

$TLT_{rct}^{i,1} = \tau_c^{i,1}(SQ_{rct}^i - I_{r,t-1}^i) + \tau_{rc}^{i,2}$;

TMC_{st} is the overall production cost of s supplier at t period, here

$$TMC_{st} = \sum_{\forall j \in J_s} [FMQ_s^j UMC_s^j + o_{st}^j OMQ_{st}^j OMC_{st}^j(\tau_{st}^{j,1}, SQ_{smt}^j)]$$

where $OMC_{st}^j(\tau_{st}^{j,1}, SQ_{smt}^j)$ denotes the production cost of j material manufactured by suppliers is relative to $\tau_{st}^{j,1}, SQ_{smt}^j$, J_s denotes the set of materials supplied by S supplier;

TMC_{mt} is the overall production cost of m manufacturer at t period, here

$$TMC_{mt} = \sum_{\forall i \in I_m} \left[FMQ_m^i UMC_m^i + o_{mt}^i OMQ_{mt}^i OMC_{mt}^i(\tau_{mt}^{i,1}, SQ_{mdt}^i) \right]$$

where $OMC_m^i(\tau_{mt}^{i,1}, SQ_{mdt}^i)$ denotes the additional product cost of m manufacturer is relative to $\tau_{mt}^{i,1}, SQ_{mdt}^i$, I_m denotes the set of product manufactured by m manufacturer;

$TPC_{mt}(t)$ is the procured materials cost by m manufacturer, where $TPC_{mt} = \sum_{\forall s \in S_m} \sum_{\forall j \in J} USP_{sm}^j SQ_{smt}^j$;

$TPC_{dt}(t)$ is the procured cost of d distributor, where $TPC_{dt} = \sum_{\forall m \in M_d} \sum_{\forall i \in I} USP_{md}^i SQ_{mdt}^i$;

$TPC_{rt}(t)$ is the procured cost of r retailer, where $TPC_{rt} = \sum_{\forall d \in D_r} \sum_{\forall i \in I} USP_{dr}^i SQ_{drt}^i$;

TTC_{*t} is the transportation cost committed in the node enterprises, where $* \in \{s, m, d\}$;

$TTC_{st} = \sum_{\forall m \in M_s} \sum_{\forall j \in J} \left(FTC_{sm}^j + UTC_{sm}^j(\tau_{sm}^{j,2}) SQ_{smt}^j \right)$, where $UTC_{sm}^j(\tau_{sm}^{j,2})$ denotes the transportation unit cost committed in s supplier distributed j material to m manufacturer that is relative to the single batch transportation time, more shorter time, more higher the transportation unit cost;

$TTC_{mt} = \sum_{\forall d \in D_m} \sum_{\forall i \in I} \left(FTC_{md}^i + UTC_{md}^i(\tau_{md}^{i,2}) SQ_{mdt}^i \right)$, the reason is same as above;

$TTC_{dt} = \sum_{\forall r \in R_d} \sum_{\forall i \in I} \left(FTC_{dr}^i + UTC_{dr}^i(\tau_{dr}^{i,2}) SQ_{drt}^i \right)$, the reason is same as above;

$TTC_{rt} = \sum_{\forall c \in C_r} \sum_{\forall i \in I} \left(FTC_{rc}^i + UTC_{rc}^i(\tau_{rc}^{i,2}) SQ_{rct}^i \right)$, the reason is same as above;

UCS_t is the unit cost committed in customer service, which is relative to SQ_{rct}^i and τ_{rc}^i;

UHC_{dt}^i is the i product operational unit cost of d distributor, which is relative to SQ_{mdt}^i, SQ_{rct}^i and $\tau_{dr}^{i,1}$;

UHC_{rt}^i is the i product operational unit cost of r retailer, which is relative to SQ_{rct}^i and $\tau_{rc}^{i,1}$; $UMC_{st}^j(\tau_{st}^{j,1}, SQ_{smt}^j)$ is the manufactured j material unit cost committed in S supplier excess investment, which is relative to $\tau_{st}^{j,1}$ and SQ_{smt}^j;

$UMC_{rt}^i(\tau_{rt}^{i,1}, SQ_{rct}^i)$ is the sold i product unit cost committed in r retailer excess investment, which is relative to $\tau_{rt}^{i,1}$ and SQ_{rct}^i;

$USP_{sm}^j(t)$ is the price of s supplier sold j material to m manufacturer, which is relative to material price and the discount determined by the transaction between two sides at t period;

USP_{mdt}^i is the price of m manufacturer sold i product to d distributor, which is relative to the product sale price and the discount determined by transaction between two sides at t period;

USP_{drt}^i is the price of d distributor sold i product to r retailer, which is relative to the product sale price and the discount determined by transaction between two sides at t period;

USP_{rct}^i is the price of r retailer sold i product to c customer, which is relative to the product price in market

at t period;

UTC_{sm}^{j} is the transportation unit cost when s supplier delivers product to m manufacturer, which is relative to $\tau_{sm}^{i,2}$;

UTC_{md}^{i} is the transportation unit cost when m manufacturer delivers product to d distributor, which is relative to $\tau_{md}^{i,2}$;

UTC_{dr}^{i} is the transportation unit cost when d distributor delivers product to r retailer, which is relative to $\tau_{dr}^{i,2}$.

On the abovementioned assumptions, the objective function of the VDS for i product satisfies: $\max W^{i} = \sum W_{*}^{i}, * \in \{s, m, d, r\}$

where $W_s^i = \sum_{s \in S^i} \sum_{j \in J^i} (PS_{st}^j - TMC_{st}^j - TTC_{st}^j - TIC_{st}^j)$;

$W_m^i = \sum_{m \in M^i} (PS_{mt}^i - TMC_{mt}^i - TPC_{mt}^i - TTC_{mt}^i - TIC_{mt}^i)$;

$W_d^i = \sum_{d \in D^i} (PS_{dt}^i - THC_{dt}^i - TPC_{dt}^i - TTC_{dt}^i - TIC_{dt}^i)$;

$W_r^i = \sum_{r \in R^i} (PS_{rt}^i - THC_{rt}^i - TPC_{rt}^i - TTC_{rt}^i - TIC_{rt}^i)$.

The constraints involve as follows:

(1) Manufacture constraints

Manufacturer constraints include three ways as follows:

(a) Throughput constraint satisfies $\sum_{m \in M_s} SQ_{smt}^{j} \le D_s^j$, i.e., all of j material are manufactured by s supplier supplied all manufacturers is not bigger than the maximum output of s supplier;

$\sum_{d \in D_m} SQ_{mdt}^{i} \le D_m^i$, that is the magnitudes of i product supplied by m manufacturer to all distributor, which is not bigger than the maximum output of i product for m manufacturer;

$SQ_{smt}^{j} = \mu^{j}\left(FMQ_m^i + OMQ_m^i o_{mt}^i\right)$.

(b) Demand constraint: product introduced market at period $t-T$ is not bigger than demand at t period, where T is the overall operational period in the VDS for i product, i.e., $0 \le \sum_{i \in I} \sum_{r \in R^i} \sum_{c \in C_r} SQ_{rc,t-T}^{i} \le FCD_t^i$ (this constraint is available for other product flow).

Here $FCD_t^i = \dfrac{\alpha_i \theta_A^i FSQ_{A,t}^i + \beta_i \theta_{FCS}^i FSQ_{FCS,t}^i}{USP_{rct}^i}$, where θ_A^i and θ_{FCS}^i represents the decision variables, i.e., θ_A^i denotes decision maker deems A advertisement effect on demand of i product, θ_{FCS}^i denotes service operation effect on demand of i product;

$FSQ_{A,t}^i$, $FSQ_{FCS,t}^i$ are the sale value based on advertising investment and service at t period;

α_t^i a bivariate function, when run advertisement or promotion, $\alpha_t^i = 1$, otherwise $\alpha_t^i = 0$;

β_t^i a bivariate function, when there is relative service in the system (for i product), $\beta_t^i = 1$, otherwise $\beta_t^i = 0$;

here $s \in S$, $m \in M$, $d \in D$, $r \in R$, $i \in I$, $j \in J$, $t \in T$.

(c) Transportation constraint: $SQ_{smt}^{j} = \phi_{smt}^{j} TCL_{sm}^{j}$, where $0 \le \phi_{smt}^{j} \le 1, \sum_{m \in M} \phi_{smt}^{j} = 1, s \in S, \forall_m \in M_s$, i.e., j materials supplied by s supplier to m manufacturer are not bigger than the maximum transportation capacity supplied by the supplier;

$SQ_{mdt}^{i} = \phi_{mdt}^{i} TCL_{md}^{i}$,

where $0 \le \phi_{mdt}^{i} \le 1, \sum_{d \in D} \phi_{mdt}^{i} = 1, m \in M, \forall_d \in D_d$, i.e., manufacturer m distributed i product to d distributor is not bigger than the maximum transportation capacity supplied by the manufacturer;

$SQ_{drt}^{i} = \phi_{drt}^{i} TCL_{dr}^{i}$,

where $0 \le \phi_{drt}^{i} \le 1, \sum_{r \in R_d} \phi_{drt}^{i} = 1, d \in D, \forall_r \in R_d$, , i.e., i product delivered by d distributor to r retailer is not bigger than the maximum transportation capacity supplied by the distributor;

$\sum_{\forall_m \in M_d} SQ_{mdt} \le MITC_d$,

i.e., all of product of distributor d which manufacturer m supplied is not bigger than the maximum input of d distributor, where $M_d \in M$ denotes the set of all m manufacturers relative to d distributor;

$\sum_{\forall r \in R_d} SQ_{drt}^{i} \le MOTC_d$,

i.e., all of product of r retailer acquired from the relative d distributor is not bigger than the maximum output of d distributor, where $R_d \in R$; here $s \in S$, $m \in M$, $d \in D$, $r \in R$, $i \in I$, $j \in J$, $t \in T$.

(2) Inventory constraints

$I_{st}^{j} = I_{s,t-1,}^{j} + FMQ_s^j + OMQ_s^j o_{s,t-1,}^{j} - \sum_{\forall m \in M_s} SQ_{sdt}^{j}$, i.e., at t period, j material inventory of s supplier is based on the remained inventory at pre-period plus j material at present then subtract from all of j material delivered to the relative m manufacturer, where $M_s \in M$;

$I_{mt}^{i} = I_{m,t-1,}^{i} + FMQ_m^i + OMQ_m^i o_{m,t-1,}^{i} - \sum_{\forall d \in D_m} SQ_{mdt}^{i}$, i.e., at t period, i product inventory of m manufacturer is based on the remained inventory at pre-period plus the manufacturing i product at present then subtract from all of i product delivered to the relative d distributor,

where $D_m \in D$;

$I_{dt}^i = I_{d,t-1}^i + \sum_{\forall m \in M_d} SQ_{md,t-TLT_{md}}^i - \sum_{\forall r \in R_d} SQ_{drt}^i$, i.e., at t period, i product inventory of d distributor is based on the remained inventory at pre-period plus the i product distributed by all of the relative manufacturers then subtract from all of i product delivered to the relative r retailer, where $M_d \in M$, $R_d \in R$;

$I_{rt}^i = I_{r,t-1}^i + \sum_{\forall d \in D_r} SQ_{dr,t-TLT_{dr}}^i - \sum_{\forall c \in C_r} SQ_{rct}^i$, i.e., at t period, i product inventory of r retailer is based on the remained inventory at pre-period plus the i product distributed by d distributor at present then subtract from all of i product sold to c customer, where $D_r \in D$, $C_r \in C$;

$\sum_{i \forall I} I_{*t}^i \le MIC_*$; $I_{*t}^i, SQ_{*t}^i \ge 0$, where $* \in \{s, p, d, r\}, s \in S, m \in M, d \in D, r \in R, i \in I, t \in T$.

To the whole VDS, the overall period means that the entire process time from supplier up to product/service delivered to the final customer. It is summation of all of the inner production/operational time and the logistics time among all node enterprises. The production/operational time among all node enterprises are illustrated in Figure 5.

Next, we will consider those relative to time.

(1) Expressions of production/operational time among all node enterprises

The production/operational time among all node enterprises build up the fixed production/operational setup time and the variable production/operational time. Where the fixed production/operational setup time involves those waiting time, such as the equipment debugging, arranging personnel, machine warm-up etc., and that variable production/operational time is the production/operational time of unit product multiply the quantities of product. Then we have

$TLT_{smt}^j = \tau_s^{j,1}(SQ_{smt}^i - FMQ_{s,t-1}^j - I_{s,t-1,}^j) + \tau_{sm}^{j,2}$;

$TLT_{mdt}^i = \tau_m^{i,1}(SQ_{mdt}^i - FMQ_{m,t-1}^i - I_{m,t-1,}^i) + \tau_{md}^{i,2}$;

$TLT_{drt}^i = \tau_d^{i,1}(SQ_{drt}^i - I_{d,t-1}^i) + \tau_{dr}^{i,2}$;

$TLT_{rct}^i = \tau_c^{i,1}(SQ_{rct}^i - I_{r,t-1}^i) + \tau_{rc}^{i,2}$.

(2) The objective function based on operational time of system

The objective function based on operational time of system satisfies:

$\min TT^i = \sum_* TLT_{*t}^\bullet, * \in \{sm, md, dr, rc\}, \bullet \in \{i, j\}$

(3) Constraints

All of constraints are analyzed as follows:

$0 \le \tau_s^{j,1} \le \tau_{s,0}^{j,1}$, where $\tau_{s,0}^{j,1}$ denotes the regular unit production time of s supplier; $0 \le \tau_m^{i,1} \le \tau_{m,0}^{i,1}$, where $\tau_{m,0}^{i,1}$ denotes the regular unit production time of m manufacturer;

$\tau_s^{j,1} * SQ_{sm}^j \ge \tau_{s,0}^{j,1} * FMQ_s^j$; $\tau_m^{i,1} * SQ_{md}^i \ge \tau_{m,0}^{i,1} * FMQ_m^i$;

$\tau_d^{i,1} \ge 0$, $\tau_r^{i,1} \ge 0$.

Based on above mentioned analysis and the economic theory, the relative costs relationships are illustrated in Figure 6. For example, the unit production/operational time of all nodes is inverse proportion to the variable cost, i.e., the production time of unit product is more shorter, the invested resources need more, would result in the production variable cost of unit product will increase. In other words, the node enterprise' production and operational efficiency improved, response ability increased, those are expense of increased production cost. Therefore, considering the relationship among time and value, time and cost, or the unit production time in all nodes, these exists an optimizing value predicatively, which result in maximum delivery value in the VDS based on IC. The relative costs relationships are illustrated in Figure 6 on the whole.

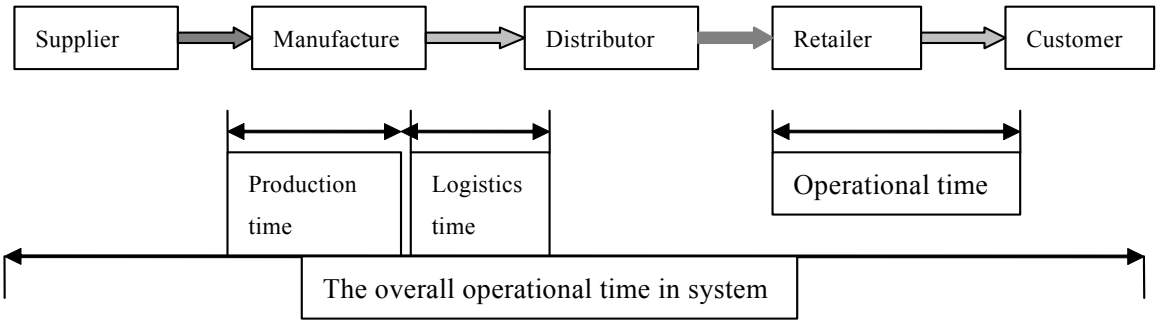

Figure 5. The overall operational time in system

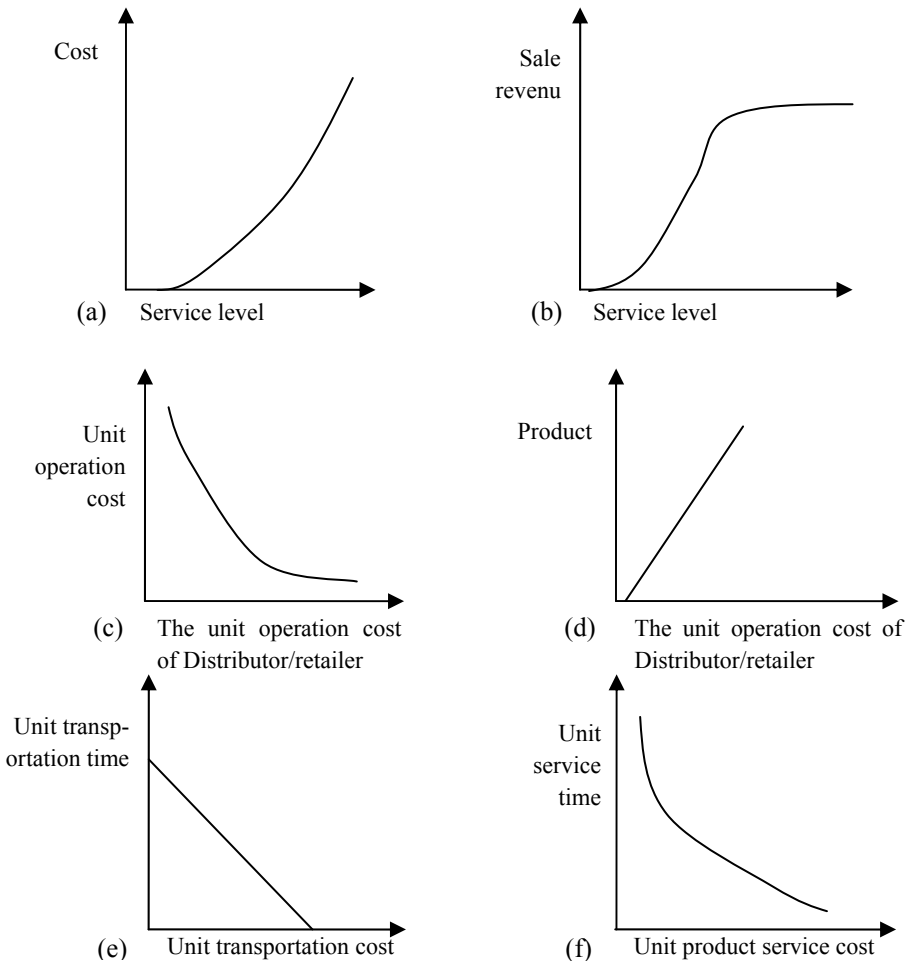

Figure 6. The relationship between time and cost, product and cost

6. Case Study-the sport suit VDS

In this section, we consider all sport suit enterprises typically selected from Quanzhou city in China. These firms are divided into two VDSs, i.e., the sport suit supply chain system or the marketing system.

(1) The sport suit supply chain system.

There are the following characteristics in the system: (a) To raw material, such as pre-investment cost is more higher, functional utilization is singularity, product type is singleness, and usually quantities are more greatest, often utilize pipelining, setup time is more longer, etc.; (b) To color, material, texture, etc., such as raw material, semi-finished product, finished product, all of these are easily out of data, since their lifecycle is relative shorter. In fact, fashionable dress will depreciate 0.7% every day, so long as sold in advance 10 days may be depreciated 7%, then can increase gross profit to 13%. (c) To product, such as the raw material nature and the supply trait are concealed the uncertainty of supply, quality and price, for instance, the seasonal diversity, material tailored in different regions, material growth environment, etc.From the production process, there are characteristics as follows: (i) There is uncertainty in output level and process time. For example, some processes are just handled a single product, i.e., thereafter, product is inhomogeneity. (ii) Production efficiency if often determined by throughput. New product are introduced in endlessly in today's sport suit industry, especially, diversification represents on design, pigmentation and brand built up, etc. Pigmentation belongs to the labor-intensive work (adding personnel or necessary technological support results in improve productivity), however, design, brand built up and more others are difficult to control, because there are a great deal of uncertainty in supply, quality, pricing and other ways. Thus, one product often need the different "recipe" to response to the different demand or the different market, such as Pierre Cardin product have already adopted the different strategies in different countries.

(2) The sport suit marketing system

The sport suit product is dominated by its brand, the core thinking of brand management is using by those such as the brand reputation, market development, sale channel, R&D, production technological management, quality control, information control, human resource, etc., form the powerful attaching strength, would bring the exterior

resources of nodes such as supply, production, sale into the VDS, then result in improve the market outspreading ability or the competitive ability.

The typical sport suit enterprise usually is based on one famous brand or some of core product, carry through development, production and management, and set up a dynamic virtual organization in countrywide regions or in global areas; the enterprise is based on production management mainly, all members according to a determinate cooperative strategy fulfill their chain's tasks, where their operational process emphasizes clear and controllable collaboration; all allied enterprises are relative independence in such organization, geographical position is quite decentralization, so need a rapid smooth information system to support enterprise's operation. For instance, ZARA in Inditex emphasized the time value. Because the brand effect is obvious to the sale level, the new incomer often spend much advertising fare or the promoting fare to improve the well-known degree or the brand value. Synthetically, the sport suit VDS has the following characteristics: the virtual enterprise management in dynamic league; information sharing enough among the union members; agile supply chain management; dynamic decision-making support.

Consider two sport suit brands but they have typical product (e.g., sportswear) supply chain. The two VDSs are illustrated in Figure 7, respectively. Where, the first product I, a new incomer, the VDS consists of suppliers, manufacturers, distributors, retailers and the final customers. The unit product needs the relative materials are 0.5 unit, the retailers of product I simultaneity sold other product; The second product II, its brand is already known very well, the VDS consists of suppliers, manufacturers, retailers and the final customers. The product is delivered by manufacturer directly to retailer. The retailer supplies the monopolistic room. Manufacturer of product II meets the customer individuation demand by customization service. Via optimization of the systems, we can compare to the advantage and their operational effect of two product's VDSs. And in order to simplify the problem, we neglect the fixed assets and apportion among the node enterprises, and that do compare and control to the variable costs of the systems, respectively. At the same time, assume that the safety inventory in each node does not change with period, so to control output and flux of each node, the safety inventory of the two contiguous periods can be counteracted. To logistics time among the nodes, once the transportation mode and transportation route are determined, its optimizing degree is often quite smaller. Thus, we neglect the logistics time optimization. Otherwise, the relationship between the operational cost and operational time in distributors and retailers is often in high-degree variable. So we will neglect the optimizing result in the following model.

Table 1. The optimized results of product I

Product I value flow ($)	W1	327400.0
Value created by the supplier ($)	WS1	11900.00
Value created by the manufacturer ($)	WM1	164400.0
Value delivered by the distributor ($)	WD1	75577.14
Value delivered by the retailer ($)	WR1	75522.86
Materials supplied by the supplier (piece)	SQS	1000.000
Product manufactured by the manufacturer (piece)	SQM	2000.000
Product delivered by the distributor (piece)	SQD	2000.000
Product sold by the retailer (piece)	SQR	2000.000
The overall operational time in system (day)	TT1	97.00000
Production period of the supplier (day)	TS	0.1000000E -01
Production period of the manufacturer (day)	TM	0.4000000E -01

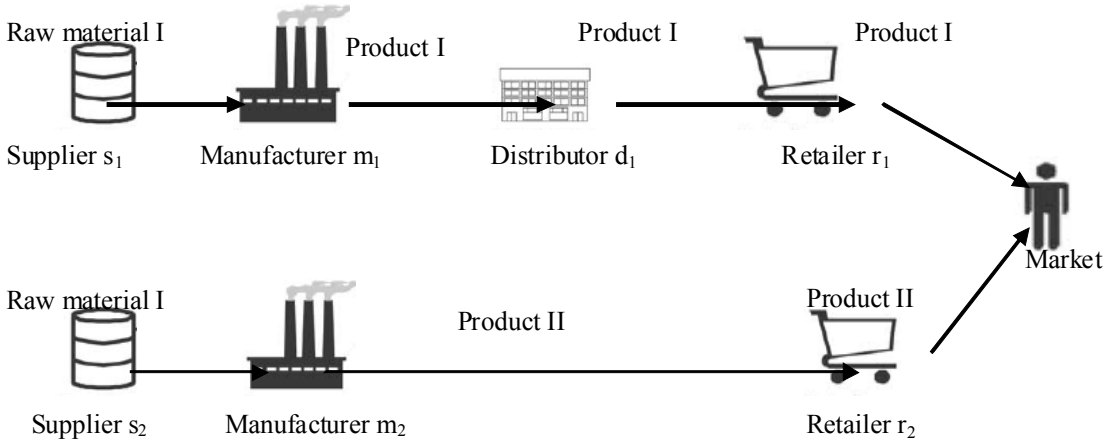

Figure 7. The VDS based on two products

In order to obtain the Pareto-optimal curve for this optimization problem, one of the objectives is specified as an inequality with a fixed value for the bound which is treated as a parameter. There are two major approaches to solve the problem in terms of this parameter. One is to simply solve it for a specified number of points to obtain an approximation of the Pareto optimal curve. The other is to solve the problem as a parametric programming problem, which yields the exact solution for the Pareto optimal curve. While the latter provides a rigorous solution approach, the former one is simpler to implement. For this reason we have selected this approach.

Based on given data and abovementioned models, we can find the retailer maximum undertaken product is the first bottleneck to the VDS. The maximum inventory of the retailer is 1000, results in sale is 1000 at this period. The improved strategy is the retailer's inventory supervised by the distributor, such as utilizing VMI strategy, adding replenishing times, then ensure the retailer meet the market demand at this period. Thereby, the transportation costs of distributor and retailer would increase, where the fixed transportation cost is 500, the unit transportation costs is 0.7, the optimized results are represents in Table 1.

Next, we will validate the necessary based on the numerical results. Firstly, we describe the time change based on lifecycle curve to forecast two product's demand at the same period, their experienced lifecycle curves are illustrated in Figure 8. Using by the market forecasting, product II demand change with period can be represented as follows:

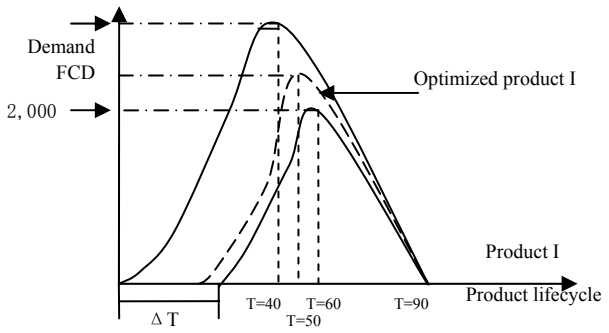

Figure 8. The compare of optimized fore-and-aft results in system

$$FCD^2 = \begin{cases} 2*T^2, 0 \le T \le 50 \\ -1.25*T^2 + 50*T + 5625, 50 \le T \le 90 \end{cases}$$

where, T denotes time, $0 \le T \le 90$.

Suppose the introducing market time difference of product I and product II are caused many factors, such as in the VDS existing the different operational period, system starting early or late, etc., then the demand function of product I can be represented:

$$FCD^1 = \begin{cases} 2*T^2 - 100*T + 800, 40 \le T \le 60 \\ -\frac{8}{9}T^2 + \frac{200}{3}T + 1200, 60 \le T \le 90 \end{cases}$$

where $40 \le T \le 90$.

Assume that all node enterprises in the VDS have not throughput restriction, then while T=50, the optimized parameters of product II are represented in Table 2.

When T=50, the optimized parameters of product I are represented in Table 3.

Table 2. The optimized results of product II

Product II value flow ($)	W2	950440.4
Value created by the supplier ($)	WS2	14750.00
Value created by the manufacturer ($)	WM2	361990.4
Value delivered by the retailer ($)	WR2	573700.0
Materials supplied by the supplier(piece)	SQS	1500.000
Product manufactured by the manufacturer (piece)	SQM	3000.000
Product sold by the retailer (piece)	SQR	3000.000
The overall operational time in system (day)	TS	0.8000000E-02
Production period of the supplier (day)	TT2	48.50750
Production period of the manufacturer (day)	TM	0.1050250E-01

Table 3. The optimized results of product I

Product I value flow ($)	W1	125920.0
Value created by the supplier ($)	WS1	4820.000
Value created by the manufacturer ($)	WM1	62760.00
Value delivered by the distributor ($)	WD1	29170.00
Value delivered by the retailer ($)	WR1	29170.00
Materials supplied by the supplier （piece）	SQS	400.0000
Product manufactured by the manufacturer (piece)	SQM	800.0000
Product delivered by the distributor (piece)	SQD	800.0000
Product sold by the retailer (piece)	SQR	800.0000
The overall operational time in system (day)	TT1	43.00000
Production period of the supplier (day)	TS	0.1000000E-01
Production period of the manufacturer (day)	TM	0.4000000E-01

Product demand is 800, the market pricing is $220,

then the VDS for product I gains the maximum value is \$125920, the minimum operational period is 43 days. To adjust value and the operational time in VDS for product I, aim is farthest shorten time delay of product introduced or is likely to create the maximum value, the following strategies would be considered.

(a) Increase product I advertisement fare, endeavor to improve product I demand. If the sale saturation level of product I is \$440,000, the sale attenuation constant is 0.4, the sale response constant is 8, the advertising budget of product I is \$44,000, sale at current period is \$176,000, then, using by the promotion strategy, product I demand would be 1300 at T＝50.

(b) Shorten the operational time, reduce the manufacturing period, quicken product introducing market speed, decrease time delay of product introduced market. If manufacturer reduces the regular unit production time to 0.02days, and that increases the unit production cost to \$35, based on Lingo8.0 technique, the optimized results of product I are described in Table 4.

Table 4. The optimized results of product I

Product I value flow (\$)	W1	200870.0
Value created by the supplier (\$)	WS1	7770.000
Value created by the manufacturer (\$)	WM1	96110.00
Value delivered by the distributor (\$)	WD1	48495.00
Value delivered by the retailer (\$)	WR1	48495.00
Materials supplied by the supplier (piece)	SQS	650.0000
Product manufactured by the manufacturer (piece)	SQM	1300.000
Product delivered by the distributor (piece)	SQD	1300.000
Product sold by the retailer （piece）	SQR	1300.000
The overall operational time in system (day)	TT1	39.50000
Production period of the supplier (day)	TS	0.1000000E-01
Production period of the manufacturer (day)	TM	0.2000000E-01

That is $SQ_s^1 = 650$, $SQ_m^1 = SQ_d^1 = SQ_r^1 = 1300$, the unit production time of the supplier is 0.01, the unit production time of manufacturer is 0.02. The maximum objective value of product I is 200870, and that operational time is 39.5 days. According to these results, we can find the optimized strategy is true, not only increase value of the system, but also shorten the operational time.

In addition, to product I, because the operational time of the system by optimized moves up 3.5days (4days approximately), thus the lifecycle curve of product I will transfer unit 4 to left axis, it is easily to see in Figure 8. And, since product I is introduced into market early, taken on a determinate competitive advantage, mostly reflected in the maximum demand increasing accordingly. Suppose that 2400, in this way, we have

$$FCD^1 = \begin{cases} 1.2*T^2 + 25*T - 2455, & 36 \le T \le 54 \\ -0.5T^2 + 5.5T + 3555, & 54 \le T \le 90 \end{cases}$$

where $36 \le T \le 90$.

When $T=50$, demand of product I is 1800, if the sale saturation level of product I is \$528,000, the sale attenuation constant, the sale response constant and the advertising budget of product I are same as above, sale at current period is \$396,000, then using by the promotion strategy, product I demand would be 2200 at $T=50$. Based on Lingo8.0 technique, the optimized result of product I is described in Table 5.

Table 5. The optimized results of product I

Product I value flow (\$)	W1	351980.0
Value created by the supplier (\$)	WS1	13080.00
Value created by the manufacturer (\$)	WM1	172340.0
Value delivered by the distributor (\$)	WD1	83280.00
Value delivered by the retailer (\$)	WR1	83280.00
Materials supplied by the supplier (piece)	SQS	1100.000
Product manufactured by the manufacturer (piece)	SQM	2200.000
Product delivered by the distributor (piece)	SQD	2200.000
Product sold by the retailer （piece）	SQR	2200.000
The overall operational time in system (day)	TT1	62.00000
Production period of the supplier (day)	TS	0.1000000E-01
Production period of the manufacturer (day)	TM	0.2000000E-01

Therefore, it can be seen, the operational time of the VDS has already gone beyond the product I time scope, i.e., all node enterprises on product I must further reduce the operational time of the system, increase resources, so as to product I just meet advertising and market demand at *T=50* within the feasible time in the system, otherwise, the advertisement is in vain.

In conclusion, under IC, the earlier introduced product often has more advantage than after-comer obviously; Via the improved strategy, shortened the operational period, would improve product status in competition and increase value delivered by the system; Optimization of the VDS

based on IC must implement the strategy of all node enterprises; Under IC environment, enterprise must take on everything, analyze its status in competition, hold the external market environment and adopt the relative strategy.

7. Conclusions

In today's market driven by customers, in which product life cycle becomes shorter and demand forecast is harder, the instantaneous competition between enterprises is very necessary. In this paper, the necessary conditions and the components of the operation of the VDS are analyzed; the every node in a VDS to make clear that the function of each of them in the value creation and addition is discussed. We firstly discuss the operational frame and classification of the VDS under IC. Secondly, we analyze the tactics of IC in supply chain system and the marketing system, both of which compose the whole VDS. Thirdly, we analyze some factors that must be controlled in a VDS. Finally, we set up a multi-objective optimization model, which is a mixed-integer nonlinear programming problem. A case study illustrates our conclusions.

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Reverse Logistics Operation Management Based on Virtual Enterprises and Complaint Service Management

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ABSTRACT

Based on analyzing the difficulties of reverse logistics operation management and discussed the new environment as the economic society developing continuously and discussing the feasibility of virtual enterprise, an operation management mode for reverse logistics based on virtual enterprise is presented in this paper. By analyzing the relationships between complaint service management and reverse logistics, the complaint service management (CSM) is considered in reverse logistics, we take into consideration the process computing of CSM by combing the computer technology, the communication technology and the information technology. Using by the computer telephone integration technology, an integration multi-channels collection can be designed; the evaluation of complaint and production is supported by intelligent decision support system; considering the different disposal countermeasures, the CSM processing system is determined to implement corresponding disposal which reflects the utility of CSM. The organization framework, the operational process, the dynamic durative of virtual enterprise, those are expounded in detail. By using Fuzzy AHP technique, the hierarchical and the multi-criteria decision making problems for virtual enterprise are considered and the optimized selection is presented.

Keywords: *Reverse logistics, Virtual enterprise, Complaint service management, Operation management, Fuzzy AHP*

1. Introduction

Reverse logistics (RL) is a new logistics form which from the customers or distributors to the manufacturers is contrary with the traditional logistics. Concretely speaking, because some productions lost the obvious use value such as the packaging, or lost the function such as the spoiled products, or are difficult to sale in the general market such as the overstocks, or must be returned for some reasons, such as the cars with disfigurement, they have to flow reversely from the downstream to the upstream in supply chain. Reverse logistics management is the process of planning, implementing, and controlling RL activities.

The rapid development of RL is along with the increased research both in practice and the theory. Some literatures have provided some feasible solving methods mainly reflected as follows: (1) Operational management meaning. Literatures represented the impact factors such as determined automated pipeline, inventory and order-based production control system [36]; cost or time [33]; product life cycle [4] etc. (2) Operational model. The main works involved return models, network structures, inventory management, information technologies etc. In return aspect, such as compared with OEM takeback, Pooled takeback and third party takeback [28]; third-party reverse logistics providers selection and evaluation [15]; a contractor of fourth-party logistics [5] etc., As far as network structures, such as network design principles [20]; the product return network structure [19]; the strategic-tactic-operational decisions framework [19]; the hierarchical model of RL network design [27]; the mix integer linear program applied in reverse network [30]; empirical study [21] etc., To inventory management, the key work centralized in optimal methods, such as optimal control model based on double warehouses [8]; newsboy problem [12]; average cost approach [12]; Lagrange function [8] and so on. For information technology, most of work reflected the definite role in RL, such as the superior performance through focused resource commitments to information technology [22]; supply chain information system [17]; material recovery and environmental impact through a Decision Support System [24]. And, other works are represented in forecast [11]; design of reverse distribution networks [32]; disassembly and reassembly [29] etc. In fact, RL has become one of important strategy for enterprises and even countries to seizure the global plateau. With the industrial ecology issues are extensive popularity among the fields of society, government and industry etc., such as 3R (reducing, reusing and recycling) strategies, cost-saving ecological ideas and plan, green production and so on. On the other hand, the leading actors in today's markets have transformed from sellers to buyers, whether or not meet customers' individuation demands become an important factor to show enterprises' talents in the competitive environment. The information asymmetry between enterprises and customers, the com-

plexity in the business environment, the diversity of customers' demands and so on, all indicate that customer complaint is unavoidable [1]. Based on the modern organizational behavior theory, the viewpoint of complaint reflects that an enterprise should admit customer complaint, even more advocates it. Customer complaint helps an enterprise win the customer again and provides with the change to improve product [10] Therefore, enterprises in supply chain must take active manners to treat customer complaint and manage it effectively. The complaint information such as the returned product from consumer is portion of RL activities; at the same time, complaint service management (CSM) in a supply chain needs to be analyzed. From the strategic view, CSM is the crucial composing of RL strategy and an effective approach of reverse information, such as, CSM can help organization build the customer loyalty and find the new value-added; an enterprise via successful managing complaint, it can improve its customer satisfaction degree, retain the old customers and allure the new customers; an enterprise via analyzing the customer complaint, it can find out its customer preference, so make for updating or developing product; the return product attached complaint information is just core activity in RL etc. Nowadays the computer technology, the communication technology and the information technology have been active and progressing aggressively. Those would give CSM important stimulus and prompting to perform more efficiently and effectively. Under the supply chain circumstance, based on online complaint management as well as auctions to sell refurbished or old parts are discussed by Rainer Alt (2000) [25]. If the partial order does not deliver on time, it is important to get the system to notify System Manager such that KiMs can initiate the action instead of customer filing a complaint [23]. The service provider's reaction can either reinforce a strong customer relationship, or change a smilingly minor complaint into a major incident. The visibility concept into the domain of mobile information systems in a supply chain, it can offer when incorporated into business customer solutions and solves company related to certain complaint management problems [31]. Aspects of Social Dialogue, freedom of association and complaint management are clearly separated as distinct issues by another enterprise representative who fundamentally distances himself from the task of forcing union participation through the companies: As an enterprise representative, one did not want to assume a mediating role for unions at suppliers', representation being the task of the unions themselves [2]. In fact, personal relationships play a fundamental role in business relations, in which technical aspects of communication prevail on emotional ones [3]. From those literatures' results, we can see the main RL activities driven by the coercive conditions or enterprise' sustaining objectives. From the customer's behavior, specially, CSM applied in RL rarely and combing the computer technology to managing complaint is unperceived.

RL operation management is restricted by the cost, the practice, the human resource and uncertainties in market etc. Considering the environmental consciousness and the policy impact, the outsourcing is the better selection for enterprises driven by economic profit. In order to make full use of the third provider services' advantage, a virtual enterprise (VE) fashion will be most appropriate. The concept of VE was proposed by Kenneth Preiss *et al*. (1991) [14]. The way of only depending on a single enterprise to respond rapidly to changing market opportunities and intensely global competition have been inapplicable. The key technique determined by utilizing agile manufacturing practices is based on VE. With the urgent demand of implementing, it is significant to find an effective operation management mode for RL. From presented works, we can see the main RL operation was presided over enterprise's oneself or cooperation fashion or third party logistics supplier, CSM applied in RL rarely and combing the computer. How to consider the VE model in RL operation, it is significance. Therefore, we represent an operation management mode based on VEs.

This paper organization is as follows: In section 2, the relationships between complaint service management and RL are analyzed, the complaint service management in RL is probed into; In section 3, we analyze primarily the difficulties of RL and the characters of VE, finding the advantages of integrating; In section 4, we discuss the framework of VE for RL, and provide an operation process, and the evaluation of VEs for RL operation is based on the firms' multi-criteria which are qualitative or quantitative is presented in section 5. Finally, a numerical example is reflected our conclusions.

2. CSM and RL

2.1. CSM is an important reason of engendered RL

As a whole, RL can be classified by return and reclaim in a supply chain. Return is "push" logistics produced by all distributors or end customers; and reclaim driven by manufacturers is called "pull" logistics [17]. "Push" logistics mostly involves reverse flowed products and information; customer complaint is just aim at the product information feedback except the government policy. One of causes for RL engendering is determined by fashion of an enterprise takes cognizance of complaint. If an enterprise is attention to the customer complaint information, throw into CSM, it will clean off obstacles of the return flow of product or information, whereas, if an enterprise disregards the customer complaint, RL service will be wave aside. In fact, any complaint may trigger reverse activities in a supply chain. When analyzing the customer complaint information professionally, some bugs in product designing or production processes could be find out,

enterprises must recall those products initiatively, i.e., results in the "pull" RL. It is obvious that CSM is an important reason for engendering RL, as shown in Figure 1.

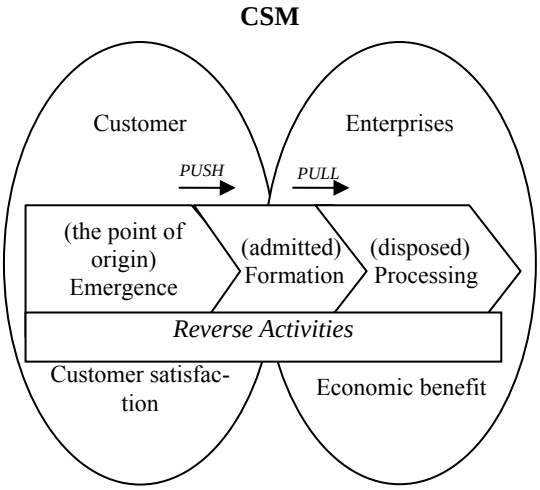

Figure 1. The fashion of "push" and "pull" RL

2.2. CSM is the crucial portion of RL management

Complaint information of customers is the feedback information, as well as products; those information and products flow conversely are just all RL activities. The drive force to implement CSM comes from customer, that because if considering the customers as the point of origin of RL, the enterprises act can be regarded as the "transfer" or terminal. Based on sufficient communication with customers, enterprises collect the external complaint information to track investigation and integrating analysis; different departments share information at the same time, such as client data, product status, processing flow etc.

From logistics management, RL activities are organized according to CSM, those activities include: Reuse-where packaging is reused or a product is returned to polish for resale to another customer; Repair/repackage-where a moderate magnitude of repairs and/or repackaging will allow the product to be reused; Return to supplier-if the product was purchased from a supplier and is returnable, or materials from return disassembled product; Resell-where the product is resold in a secondary market "as is." Some logistics companies have found a niche in matching sellers with buyers in secondary markets and say that there is a market for virtually anything; Recycle-where the product is broken down and "mined" for components that can be reused or resold; Renew-where a used product's utility is restored by replacing worn parts or remanufacturing in some manner, such that the product can reuse; Harmless disposal-where the unworthiness item is sent to a landfill, which can be fired with high temperature or buried. There is a far more expensive choice than most organizations operation, e.g., transportation costs, disposal facilities and IT cost etc. When payment for goods or compensation has happened between enterprises and customers, the content of CSM involve financial management committed in RL. In fact, CSM will help enterprises to implement RL operation exactly [6].

2.3. CSM objective is based on customer satisfaction

CSM is aim to improve customer satisfactory degree, this is not contradiction to the objective of the enterprises' economic benefit in implementing RL. If enterprises want to win customers, customers enjoyable is necessary, there is need to provide the better service after purchased. That is to say, RL strategy is of an important approach to meet customer demand involving repair, replacing etc. To develop CSM, enterprises can implement RL management to reclaim actively the spoiled products in customers or overstock in downstream distributors, these ways will be propitious to improve the relationships with downstream actors as distributors and customers, and then increase satisfaction degree availably. With satisfaction degree improving, a good brand will prevail widely, after then higher market share and production profit will be received. On the other hand, reproducing for spoiled, rebuilding for disused etc., form which enterprises can excavate more potential value.

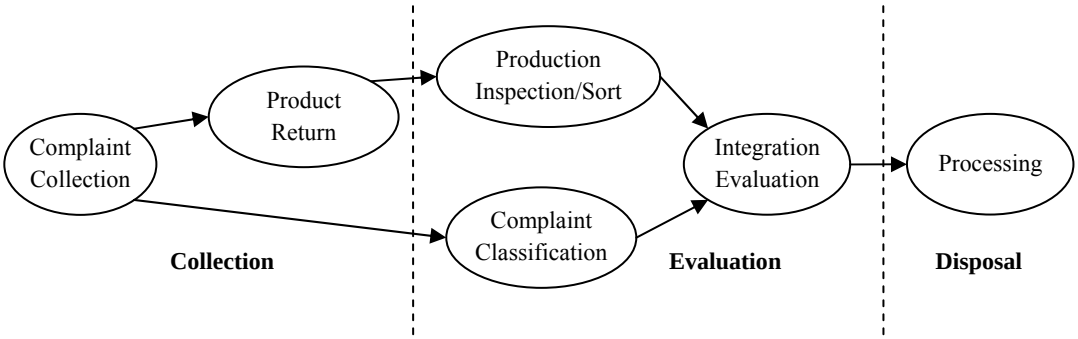

Figure 2. CSM of RL in a supply chain

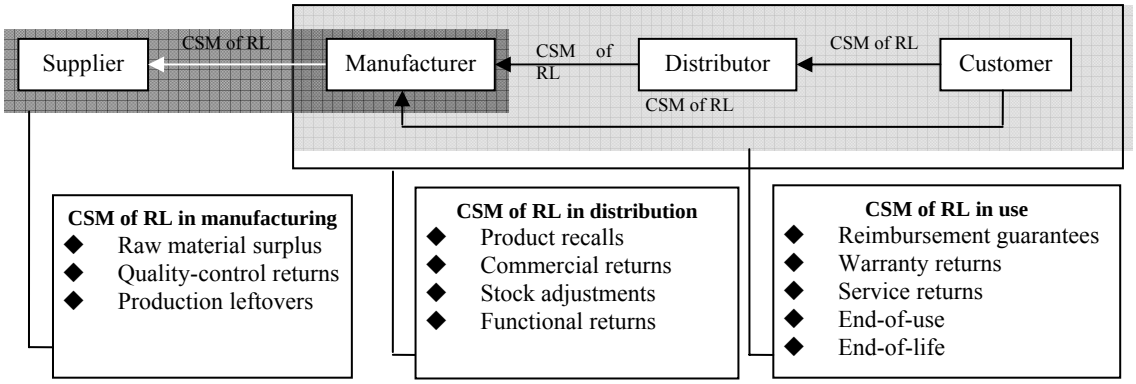

Figure 3. The process of CSM

2.4. Process management of CSM

The different emergence patterns of RL in a supply chain affect the application of CSM in RL, which can be split into three aspects: in manufacturing, in distribution, in use, see Figure 2 shows.

As shown in Figure 2, we consider CSM of RL in manufacturing as an example. CSM of RL in manufacturing activities refers to raw material surplus, quality- control returns and production leftovers etc. Considering a supplier as an "enterprise", a manufacturer then means the a "customer", there maybe some complaints form the manufacturer follows materials that supplier supplied, such as quality, fashion etc., so the supplier must respond to those matters quickly in order to meet customer demand. CSM of RL is one of the important items in RL strategy, via implementing process achieves three functions: collection, evaluation and disposal, see Figure 3 shows.

2.4.1. Collection

Complaint Collected: To capturing complaint information, enterprises need to lower "the threshold" to invite the voice of complaint. Some inspirit methods can be used, such as the initiative consultation, using by gifts to encourage complaint etc; to customers, there are not any proper routes to express complaint, so enterprises should open the relative channels, such as Internet, poster, phone or fax, E-mail etc. To unwillingness expression complaint customers, enterprises must launch some trigger strategies initiatively to search for the customer's dissatisfaction. The familiar forms are questionnaire, consultation, visit, promotion etc.

Product Return: based on the customer complaint information, enterprises can collect the returned product that dispersed in customers' hands. Those activities include collection, transport, and storage etc.

A convenient channel is very important to improve the response service to RL. Traditionally, the complaint channels that enterprises provide to customers are telephone, letter, fax, etc; nowadays, the web language, wireless information technology are new emerging field. These techniques all have their own advantages. To maximize the customer satisfaction, the integrated multi-channel service model should be a good choice. Before completely integration of the channels, let us consider a computer integration technique, the Computer Telephone Integration system called CTI for short. Generally speaking, the phonetic system is separate from a computer network system, but CTI technique can integrate the two functions together [35]. A typical service process of CTI is represented in Figure 4.

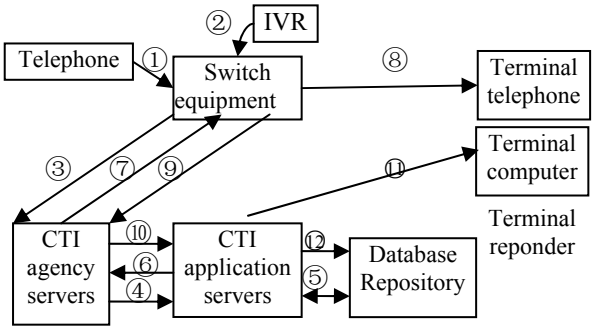

Figure 4. The CTI service process

(1) Customer-call-organization switch equipment. The switch equipment receives the key request service number via Automatic Number Identification (ANI) and Dialed Number Identification Service (DNIS).

(2) If Interactive Voice Response (IVR) equipment is available, the switch equipment will memorize the key-press information of customers automatically.

(3)The switch equipment can transfer the numbers and key-press information from step ① and step ② to the CTI agency servers.

(4)The information format is transformed in the agency servers, then the information is sent to the CTI application servers.

(5)According to the input parameters, the CTI application servers will implement relevant logical operations, for example, search for the best responder in the database.

(6)Return the search result (the best responder) to the CTI

agent servers.
⑺The CTI agent servers send the information of the best responder to the switch equipment.
⑻The communication is turned into the best responder by the switch equipment.
⑼After finished the communication, the switch equipment send the end-of-exchange signal to the CTI agent servers.
⑽The success-of-exchange signal is transmitted from the CTI agent servers to the CTI application servers.
⑾ The CTI application servers transmit the data information to the terminal responder, such as pop-upping the calling prompt automatically, calling the videotext of customers, and so on.
⑿ The all related complaint information is recorded in the CSM database and repository.

We can design an integrated multi-channels collection routeway based on the CTI technique. The CTI service process is extended as shown in Figure 5.

The details of every process in the Figure 5 above are similar as the CTI service process; so there are not repeated expatiations. The complaint information via the integrated multi-channels in CSM could achieve the CSM processing system which will be represented in detail in the next part.

2.4.2. Evaluation

Production Inspection/Sort In this phase, the returned products are being sorted based on their current quality, spoilage degree, etc., after that it is the enterprise's turns to determine the reuse manner of the products and then classify them. Those products can be divided into no spoilage, partial spoilage, or complete spoilage and so on.

(i) No spoilage: If returned products keep in the good state, then can often be reused directly by using cleaning or maintaining easily.

(ii) Partial spoilage: If returned products have been damaged partly, and need to be disassembled, inspected or tested, and repaired or replaced by parts, in this way their quality may be lowered. Usually, the products may be delivered to customers, or be sold at a discount in the secondary market.

(iii) Complete spoilage: If returned products are damaged or deteriorated badly, though they may include valuable components, but that can be reused restrictedly. So enterprises just implement the relative operation activities, such as recycle, remanufacture or harmless process etc.

Complaint Classification Customer complaints can reflect different information according to the diversities of customer preference, the types of products etc. Therefore, enterprises need to apply different processing techniques; it is necessary to classify the complaint information firstly. Based on the customer response, the complaint information is split up into three levels. Level I: Customers feel the complaint is too inappreciable and do not want to unfold, such information is obtained often through questionnaires.

Level II: Customers have some tempered complaint or appeal, which they want to make enterprises known. The integrated multi-channels collection route in CSM could be their right choices.

Level III: The customers are with a strong fashion or conflict. When appeal to enterprises they may take violent attitudes and insist on own viewpoints all along.

Evaluated Conclusion The integration evaluation conclusions are determined by the comparison of customer

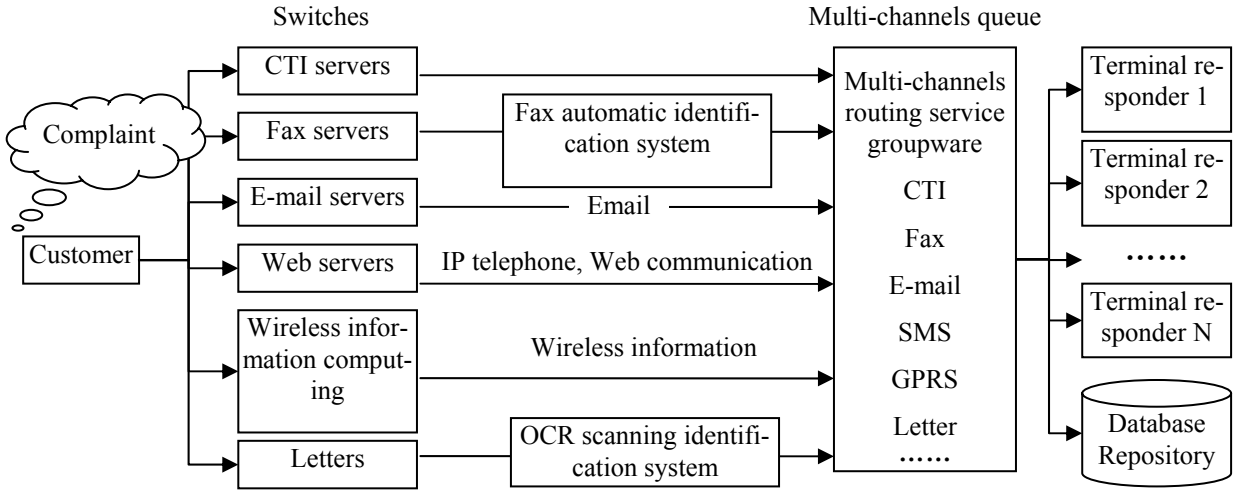

Figure 5. The integrated multi-channels collection route in CSM

complaint and product quality; it is the key gist for CSM of RL. The different customers have the different apperceptions of product and service utility. It is necessary for enterprises to discern the customer reaction based on the product spoilage degree, or the spoilage degrees based on the customer complaint levels in order to reply with the corresponding disposal countermeasure.

In modern times, the intelligent system is extensive applied to help decision-making increasingly. The intelligent "experts" based on the database and data-storage can respond customer complaint quickly. With the advance of complaint level, in order to respond customer complaint exactly, the database and data-storage should integrate more comprehensive information about customers and products. Intelligent decision support system (IDSS) is integration of artificial intelligence (AI) and decision support system (DSS). By using expert system (ES) technique, we can make the traditional DSS more humanized and flexible [13] [34]. The framework of IDSS consists of three subsystems, inlaid languages system (LS), problems processing system (PPS) and knowledge management system (KMS), namely 3S system. Figure 6 presents the framework of IDSS model. In practice, enterprises may setup an expert team together with IDSS to evaluate the relative complaint. At the same time, utilizing "the virtual expert team" based on Web (knowledge database) is good fashion.

There are some main advantages of IDSS: first, it is the synthesis of AI techniques, mathematics techniques and decision-making approaches, i.e., the integration of knowledge consequences and mathematics calculations to provide strong support to decision-making; second, it is based on the thoughts of ES or KMS (Knowledge Management System) to implement uniform preparation, uniform management, uniform control etc.; third, it makes full use of experts' knowledge, experience, judgment and decision-making cases. Consequently, the evaluation processing in CSM of RL will be supported by IDSS effectively.

2.4.3. Disposal

Disposal countermeasures

According to abovementioned, the disposal countermeasures of CSM in RL are presented in Table 1.

Utility of CSM

Customers' responses to the spoiled product show the expectation of the purchased products, so the utility of CSM in RL reflecting the customer expectation can be measured by two factors, i.e., the product spoilage degree and the customer complaint level. The more serious complaint means the higher customer's expectation, here the utility of CSM in RL will be greater. The lower expectation of customer may be easy to satisfy, so the utility of CSM will not be great any more. It is obvious that the utility of CSM in enterprises have inverse ratio with the spoilage degree, and direct ratio with the complaint level.

Suppose that α denotes the return relative index in RL, such as spoilage degree, return ratio etc., and β denotes the customer complaint level. γ is the utility of CSM, namely $\gamma = \beta / \alpha$. Let us see the slanting diagonal in Table 1, if just considering spoilage degree, the value of γ equal or approach 1 in the conditions of No spoilage-Complaint on Level I, Partial spoilage-Complaint on Level II, Complete spoilage-Complaint on Level III. These show the well-balanced utility of CSM in RL. Compartmentalize the table into two parts according to this diagonal, the value is $\gamma > 1$ in the top right. Here customers have high product expectation; CSM in RL is significant and implies a great utility. In the lower left of the diagonal, $\gamma < 1$ means the low customer expectation. To improve the utility of CSM and increase the customer satisfaction, enterprises should take into more consideration the product design and marketing.

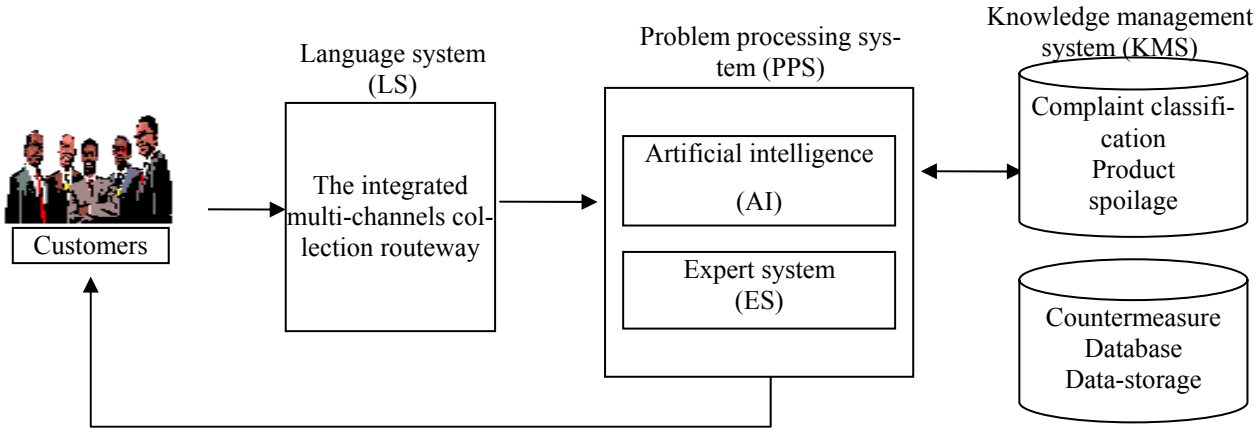

Figure 6. The framework of IDSS model

Table 1. The disposal countermeasures of CSM in RL

	Complaint on Level I	Complaint on Level II	Complaint on Level III
No spoilage	—	Explain carefully; Good service	Replace by new products; Resell the returned ones at a discount or in a secondary market
Partial spoilage	Reclaim the products in lower price; Sales promotion; Resell the return ones at a discount or in a secondary market after being repaired	Give the returned ones back to the customers after being repaired	Replace by new products; Resell the returned ones at a discount or in a secondary market after being repaired
Complete spoilage	Reclaim the products free; Sales promotion Recycle, remanufacture, or dispose the returned ones harmlessly	Replace by inferior products; Recycle, remanufacture, or dispose the returned ones harmlessly	Replace by new products; Resell the returned ones at a discount or in a secondary market after being recycling, remanufacturing, or harmless disposal; A compensation perhaps

The CSM in RL processing system

By receiving the complaint information and inspecting the products, the experts would give a reasonable disposal countermeasure. When the level of customer complaint is lower and the product spoilage is not bad, the feedback can be disposed in the place of distributors, such as wholesalers and retailers. Especially, the retailers must keep in touch with the customers directly, which are the chief and basic nodes for CSM in RL. For the complaint on Level I, the good customer service is necessary, such as the feasible propaganda in the right time. To reply the customer complaint on Level II and Level III, a lot of different means should be chosen based on the product status, for instance recycle the products at a discount, replaced by new products, and so on. Then the returned products can be resold in a secondary market after being repaired.

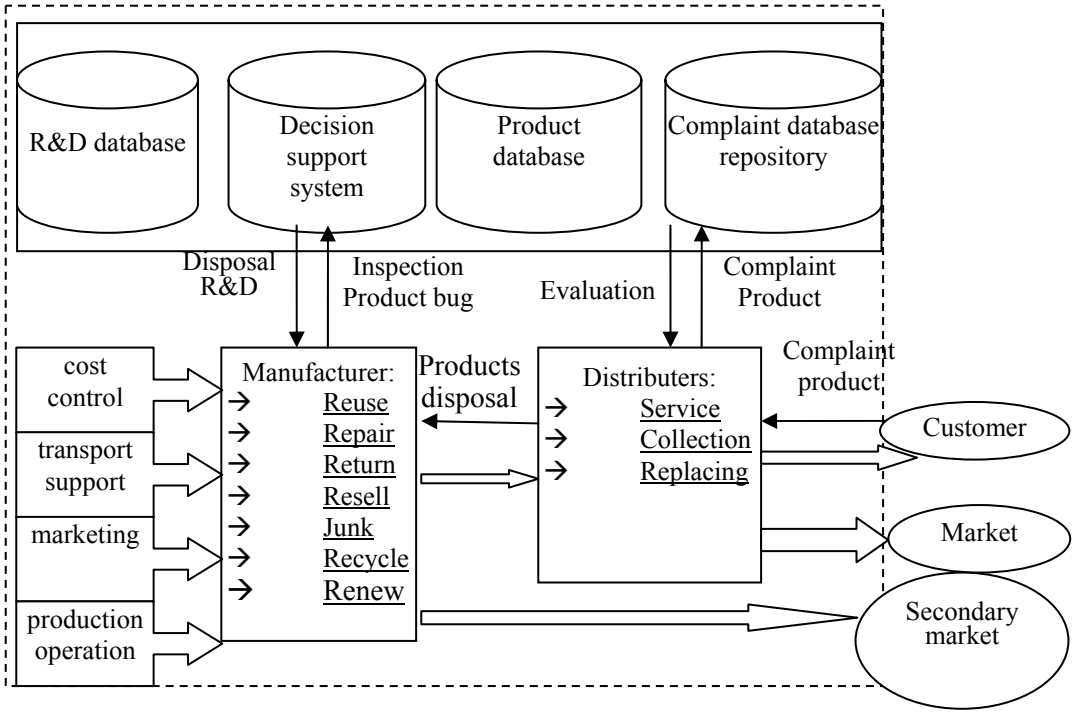

Figure 7. The CSM processing system

If the products are broken or even damaged badly, they should be transported to the manufacturers directly. The professional processing of manufacturers is significant for customer satisfaction. In a word, there is corresponding process for CSM processing system in RL as follows in Figure 7 [30].

The CSM processing system in allusion to different disposal countermeasures is supported by the embedded information system; the real-time information exchange helps to provide the decision-making with support and improve the manufacture technique. Furthermore, the functions of the CSM processing system are controlled and supervised by related function modules, such as cost con trol, transport support, channel management, marketing, production operation etc., to help enterprises construct the resources economized and harmonious system [26].

3. The VE and RL Operation Management

3.1. Existing Barriers of RL Operation Management

RL operation management is a bran-new field for the modern enterprise, which their objectives of reducing risk and pursuing profit is conflicted by a great many of uncertainties and the large investment risks at the beginning. Comparing with the tradition logistics, RL is more complex and uncertain. The uncertainties of RL involve four characteristics mainly as follows:

The uncertain time: different people favoritism often result in products having different lifecycle, such that RL happening time is difficult to speculate.The uncertain place: The customers distribute all over the world, that means RL happening place is possible everywhere.

The uncertain reason: The reasons of RL is involved in multi-factors, such as changing market, product quality, usage method etc., which resulting in uncertainty.

The uncertain disposal: The numerous reasons of RL done bring on different measures to dispose. The corresponding disposal can not be identified until inspecting.

Consequently, the flexibility and agility of RL operation management must be taken more attention, and we need analyze the characteristics of uncertainties in time, place, reason and disposal.

For most enterprises, specially the RL operation based on themselves, so RL operation management needs to invest the large of money and resource, influence the enterprises in every ways, e.g. the planning is adjusted just for the potential reverse logistics; a new network need to design; the inventory management is impacted by the bidirectional flow; it must be supported by increasing the special equipment and training employee, etc. Furthermore, the economic benefits from RL hiding in total profit can not display obviously in account, which enlarges the investment risk for an enterprise. In addition, RL theory and application that is still in a developing process and few successful cases for references are also the barriers.

3.2. The characteristics of a VE

To overcome the abovementioned barriers, we analyze some important characteristics in a VE as follows:

Virtual function: The theory of core competency figures that an enterprise is a set of resources and capabilities; the heterogeneous resources and the special capabilities are the key strengths, called the core competencies differentiating it from other enterprises. A VE is a function aggregation; the subdivided functions are assigned to several independent enterprises according to their particular competencies.

Virtual organization: Nowadays, the rapid development of information technology and the computer technology bring an opportunity for the organizing mode of modern enterprise. The VE is also a dynamic alliance, made up of independent enterprises, which can be self-organization. They may locate in the world everywhere and communicate with each other via Internet and Intranet, i.e. it is a virtual organization without fixed place.

Virtual region: The advancement of science and technology also are impelling the development of transportation industries; the information systems applied in model logistics result in physical distribution among enterprises more effective and efficient, i.e., the distance is not the barrier any longer; the goods can flow among partner enterprises at any moment.

3.3. The advantages of RL operation management based on a VE

In today's competitive market, the enterprises should adjust their strategies, organization structures, and operation management, i.e., change from the traditional competition strategy to the value-renovation strategy based on cooperation – from the pyramidal organization structure to the flat organization structure forming a dynamic network, from the close-operation management that considers competition in cost and quality, to the open-operation management that considers competition in time and speed. VE, a dynamic alliance consisting of several quick (or agile) independent enterprises quickly, is triggered by sudden market opportunities in order to overcome the uncertainties of the RL, reducing cost and increasing profit by utilizing the core resources of partner enterprises. The advantages of RL operation management based on a VE are focused on four aspects:

Rapid response: RL is often paroxysmal. When the affairs beyond the planning take place, RL management play the role of remedy (e.g. the cars recalled for disfig-

urement); sometimes the happening is foreseeable but it is hard to know the exact time and clear place (e.g. the electronic products of end-of-life). The outstanding advantage of VE is to respond the market changing rapidly, that will endow operation with agility. Based on VE obviating mass preparation, the operation management of RL can integrate the particular resources of partner enterprises together at once to cope with the changing environment, by improving the competition.

Flexibility: The flexibility motivation comes from two aspects: the uncertainties of RL require multiform disposal; for most enterprises, RL from begin to end is just a short-term process, so the flexibility and efficiency are regarded as the key factors. RL will benefit from the flexibility attribute of a VE. The organization structure formed by some independent enterprises provides more options of disposal. Besides we notice that a VE is from configuration to disbandment along with the appearance and disappearance of market opportunity. The driven-market feature will suit for the flexible operation of RL.

Reducing cost: Generally speaking, RL is often driven by legislation constraint and environmental responsibility. Nevertheless the enterprise with the aim at profit pays more attention to the direct or indirect economic benefits. The operation management mode based on a VE is an effective approach to reduce the RL cost, in respect that enterprises make use of the external strength to cut down cost by reason of homologous resource advantage.

Sharing risk: RL is also a large challenge for enterprises with respect to the long-term operation of traditional logistics. It induces several risks, e.g. the assets proprietary risk. In contrast with the high risk of single e nterprise, the subdivided operation can share risk among partner enterprises. It has been noticed to elude the exter nal manage risk resulting from many enterprises combination.

4. RL Operation Management Based on AVE

4.1. The framework of organization

The difficulties of RL management are enlarged by lots of partners and their flexibility. Thus a “leader enterprise or organization” is necessary to administer the VE, namely the leader enterprise. The sponsor manufacturer always plays the role of core enterprise, e.g., the large-scale enterprise or the fourth-party service provider is also an appropriate option [6]. Comparing with the traditional organization structure, the VE organized by two layers (core enterprises and non-core enterprises) is flat, allowing interaction of partners. The flat structure is easy to respond the changing market, as well as to eliminate the information distortion effectively.

There are three main reverse logistic functions: collection, inspection/sort, and reprocessing. Collection refers to bringing the products from the customer to a point of recovery, including return, transportation, and storage etc. At this point the products are inspected, i.e. their quality is assessed and a decision is made on the options of disposal, then the products are sorted. The disposal of reprocessing includes the following options: direct reuse, repair, recycling, remanufacturing and harmless disposal. The type of recovery can be separated between product recovery, component recovery, material recovery and energy recovery etc. The abovementioned functions are necessary for RL. Based on the VE operation, subdividing the functions to several independent enterprises by integrating their core competencies is just the advantage we hope seek, e.g., lowering cost, evading risk, etc. Therefore, the organization frame of RL operation management based on a VE can presented, as shown in Figure 8.

4.2. The process of operation management

Table 2 depicts the process of RL operation management based on a VE, which follows four phases:

Identifying opportunity: In order to utilizing the rapid response attribution of a VE with respect to the uncertainties of RL, enterprises have to track the trends of market development timely. A mass of collected data using for forecasting should be from enterprises, customers, industries, markets, legislation and so on. The useful information will be evaluated relative to reliability, worthiness, feasibility.

Organization configuration: Based on abovementioned, a VE means the integration of the core competencies for participating in enterprises. Therefore identifying the core competency, evaluating the alternative enterprises and estimating the entire performance are crucial, that directly influence the operation efficiency of RL. The core competencies concerning RL reflect return channels, logistics capabilities, R & D technology, manufacture arts and crafts, assets proprietary etc., and are determined by the relevant decision support system (DSS). Information system and the logistics network are necessary absolutely to support the VE.

Organization operation: The organization form of a VE is at the expense of coordination among partners. It implies that the excellent organization management is the precondition of the VE operation. The operation management is extended to the application of coordination mechanism, dynamic contract by stages, risk identification and control etc. As the dynamic developing, examine the running status continuously, and improve the process according to the feedback.

Organization disbandment: The disbandment of a VE takes place after the disappearance of market opportunity. There is the assets liquidation among partner enterprises.

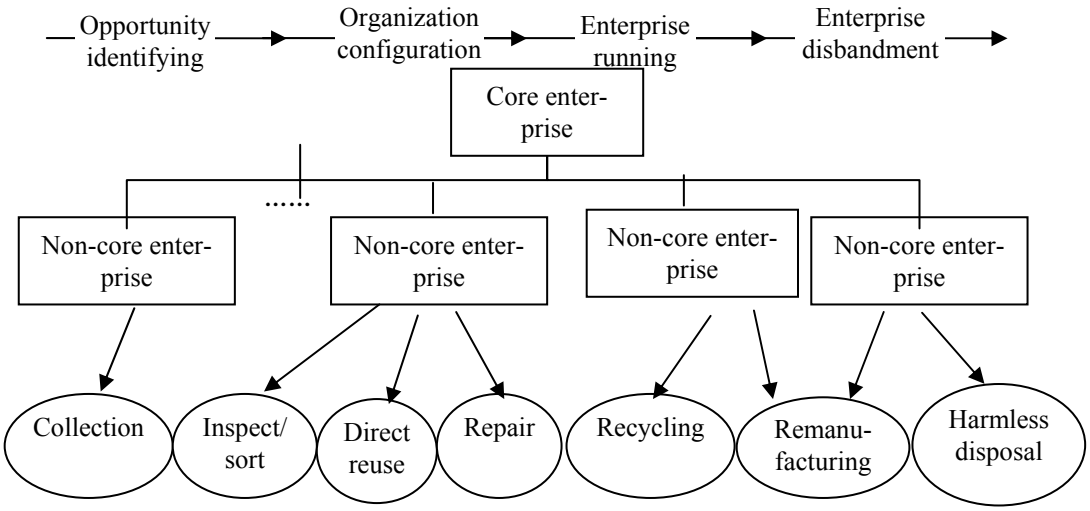

Figure 8. The organization framework of a VE for R

Table 2. The operation management mode of RL based

Opportunity identifying
✓ information collection ✓ data mining ✓ analysis and estimate
Organization configuration
✓ the core competency identifying ✓ evaluating and selecting partners ✓ the information system and RL network ✓ estimating the holistic performance
Organization operation
✓ coordination mechanism ✓ dynamic contract ✓ risk identification and control ✓ monitor system and improvement
Organization disbandment
✓ the assets liquidation ✓ knowledge management

The knowledge management runs through the whole operation management of the VE.

4.3. The dynamic durative of a VE

It is easy to see, depending on a VE, that there is every chance of RL in developing market. However, considering RL exist in enterprises at all times, the operation management based on the VE do not end after disbandment. Contrarily, it is the beginning of the new VE. Facing the uninterrupted opportunities the independent enterprises broke from one VE, can then take part in another dynamic alliance immediately. In fact, the VE is that organization of the older members left and the newer members' enter. So the VE for RL is the dynamic durative process organization from the phase of opportunity identifying to the phase of organization disbandment as shown in Figure 9:

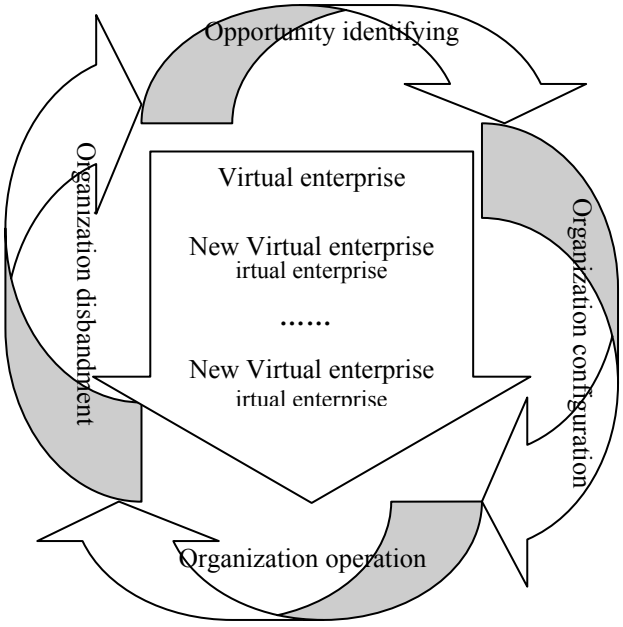

Figure 9. **The dynamic durative of a VE for RL operation m anagement**

4.4. The compare with the traditional mode

In contrast with the traditional logistics management, the operation management of RL based on a VE is improved in agility, flexibility, lowering cost and sharing risk as abovementioned. The details of the compared conclusions are listed in Table 3.

5. Evaluation Method and Process

5.1. Evaluation method and process

The evaluation of a VE for RL operation is based on the firms' multi-criteria which are qualitative or quantitative. AHP is often used in such problems [36]. But, the unbalanced estimations, unconsidered the uncertainty and risk, the subjective judgment error etc., those show the technique exists some disadvantages. Based on those reasons, we integrate the concept of fuzzy set theory with the AHP to overcome some above disadvantages in our proposed model [7]. Fuzzy AHP approach is applied in some practical problems widely. In order to facilitate comparison, all elements of the judgment matrix and weight vectors are represented by the triangular fuzzy values. The VE for RL selection process are as follows:

(1)Determine alternative firms and construct the evaluating hierarchical structure. RL first choose the alternative VEs from those which can bear reverse activities, based on the basic requirements, such as Quality Certificated. Then, the hierarchical structure is constructed by the criteria of SCOR model and the chain which is linked by the product flow, see Figure 10, the alternative VEs are considered as similar types on the similar phase. The SCOR (Supply-Chain Operations Reference-model) is a process reference model that has been developed and endorsed by the Supply-Chain Council as the cross-industry standard diagnostic tool for supply-chain management. SCOR enables users to address, improve, and communicate supply-chain management practices within and between all interested parties. SCOR is a management tool. It is a process reference model for supply-chain management, spanning from the supplier's supplier to the customer's customer. The SCOR-model has been developed to describe the business activities associated with all phases of satisfying a customer's demand. By describing supply chains using process building blocks, the Model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be linked to describe the depth and breadth of virtually any supply chain.

Considering that the full chain or part of supply chain can be selected by VEs, and many firms are involved in the scope and may operate different industries. So, there is more diversity among those, and SCOR model adapt to the cross-functional framework, the metrics of Level Ⅰ of SCOR model as the criteria and sub-criteria of alternative will be referenced ,see Table 4.

These 13 sub-criteria can be categorized into the qualitative criteria and the quantitative criteria. Unmeasured indirectly through firms' historical data are called as the qualitative criteria. And measured directly are called as the quantitative criteria. All values are listed in Table 5. The quantitative criteria can be found from the historical data, and the qualitative criteria can be evaluated by experts and experiential managers, based the firm's correlative data and their experience, which can decrease the subjective errors.

(2)Evaluate the alternative VEs. Based on the defined scope, the experts begin to evaluate those alternative firms, based on the criteria of SCOR model. The quantitative criteria can be gained by the VEs historical data and the alte rnative degree measured by five scales from the worst to t he best, here we use 1-9 triangular fuzzy number (from (1, 1, 3) to (7, 9, 9)) that is similar to Wu Lei and Guojun Ji (2006) [16]. The qualitative criteria are obtained by the experts evaluating values. To reducing the experts' subjec tive effect, the following approach is adopted for the qualitative criteria. Suppose that there are S_i experts to score on level i, $\tilde{C}_{ijts}$ is a basic value which Expert s scores VE j on level i about Sub-criteria t ($i=1,2,\cdots,N$, N is the total number of levels in the RL; $j=1,2,\cdots,M_i$, M_i is the total number of firms on the level i in RL; $t \in Q$, Q is the subscript set of the qualitative criteria, then $\overline{Q}$ is the subscript set of the quantitative criteria). The expert's lingual descriptions from the worst to the best are relevant to the fuzzy number from (1, 1, 3) to (7, 9, 9) using by five scales. Let $\tilde{C}_{ijts} = (l_{ijts}, m_{ijts,} u_{ijts})$, $L_{ijt} = \min(l_{ijts})$, $M_{ijt} = \dfrac{\sum_{s=1}^{S_i} m_{ijts}}{S_i}$, $U_{ijt} = \max(u_{ijts})$, then the integrated fuzzy number is $\tilde{C}_{ijt} = (L_{ijt}, M_{ijt,} U_{ijt})$ based on the S_i experts' evaluating result on level i.

(3)Evaluate the VEs relationship. The RL is constructed by selecting firms from VEs and the relationship among the firms is evaluated. The basic values in step (2) may be considered the average value of the VEs criteria, and that the effect of the upstream and downstream to the firms may be positive or negative. But the relationship among the firms is not determinant factor to some performance criteria. It happens that the double effect of performance. In addition, the negative effects produced by the relationship to the performance criteria can not reach zero. Herein, these two situations need not discussed. The relationship Coefficients are from 0 to 2 ranked by 9, which are relevant to some sub-criteria from descending by 100% to ascending by 100%. Assume that S experts score the relationship among the firms, and let r_{ikjs} denotes that the relationship coefficient which expert s firm j on level i and let r_{ijls} denotes that relationship coefficient which Expert s scores the relationship be tween firm j on level i and firm l on level $i+1$. Therefore, scores the relationship between firm k on level $i-1$ and

Table 3. Differences between two modes in the process of RL

Process	Traditional management	VE
Identifying opportunity	Simple collection, forecasting and decision-making	Special information collection, data mining and evaluation; forecasting with precision; quick response
Organization configuration	Most activities in-house, a little even none by outsourcing; large resources and money invested; adjusting continually	Most activities by utilizing the third party; lower investment for single enterprise; constructing virtual enterprise fast
Organization operation	Widely influence to the current process; high risk; simple disposal	Cooperating with the partner enterprises; the risk sharing between enterprises; more special, flexible and agile
Organization disbandment	Hard to take full advantage of the resources and upgrade the competence	The dynamic durative of virtual enterprise to make use of the resources fully; well-collaboration with other enterprises; accumulating knowledge; mining knowledge

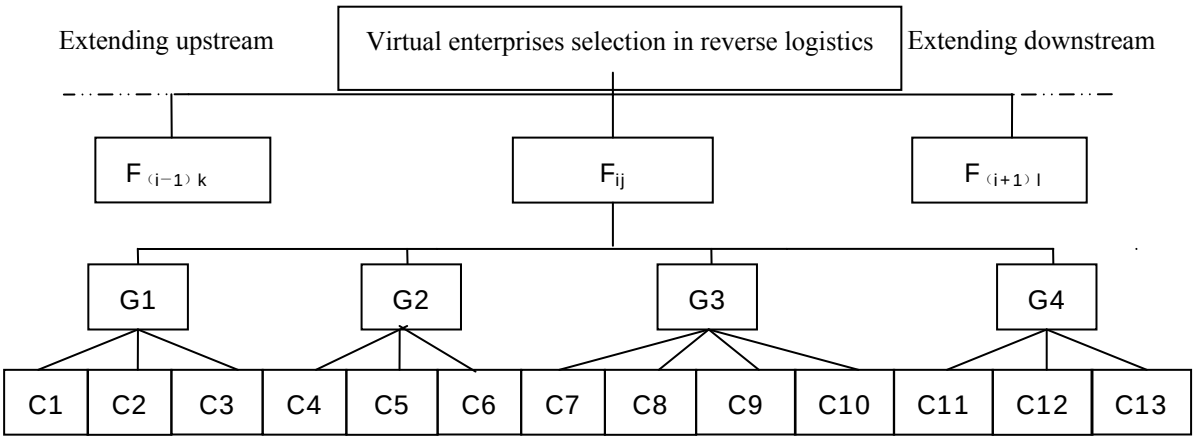

Figure 10. The hiberarchy of VEs selection in RL (Where Fij represents firm j on stage i in the supply network, F（i−1）k represents firm k on stage i-1 in the supply network, F（i+1） represents firm l on stage i+1 in the supply network)

Table 4. The criteria and sub-criteria from the metrics of Level Ⅰ of SCOR model

Criteria and Code	Sub-criteria and Code	Criteria and Code	Sub-criteria and Code
Delivery Reliability(G1)	Delivery Performance(C1); Fill Rates(C2); Perfect Order Fulfillment(C3)	Cost(G3)	Cost of Goods Sold(C7);Total Logistics Management (C8); Value-added Employee Productivity(C9); Warranty/Return Cost(C10)
Responsiveness and Flexibility(G2)	Order Fulfillment Lead Time (C4); Supply Chain Response Time(C5); Production Flexibility(C6)	Asset Management Efficiency(G4)	Cash-to-cash Cycle Time(C11); Inventory Day of Supply(C12); Asset Turns(C13)

Table 5. The category of sub-criteria

Category	Sub-criteria
Quantitative	C2; C4; C5; C7; C8; C10; C11; C12
Qualitative	C1; C3; C6; C9; C13
Exterior Correlated	C1; C2; C3; C4; C5; C7; C8; C10; C11
Interior Correlated	C6; C9; C12; C13

by integrated S experts' evaluations, the values are $r_{ikj} = \frac{\sum_{s=1}^{S} r_{ikjs}}{S}$ and $r_{ijl} = \frac{\sum_{s=1}^{S} r_{ijls}}{S}$, respectively.

(4)Integrate the basic value of the criteria of the firms with relationship coefficients. Relationship coefficients just effect on the exterior correlated criteria and not on the interior correlated criteria. Let Z denotes that the subscript set of the exterior correlated criteria and let $\overline{Z}$ denotes that the subscript set of the interior correlated criteria. Relationship coefficients are measured the relationship between the firm and its nearness firms, thus the upstream firm and the downstream firm both effect on it. To integrating two relationship coefficients, the Integrated Relationship Coefficients are $r_{ikjl} = \sqrt{r_{ikj} r_{ijl}}$. On the boundary of the defined supply chain, let $r_{ikj} = 1$ while $i = 1$ and let $r_{ijl} = 1$ while $i = N$. The Integrated Sub-criteria based on effect of the upstream and downstream firms satisfy

$$\tilde{C}_{ikjlt} = \begin{cases} (L_{ijt} r_{ikjl}, M_{ijt} r_{ikjl}, U_{ijt} r_{ikjl}) & t \in Z \\ \tilde{C}_{ijt} & t \in \overline{Z} \end{cases}$$

Then Integrated Criteria are defined as follows:

$\tilde{G}_{ikjl1} = \sum_{t=1}^{3} \tilde{C}_{ikjt}$, $\tilde{G}_{ikjl2} = \sum_{t=4}^{6} \tilde{C}_{ikjt}$, $\tilde{G}_{ikjl3} = \sum_{t=7}^{10} \tilde{C}_{ikjt}$,

$\tilde{G}_{ikjl4} = \sum_{t=11}^{13} \tilde{C}_{ikjt}$, respectively.

(5)Evaluate the fuzzy weight vector. The industrial experts evaluate the four criteria of the firms and the weight of any levels, then the weighted vectors are obtained $W_i = (\tilde{w}_{i1}, \tilde{w}_{i2}, \tilde{w}_{i3}, \tilde{w}_{i4})$ and $W = (\tilde{w}_1, \tilde{w}_2, \cdots, \tilde{w}_n)$, respectively.

(6)Synthesize the criteria and the weighted values, after that select the optimal VEs. The total fuzzy score of Chain x among X supply chains is expressed as follows: $\tilde{H}_x = \sum_{i=1}^{N} \left[\tilde{w}_i \otimes \sum_{q=1}^{4} (\tilde{G}_{ikjlq} \otimes \tilde{w}_{iq}) \right]$. The supply chain has the greatest finial score is the best one using by compared the finial score which is deduced by the following steps: Let

$$\tilde{H}_x = (L_x, M_x, U_x) ,$$

consider that $h_{xl}^{\lambda} = L_x + \lambda(M_x - L_x)$ and $h_{xr}^{\lambda} = U_x - \lambda(U_x - M_x)$ (where λ （$0 < \lambda < 1$） is the degree of confidence), and define that $H_x^{\lambda} = \left[h_{xl}^{\lambda}, h_{xr}^{\lambda} \right]$, then the finial score is calculated by $H_{x\beta}^{\lambda} = \beta h_{xl}^{\lambda} + (1-\beta) h_{xr}^{\lambda}$ (where β ($0 < \beta < 1$) is the risk index).

5.2. Numerical example

Considering a three-stage network of the electronic industry is incorporated by two VEs (denoted by F11 and F12), two manufactories (denoted by F21 and F22) and one retailer. The VEs implement the reverse activities, and the manufactories perform assembly line work to achieve the finial products. The retailer sells these products. According to their historical data, our aim intends to evaluate every VEs. Let $\lambda = 0.5$ and $\beta = 0.5$, By using above-mentioned processes, and the solution is presented in Table 6.

Table 6. The final scores of Ves

Supply chain	$H_{x0.5}^{0.5}$	
	No considering the relationship	**Considering the relationship**
F11-F21-F31	52.67244	57.22441
F11-F22-F31	41.74084	56.32318
F12-F21-F31	49.99745	50.00566
F12-F22-F31	50.42136	48.44038

It is easy to see the best VEs that formed chain are F11-F21-F31. At the same time, we can find that the chain relationship effect on the order of finial scores, i.e., VEs should pay attention to the chain relations in course of constructing the RL. In addition, VEs can comprehend the important degree of every criterion in the different industries by using the criteria weight evaluation, thus performance can be improved efficiently. In the same time, such technique can be used as a decision support system in VEs. VEs can provide more consulting service and realize the integrative optimization of RL.

6. Conclusions

In this paper, CSM was considered in RL. Based on the computer telephone integration technology, an integration multi-channels collection has be designed; the evaluation of complaint and product is supported by intelligent decision support system; in accord with the different disposal countermeasures, the CSM processing system was established to implement corresponding disposal which reflects the utility of CSM. The operation management mode of RL based on a VE was analyzed. The organization structure, RL functions and the framework were discussed too. The process of operation management based on a VE includes opportunity identifying, organization configuration, organization operation and organization

disbandment, in that the superiority of a VE in contrast with traditional management is unveiled. The evaluation of VEs for RL operation was based on the firms' multi-criteria which are qualitative or quantitative. By using Fuzzy AHP technique, the hierarchical and the multi-criteria decision making problems for VEs were considered and the optimized selection is presented. Our conclusions help to impel the development of RL in practice.

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A Risk Assessing Approach on Hi-tech SMEs of China: Based on Multi-stage Compound Real Options

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ABSTRACT

The Small and medium-sized enterprises (SMEs) typically have very limited capital and rely on external finance although they may self-finance. When seeking external finance, most SMEs rely on the banking sector. Because the direct financial market and venture capital (VC) system need to be further improved in China, financing from commercial bank undoubtedly becomes the main support for hi-tech SMEs. While the high risk of hi-tech SMEs requires commercial banks make credit decision based on effective risk management. Focusing on the characteristics of hi-tech SMEs, this paper reviews the risk assessing approaches in VC, and puts forward an innovation of using the multi-stage compound real option approach in risk assessing for hi-tech SMEs and achieving a multi-stage loan's decision making for hi-tech SMEs based on the firms' value of each stage. In this way, commercial banks can admeasure hi-tech SMEs' credit reasonably and can support the development of hi-tech SMEs efficiently.

Keywords: *hi-tech SMEs, risk assessing, commercial banks, compound real option*

1. Introduction

1.1. Hi-tech SMEs rely on the banking sector in China

Mostly, in any economy, about 90% of all firms are small and medium sized enterprises (SMEs) and these employ the most people. A September 2002 survey in Hong Kong revealed that 98% of companies are SMEs and that they provide about 60% of total employment [1]. SMEs provided more than 60% of new jobs in the USA by 2005. In the European Union alone, they employ more than 74 million people [2]. Similar figures were recorded in Australia and the UK. Although individually small, SMEs as a group form the prime mover of a nation's economy. The future of the world economy depends on SMEs, especially the hi-tech SMEs. Because hi-tech SMEs will also continue to be the engines of innovation in the next century [3].The rise of hi-tech SMEs has not only become an important force behind the rapid and sustainable development of the economy, but also played an active role in structural adjustment, knowledge or products innovation and job creation in China [4]. As the rapid growth of hi-tech SMEs in China, they need substantial capital support; while the inadequate financial mechanism is one of the factors that seriously constrain the development of hi-tech SMEs. For a long time, researchers and academics set their hopes in direct financial market and expect to follow the experience of American's venture capital (VC) and NA SDAQ to solve the financing problem of hi-tech SMEs. Nevertheless, different from advanced financial markets in west countries, banks and the indirect financing are still the main body of the financial systems in China now. Many hi-tech SMEs in China still have a long distance from direct finance. When seeking external finance, most hi-tech SMEs rely on the banking sector. Hi-tech SMEs at starting stage face high uncertainties in R&D, production and operation. They have neither little capacity to provide collateral, nor do they have credit record and transparent information. Hence, it remains hard for them to obtain financing. Because it is difficult for banks to accurately judge the yield and risk of the potential loans, thus impeding the lending.

1.2. Gaps between hi-tech SMEs and banks in China

Actually, according to the experience of foreign SMEs' growth, credit from banks is a very important financing for SMEs'. Nevertheless banks are not very affirmative for fear of high risk of hi-tech SMEs. Shortening life span of technologies, customer-oriented production, company networks, as well as new products and operations place new challenges on risk management in hi-tech SMEs [5].

The gaps in conventional financing for hi-tech SMEs are① risk gap: resulting from a general unwillingness of conventional lenders to provide financially riskier loans even at higher interest rates; ② size gap: resulting from the higher relative costs involved in preparing and assessing small-amount business loans; ③ the flexibility gap: resulting from the lack of flexibility in tailoring

repayment terms and conditions to a company's growth and revenue streams; ④ the guaranty gap: reflecting lenders' reluctance to provide loans because of entrepreneurs' lack of tangible assets to secure a loan and lenders' lack of special industry knowledge. Hi-tech SMEs are often 'grouped' or 'categorized' together for risk identification and assessment by banks. The hi-tech SMEs' risk perceptions of banks are lack of capital makes SMEs more vulnerable to failure; limited suitability assets as collateral; owner/manager guarantees may be impaired by personal revenue reliance on SME business; and some SMEs do not disclose adequate information. So there are different perspectives between hi-tech SMEs and banks. The perspectives of hi-tech SMEs are looking at financial soundness being their ability to achieve business targets and success; trying to predict and portray future positive outcomes to satisfy repayment terms. While the perspectives of banks are looking at the likelihood of business failure and payment default; considering how to protect themselves from future negative outcomes. It's critical for commercial banks know how to select correct hi-tech SMEs client effectively.

It is very hard for hi-tech SMEs to compete against big ones, but SMEs still have some advantages in the field of technique innovation and adaptability to the market that big enterprises have not. Their decision-making structures are often flatter and more nimble, enabling them to move more quickly when needed. More and more banks have cognizance of profitable advantages of SMEs. HSBC is anticipating more SMEs coming under the bank's umbrella. The increase in trade obviously means a healthy proliferation of developing businesses, including a large number of hi-tech SMEs. This sector has grown a lot during these years that HSBC receives much of its income from hi-tech SMEs in emerging markets figuring heavily in 2007 [6]. In recent years, the financial sector of China has taken concrete measures in accordance with the Act on Promoting Small and Medium-sized Enterprises and other policies of the state. According to the survey launched by the People's Bank of China (PBC, the central bank of China), loans to SMEs have accounted for more than 50% in total credit assets in the past few years [4].

1.3. Risk assessment in traditional banking and the VC

Compared with VC, traditional banking has several differences: ① In the view of asset, the precondition of bank crediting is safety, therefore banks concern about tangible assets, mortgage assurance and credit status of borrowers. While VC is based on the pursuit of high returns, concerning about the intangible assets and potential growth value of borrowers. ② In the view of market, banks always provide loans to mature market, while VC tends to support potential market. ③ In the view of technology, banks provide finance to mature technology of hi-tech SMEs, while VC only requires relatively mature technology with good anticipation of further development and potentiality. ④ In the view of capital, banks' loans depend on repayment safely, but VC will achieve their invest aim through transferring of ownership. ⑤ As to the extent of participation, banks don't participate in the management of enterprises, while VC must do that.

Owing to the characteristic of hi-tech SMEs, the evaluation models for common companies are not suit for the hi-tech SMEs, such as Discount Cash Flow approach, Replace Cost approach, Tobin Q, EBO and EVA, AHP, Fuzzy theory and ANW on risk assessment. Therefore this paper focused on the option property of hi-tech SMEs, applied the multi-stage compound real option approach of VC risk evaluation to rate the risk of hi-tech SMEs. The second part of this paper discusses the option property and risk elements of hi-tech SMEs in China; the third part analyzes the assessment approaches in VC program; the forth part investigates the problems of hi-tech SMEs credit risk assessing in China; the fifth part proposes the risk assessment approach based on multi-stage compound real options and the practical example.

2. Option Property and Risk Elements of Hi-tech SMEs

For the purpose of this research, hi-tech SMEs are defined as manufacturing enterprises with fewer than 100 employees and non-manufacturing enterprises with fewer than 50 employees, which resembling or making use of highly advanced technology, devices, industrial materials, or design.

2.1. Actuality and structure of hi-tech SMEs in China

The survey on the hi-tech SMEs in Zhong-guan-cun of Beijing in Feb. 2007 revealed that technology, capital and markets were the fundamentals in the growth of these companies; hi-tech SMEs had a great difficulty in capital rising, such as the complexity of loan applying, scarcity of mortgaged assets, and high profit rate requirement (net profit more than 20%) in loan. There are some operational structure characteristics of hi-tech SMEs in China.

2.1.1. Information and knowledge are main resource

Information, as well as capital, becomes critical resource in hi-tech SMEs. Technology and human resource become the carrier and media of information. The capacity and the increase rates of human resource and knowledge become indicators measuring the creativity and active of hi-tech SMEs [7].

2.1.2. More flexible structure and fuzzy boundary

Modern communications technology impaired the restriction of human resources by boundary of company.

Modern organizations are getting more and more flexible.

2.1.3. Self-systematization in hi-tech SMEs

Self-systematization in hi-tech SMEs means that process of exerting resource operated by intellectuals based on their preference and/or their knowledge without any special interfere. The structures of organization become more flat because of the high frequency of communion among individuals in organization and their independence and individuation.

2.2. Option property of hi-tech SMEs

Human resources in hi-tech SMEs possess the inseparability with the owner, heterogeneity and team spirit. And there is much uncertainty during innovation process in hi-tech SMEs. Therefore, hi-tech SMEs have option property as follows.

2.2.1. Agility option

Hi-tech SMEs can catch optimal invest opportunity according to information, make decision on altering invest size and keeping invest or not, based on operational status and transfer degree of technology.

2.2.2. Volatility of value and risk in hi-tech SMEs

A hi-tech SME may face many risks in its industrialization, such as technical risk (the risk from the immaturity, and fallibility of technology); production risk (the risk from production technique, instrument, facility, raw materials and personnel); market risk (risk from the variation of market demands and size of the market, substitute of congener products); management risk (failure of new products exploitation caused by misplay in management); and environment risk (the risk from fluctuation of market demands caused by the changing in policies, laws, economy, and society culture). All kinds of these risks in hi-tech SMEs have their given fluctuating processes (such as pervasion, skipping process, and mean self-regression process) that determine the value volatility of SMEs. That's to say, the risks contained in hi-tech SMEs result in their option value.

Traditional banks' finance cannot fulfill the new demands of market as hi-tech SMEs become an economic growth impetus gradually. Compared with VC, banks also pursuit for investment return at the precondition of safety, also need concern about potential SMEs client. Although the capital flow is different between banks' loan and VC, the main effects in them are same. Although the banks' loan can't make great and rapid progress in VC, but if using the mature VC evaluation approach to evaluate SMEs' credit risk, banks will certainly control the risk of hi-tech SMEs effectively and become the brooders of hi-tech SMEs.

2.3. Elements of the risk assessment of hi-tech SMEs

Unwieldy and mechanical models and practices restricted to specific types of risk in hi-tech SMEst. They need practical tools that cover a wide range of risks, readily adaptable to specific needs and quickly applicable. With hi-tech SMEs own resources, and through co-operation with experts and authorities, it is possible to bring in the required new viewpoints and a variety of approaches. The effective risk management and assessment model should cover a wide range of risks in operation of hi-tech SMEs and provides information about the basic elements of risk management (see Table 1).

Table 1. Elements of risk assessment in hi-tech SMEs*

* Source: Teuvo Uusitalo, 2003. [5]

Basic Elements	Main Content
Operational prerequisites	· Machines and equipment · Raw materials and admixtures · Waste and releases · The quality of products and services
Personnel	· Accidents · Ability to work and illnesses · Change of employment · Recruitment and assignment · Utilization of specialists
Property and interruptions	· Fire/Leakages · Equipment failure · Information risks · Criminal activity · Transportation damage
Organization of operations	· Development of operations · Dependencies · Agreement and liability issues
Interest groups	· Customers · Financers · Subcontractors · Authorities
Business economy	· Profitability · Solidity · Liquidity

3. Review of Assessment Approaches in VC

VC assessment is a very important step in the operation of VC, and is useful as reference to banks' financing decision making. Regarding to the development of VC assessing approaches, it mainly contains traditional and modern approaches.

3.1. Traditional VC evaluation approach

Such as NPV, AHP and DTA, Trigeorgis & Mason [8] pointed out that traditional investment decision theory implies an assume that future cash flow is static and unchanging, thus the uncertainty and management flexibility can not be measured and only a wrong result can be got.

3.2. Real option approach of VC evaluation

For the deficiency of traditional evaluation approach, the option pricing theory applying to investment evaluation of physical assets gradually becomes a hotspot in relative researches.

In the point of theory, scholars generally considered that real option approach is superior to traditional method. While Myers [9] and Luehrman [10] considered that traditional methods are inapplicable to VC project according to its characteristics with uncertainty, and multi-stage decision. They used NPV and real option approach to evaluate network of enterprises separately. Compared with NPV, uncertainty can be disposed with real options. In this point, uncertainty is viewed as a source of value.

In the perspective of business structure, scholars focus on the characteristic of multi-stage. Keeley [11] indicated that the theory and model about evaluation of the venture enterprise should reflect VC's characteristics of high-risk and multi-stage. They considered that the serial and continuous investment decision-making points are included in VC contracts as compound options. Hus [12] pointed out that multi-stage investment as a whole process can effectively control the investment risk. Jeffery Shah and Sweeney [13] studied the evaluation of single-stage and multi-stage value. They pointed out that in certain risk conditions, owing to the flexibility of decision-making, the more implementing stage the project has, the more option value the investment has and the higher whole value of the project is.

Regarding to the model, scholars put forward pricing model by integrating real options and other theories. Miles (1986) [9] used CPAM to evaluate company's assets value and growth value and educe that a company's value equals to company assets and growth optional value. Trigeorgis, Praeger (1995) [8] put forward jumping model, which replace Winner process used in B-S model with Poisson distribution process to describe the fluctuating price of assets. Seppä & Laananen [14] studied the trade data acquired from AMEX, and put forward a two-branch model to evaluate VC item. They considered that this model is better than traditional ones and the latent fluctuating rate of the enterprise's value will become smaller in the late stages. Dias & Teixira [15] provided a summary of option game theory based on continuous time, discussed the symmetric and asymmetric duopoly model under the condition of uncertainty, and put forward the specific method to calculate particular value of investment leaders and followers and the followers' boundary of implementation option.

4. Assessing Problems on Hi-tech SMES in Chinese Blanks

4.1. Risk assessing approaches on hi-tech SMEs

According to a survey, the administrative cost of SME loans is on average 5 times that of large enterprises. As a result SMEs will have limited access to bank loans. Hence, we need change the traditional way of thinking and encourage banks to price the risk associated with SME loans so that they can explore new source of profits. Since the PBC removed the ceiling on lending rates on October 28, 2004, we have observed that some banks began to utilize the new policy to foster their risk pricing capacity.

In the credit market of our country, there is high percentage of bad loans due to a variety of complicated reasons. The deterioration of quality and operation of the asset become a heavy burden of banks. Banks are increasingly cautious and credit rating system is carried out. The purpose is keep benefit from adverse selection and moral hazard caused by asymmetric information exists between enterprises and banks. As a result, some borrowers will be excluded from the credit market; unfortunately most of them are SMEs. Current credit risk rating system adopted by commercial banks does not accommodate the operations and accounting information disclosure patterns of SMEs. For the lack of statistical data and the complexity of the model, most banks cannot use this credit scoring to assess the risk of Hi-tech SMEs efficaciously.

Meanwhile, banks are encouraged to improve credit management and develop new products oriented towards SMEs including loan approval, credit rating, collateral, guarantee, pricing and loan management. Since China Banking Regulatory Commission (CBRC) promulgated The Guidance for Banks to Develop SMEs Credit in July 2005, more and more commercial banks pushed forward towards hi-tech SMEs credit.

4.2. Studies on banks' risk assessing on hi-tech SMEs in China

Wang & Zhang [16] considered the influence of signal discriminative of loan pledge and credit approval cost, and then constructed a credit rating model. In their opinion, SMEs with assets value lower than required pledge value will be excluded. Credit scoring model should be adjusted moderately according to the change of region and time; otherwise the accuracy of the model will be decreased. This is inconvenient both in operation and contrastive analysis. Credit scoring approach sets the strict requirements for data, such as sample data would be sufficient and must cover each stage of economic cycle. It's very difficult for hi-tech SMEs to achieve these requirements because most hi-tech SMEs in the seed stage or start up stage are scarce of data. So SMEs credit status cannot be derived from the traditional credit scoring. Rui [17] created a dynamic game model, and

found that in the game of SMEs's financing the original Nash equilibrium does not exist and the new equilibrium is that banks refuse hi-tech SMEs credit at the beginning.

Regarding to pertinence of decision, hi-tech SMEs' loan must satisfy with its traits, which are ① high risk means only a few can survive from the competition and get the chance to develop;② obvious lifecycle, such as Seed stage, Start up stage, Expansion stage, Bridge stage; ③ Contain potential value, such as patented technology, research and development value, and advanced management mode etc. Current credit scoring method is still inadequate. Many banks in China reject the hi-tech SMEs and miss the potential good clients easily.

This is crucial for the sustainable development of the banks. Therefore, banks must carry out the credit assessment which adapts to the characteristics of the hi-tech SMEs. Banks can provide multi-stage loan aiming at hi-tech SMEs' life cycle and high-risk characteristics, and use option theory to assess hi-tech SMEs' value.

5. Risk Assessment on High-tech SMEs on Multi-stage Compound Real Option

According to above discussion, we use multi-stage compound real options model to evaluate each stage in the lifecycle of hi-tech SMEs, in order to help banks to make credit decision, including lending rate and quantity.

5.1. Rationality of using real option

The traditional assessing approaches regard risk as disadvantage, and the bigger risk goes with bigger discounted rate. So the *NPV* adopted is smaller. Actually, risk comes from uncertainty, which has two interaction directions: the positive (possibility of profit) and the negative (possibility of loss). Option theory differentiates the outcomes of risk. According to option theory, the bigger risk goes with bigger value (Figure 1). Therefore, despite a negative *NPV*, as long as it has a biggish optional value, it's worthy of investment. And VC item's value can be described as "*V*= traditional *NPV*+ option value *C*".

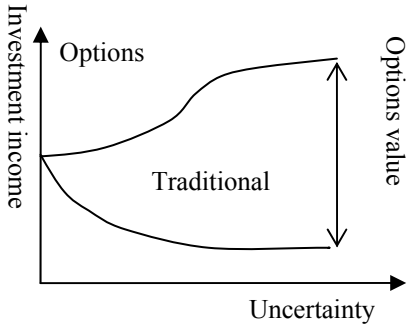

Figure 1. Investment income curve under uncertainty

In VC, we can make the next decision according to the assessment on the former stage. This flexibility comes from the former investment can be regarded as the compound options. Accordingly, we can make the next credit decision on the basis of the former credit evaluation. Therefore hi-tech SMEs' credit risk can be priced as compound options.

5.2. Multi-stage compound real option model

5.2.1. Hypotheses of the model

Hypothesis 1: The random process of hi-tech SMEs item's potential value V obeys geometric Brownian motion:

$$\frac{\mathrm{d}V}{V} = \mu \mathrm{d}t + \sigma \partial_r \sqrt{\mathrm{d}t} \tag{1}$$

Namely, the enterprise value is composed of two parts: the determined expected growth rate (μdt) and undetermined parameter $\sigma \partial_r \sqrt{dt}$. V means VC item's potential value; μ means the instant expected growth rate; ∂_r means standard variable of normal distribution; σ is the fluctuating rate of instant growth rate, calculated by its twin securities, which is a negotiable security having the same risk with the one we evaluate.

Hypothesis 2: The movement of risk in potential value of hi-tech SMEs is a jumping diffusion process. Owing to the environmental influence during development of the enterprise, the value is seldom in a continuous and smooth process. Therefore, the random process of hi-tech SMEs' potential value can be described through substitute random process by Cox and Ross [18].

$$\frac{\mathrm{d}V}{V} = \mu \mathrm{d}t + \sigma \mathrm{d}z_r + \eta \cdot \mathrm{sgn}(\varepsilon) \cdot \lambda \mathrm{d}t \tag{2}$$

η -the extend jump generated; λ -the probability jump happens.

$$\mathrm{sgn}(x) = \begin{cases} 1 & (x \geq 0) \\ -1 & (x < 0) \end{cases} \tag{3}$$

5.2.2. Uncertainty of hi-tech SMEs' cost

The cost of hi-tech SMEs' item is in a random process of the expected whole cost. In an enterprise's operation and a real option, executive price of compound real option and target option has different meanings. So investment in R&D period and in business period should be differentiated as follows:

$$\mathrm{d}K^R = I\mathrm{d}t + \hat{\beta}(IK^R)^{1/2}\mathrm{d}z_{K^R} \tag{4}$$

$$\mathrm{d}K^W = MK^W\mathrm{d}t + \pi K^W \mathrm{d}z_{K^W} \tag{5}$$

Formula (4) shows the changing rate of investment in unit time during R&D period, K^R means investment in R&D period; I means investment rate in R&D period; $\hat{\beta}$ -factor of technology uncertainty; so the changing rate of

investment in R&D period is related to the changing of investment and the influence of technology uncertainty. Formula (5) shows the changing rate of expected investment in unit time during business period. K^W means the expected investment in business period; M means investment rate in business period; π means uncertainty coefficient of business cost, the changing rate of investment in business period is related to the changing of investment rate and the influence of cost uncertainty in business.

5.2.3. Real option model of Hi-tech SMEs item evaluation

As European-called option pricing formula is:

$$C_t = e^{-r(T-t)}\mathrm{E}_{\mathrm{Q}}[\mathrm{Max}(S_T - X,0)] \quad (6)$$

S_T - price of the target assets on term; X-executive price of option; E_Q -calculate gene of risk neutrality; r-risk-free interest.

Suppose in the fifth stage the enterprise comes into the market, VC company sell out stock held in the forth stage and the value of the stock will come true. So this option can be figured as $Max(V_{t_5} - I_{t_5},0)$. When the enterprise value exceeds its IPO market value, VC Company will execute option, this option can be figured as $C_{t_5t_4}$, the first suffix means the maturity date and the second suffix means the date evaluate the option. Although bank's credit loan need not to be sold out in the stock market, we can also use the same approach to assess the option value and enterprise value of hi-tech SMEs in different stages.

VC Company will decide whether supply investment or not according to $C_{t_5t_4}$ in the stage before the enterprise IPO. If $C_{t_5t_4} - I_{t_4} > 0$, the option value of IPO will be higher than the investment at present, VC Company will supply finance continuously. Otherwise, it will give up. This option can be figured as $Max\,(V_{t_5t_4} - I_{t_4},0)$. In this view, VC Company's decision making is same as bank's credit decision. Only when the value of hi-tech SME is bigger than credit quantity, banks will be faced with a low credit risk. Otherwise, if the enterprise's value is less than credit, banks will be faced high risk.

Seed stage:

$$C_{t_2t_1} = e^{-r(t_2-t_1)}\hat{\mathrm{E}}[\mathrm{Max}(C_{t_3t_2}\text{-}I_{t_2},0)] \quad (7)$$

Start up stage:

$$C_{t_3t_2} = e^{-r(t_3-t_2)}\hat{\mathrm{E}}[\mathrm{Max}(C_{t_4t_3}\text{-}I_{t_3},0)] \quad (8)$$

Expansion stage:

$$C_{t_4t_3} = e^{-r(t_4-t_3)}\hat{\mathrm{E}}[Max(C_{t_5t_4}\text{-}I_{t_4},0)] \quad (9)$$

Bridge stage:

$$C_{t_5t_4} = e^{-r(t_5-t_4)}\hat{\mathrm{E}}[Max(V_{t_5}\text{-}I_{t_5},0)] \quad (10)$$

Some of the parameters in this model are derived from company's annual reports, some are estimated from enterprise's operation program, and the others are calculated from "twin securities" using Monte Carlo simulation. Banks can estimate the parameters more accurately according to their abundant data. Credit market and capital market mainly differ in the fact that there is a one-to-one negotiation between banks and their customers. Hence, banks are in a better position to get management information, make judgment on risks and price the loans. Therefore, banks can tailor their products for SMEs according to their financing needs at various stages.

According to "VC item's value *V*= traditional *NPV*+ option value *C*", banks can determine the credit quantity of each stage on the basis of option value and the NPV in each stage in lifecycle of hi-tech SMEs. And credit interest can be determined by the increment of enterprise's value.

5.3. Illustrative example on the mode

In order to illustrate the usage of the assessing model, we chosen a private hi-tech Ltd. company in Wuhan, China as an illustrative example, called company A. It was founded in October 2001, which is engaged in R&D and marketing of administrative software and has three dominant products. Company A input 1.7 million Yuan in prophase for development of the new product, primarily for R&D, marketing and cash flow. The three serial existing products have a vast market space and high growth, and the company has confidence and ability to acquire an income growth with no less than 30% and higher scale growth. At present, the company requires a bank to provide loans. If the bank can provide loans for it on the basis of integrated appraisal, multi-stage compound real option model can be used here to calculate the company's value in each stage, which will help the bank to make a credit decision. Table 2 shows the parameters used in the model which are calculated from the illustrative case (Company A) and the market. Table 3 shows the investment schedule in the company A.

The result of Monte Carlo simulation process using the time schedule in Table 3 is as follows:

Bridge stage: $C_{t_5t_4} = 1963024$; Expansion stage: $C_{t_4t_3} = 1250793$; Start up stage: $C_{t_3t_2} = 786481$.

Suppose the NPV of company A in each stage can be estimated, according to "V=NPV+C", the whole value in each stage of A can be measured. Suppose we use N_1, N_2, and N_3 standing for the NPV of each stage, so the total value of each stage are as follows,

Bridge stage: $V_1 = C_{t_1t_2} + N_1$;

Expansion stage: $V_2 = C_{t_2t_3} + N_2$;

Table 2. Case company's parameters in model

parameter	mathematics symbol	value
Potential value of the item	V0	3000000
investment rate in R&D period	I	0
Fluctuating rate of the item value	σ	0.25
technology uncertainty	β	0.2
business cost uncertainty	π	0.2
the probability jump happens	λ	0.18%
Risk-free interest	rf	7.86%
The average extent of jump	η	0.1
Correlative coefficient	ρ	0.8
investment rate in business period	M	0

Table 3. Investment schedule of case company

Bridge stage t5，t4：2 years	Kr	0
	Kw	1000000
Expansion stage t4，t3：2 years	Kr	200000
	Kw	400000
Start up stage t3，t2：1 year	Kr	300000
	Kw	0
Seed stage t2，t1：0 year	Kr	0
	Kw	0

Start up stage: $V_3 = C_{t_3 t_4} + N_3$. Hereby, the bank can make the decision of the credit quantity stage by stage. For example, we can decide the credit rate of each stage according to the company's value increasing rate such as $(V_2 - V_1)/V_1$,$(V_3 - V_2)/V_2$ etc.

In this way, considering the growth value of A, they can support company A and also avoid the high credit risk from blind borrow. The bank can properly adjust the interest through the increment extent of company A.

6. Conclusions

Nowadays, the hi-tech SMEs play more critical role in China economy than anytime before. While the choke point in their growth is lacking capital. It's useful for banks and hi-tech SMEs to study new methods to assess hi-tech SMEs' value accurately. In this paper, one of the VC approach, multi-stage real options, is used in banks on hi-tech SMEs' risk assessing. The model is: first, to survey the hi-tech SMEs' project, determine the special industry it belongs to, and collect the data relate to their strategy and the financial data; secondly, to find the "twin securities" in the secondary securities market, collect and process the data; thirdly, to calculate option value of hi-tech SMEs in each stage by using multi-stage real option value, so the credit quantity can be determined by the option value of the SME together with the NPV in the same period.

6.1. Advantages of this model

The advantages of this model are mainly focused on the option property of the hi-tech SMEs: ①Compared with the traditional approach, in hi-tech SMEs credit risk assessing, multi-stage option theory are more suitable for the property of option in hi-tech SMEs. ②It makes accurate calculation more possible based on multi-stage for banks make the credit decision dynamically. ③Additionally, using the Monte Carlo simulation program can reduce the computational complexity obviously. ④This model also promotes hi-tech SMEs' risk management, which is a kind of complementarities for enterprise management. This can be achieved through the restriction item of credit contract. Banks can put Some key requirements for hi-tech SMEs to raise finance in the contract: good market prospects, ability to generate sustainable profits, proven competencies of management team, credibility of business strategy and plan, business targets and action plans achieved, quality of customers, suppliers and products/services, and adequacy of capital and business cash flow to overcome unforeseen or unexpected circumstances. ⑤The bank can design a several-stage credit contract under the total credit quantity. The quantity in each stage can be determined by the model in this paper. And there are some indicators should be set in the contract, such as market share, investment returns etc. At the end of a stage, the third party institution will assess these indicators. If they are satisfied with the contract, the bank should supply loans. Or, the bank will stop financing.

6.2. Disadvantages in using this model

The disadvantages of this model mainly derived from the market environment: ①At present, owing to the secondary securities market hasn't been developed adequately, the "twin securities" used in this model can not be found easily, and this is the difficulty the model put into practice. This disadvantage will be dissolved as the development of securities market in China. ② Monte Carlo simulation used in model calculation has the advantage of portraying the option shape of hi-tech SMEs, but it needs big samples to derive perfect distribution.

Therefore, case study and empirical analysis will be

done in further study on this research line. The model can be modified through using a mass of analyzing data, in order to make the model more accordant with the characteristics of hi-tech SMEs risk assessing.

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Empirical Research on Repo Rates Based on Exponential Smooth Transition Autoregressive Model

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ABSTRACT

In the process of China's marketization of interest rates, researching the characteristics of interest rates has very important theoretical and practical significance. Based on Chinese interbank repo interest rates, the characteristics of daily interest rates and monthly interest rates and their spreads have been researched, and unit root tests are paid to the level, the first difference and the spread of daily interest rates and monthly interest rates based on the traditional method and the exponential smooth transition autoregressive method (ESTAR) respectively. The results show: Firstly, as for different term of repo interest rates, the characteristics are different. Secondly, both lists of daily rates and monthly rates are integrated of order 1. Thirdly, the spread of daily interest rates and monthly interest rates is not stationary by use of ADF, but stationary by use of ESTAR. Finally, the long-run equilibrium relationship between daily repo interest rates and monthly repo interest rates is stable with nonlinear adjustment.

***Keywords**: Repo interest rates, Unit root, Nonlinear, Augmented Dickey-Fuller (ADF), Exponential smooth transition autoregressive (ESTAR)*

1. Introduction

Term structure of interest rates provides a characterization of interest rates as a function of maturity. It is the benchmark of assets pricing, financial product design, risk management and investment such as discussed in [1,2,3].Because of its numerous uses, estimation of the term structure has received considerable attention from researchers and practitioners, such as Xie Chi and Wu Xiong-wei (2002), Xie Chi (2004,2005,2006) [7], Zheng Zhen-long and Lin Hai (2003,2004,2005,2006,2007), ZHOU Rong-xie and QIU Wan-hua(2004), WANG Xiao-Fang(2006), Fan Long-zhen(2006), He Qi-zhi (2007)[4,5], etc..But most of the researches are only about how to estimate the term structure of interest, and few involved in the relationship between the different maturities of interest rates.

The expectation theory regarding the term structure of interest rates is one of the bases of finance and macroeconomy. According to the expectation theory, the yield spread between different-term interest rates is stationary, or different-term interest rates have the cointegration relationship with cointegrating vector (-1,1). Thus it is helpful to judge the existence of the expectation theory by checking the cointegration relationship between different-term interest rates. Many documents have studied the expectation theory by use of the traditional unit root tests (DF and ADF)and cointegration tests (EG and AEG), such as Campbell,J.Y. (1987, 1995) ,SHI Min,WANG Shou-yang(2005)[6], and Wu Dan, Xie Chi(2005)[7],etc..

These traditional tests assume only linear adjustment. There are, however, economic situations where a non-linear adjustment process may exist [8]. For example, policy intervention may take place only when the economy deviates from equilibrium by a certain margin. The nature of the policy action may also differ, depending on the direction of that deviation. Another example is that arbitrageurs enter the market only if the price deviation of an asset from its no-arbitrage equilibrium is sufficiently large to compensate for transaction costs. As to the empirical research of the expectation hypothesis of the term structure, for the sake of simplicity, many researches have neglected the inherent nonlinear adjustment of the term structure of interest rate. In fact, sometimes only series of moderate length are available and the number of observations is small. The small number of observations and the market friction including transaction costs in financial assets markets is likely to lead to nonlinear speeds of convergence to equilibrium of rates of return, and often lead to the nonlinear adjustment of term structure of interest rates.

Recently, some authors have emphasized such nonlinear features and adjustment of economic variables [9]. Typical nonlinear time series models which appear useful in practice concern various forms of regime-switches. Since the seminal articles of Teräsvirta and Anderson (1992)[11] and Teräsvirta (1994) [11], smooth transition autoregressive (STAR) models have become one of most popular classes of non-linear models in modern applied economics [10]. The STAR models have been employed in modeling the dynamics of various types of economic time series, for

example industrial production in Teräsvirta and Anderson(1992) [11],unemployment in Skalin and Teräsvirta (2002) [11], interest rates in van Dijk and Franses (2000) [9], exchange rates in Taylor, Peel, and Sarno (2001), real interest and exchange rates in George Kapetanios, etc.(2003)[11], *inter alia*. Most recently, Maki, Daiki (2005, 2006) [12, 13] investigated the term structure of interest rates in Japan using the nonlinear unit root test: ESTAR. His results provide strong evidence against the unit root of the yield spread between long-term and short-term interest rates, compared with standard unit root tests assuming only linear adjustment.

The purpose of this paper is to investigate the term structure of interest rates in china using the unit root test in the exponential nonlinear smooth transition autoregressive (ESTAR) framework, as proposed by Kapetanios (2003) [11]. Their ESTAR approach tests for a unit root against a nonlinear stationary process based on the STAR process. In that paper they analyzed the implications of the existence of a particular kind of nonlinear dynamics for unit root testing procedures, and provided an alternative framework for a test of the null of a unit root process against an alternative of a nonlinear exponential smooth transition autoregressive (ESTAR) process.

The plan of the paper is as follows: section 2 addresses the expectation theory and the traditional unit root test (DF, and ADF). Section 3 introduces the nonlinear unit root test proposed by Kapetanios (2003) [11] and applied by Maki, Daiki (2005, 2006) [12] [13] in Japan. Section 4 presents empirical applications in china. Section 5 provides a summary of the paper, and contains some concluding remarks.

2. The Expectation Theory Regarding Term Structure and the Unit Root Test

2.1. The expectation theory regarding term structure

The expectation hypothesis expressed by SHI Min,WANG Shou-yang (2005) [6] is as follows:

$$r_t^{(n)} = \frac{1}{k}\sum_{i=0}^{k-1} E_t r_{t+im}^{(m)} + \theta^{(n)} \tag{1}$$

Where n and m represent respectively the long term and short term, k equal to [n/m], $r_t^{(n)}$ is the time t continuously compounded yield to maturity of the n period, $r_{t+im}^{(m)}$ is the time $t+im$ continuously compounded yield to maturity of the m period, E_t is the expectation operator based on available information, and $\theta^{(n)}$ denotes term premium.

Both sides of equation (1) subtract $r_t^{(m)}$:

$$\begin{aligned} s_t^{(n,m)} &= r_t^{(n)} - r_t^{(m)} = \frac{1}{k}\sum_{i=0}^{k-1}(E_t r_{t+im}^{(m)} - r_t^{(m)}) \\ &+ \theta^{(n)} = \frac{1}{k}\sum_{i=0}^{k-1}\sum_{j=1}^{i} E_t \Delta r_{t+jm}^{(m)} + \theta^{(n)} \end{aligned} \tag{2}$$

Known from equation (2), if $r_t^{(n)}$, $r_t^{(m)}$ have a unit root, $r_t^{(n)} - r_t^{(m)}$ will be a stationary process, or $r_t^{(n)}$ and $r_t^{(m)}$ have the cointegration relationship with cointegrating vector (-1, 1)'. Thus we can test for cointegration using unit root tests including the traditional unit root tests (DF and ADF).

2.2. The traditional unit root tests (DF and ADF)

From theoretical and applied point of view, the traditional unit root tests (DF) can be represented as follows[1]:

$$\Delta y_t = \delta y_{t-1} + u_t \tag{3}$$

$$\Delta y_t = \beta_1 + \delta y_{t-1} + u_t \tag{4}$$

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + u_t \tag{5}$$

Where δ, β_1, β_2 is the parameter, δ represents the intercept, $\{y_t\}$ denote variable list, t denote time or trend variable, u_t i.i.d. $(0, \sigma^2)$.

A null hypothesis with a unit root implies that $\delta = 0$. The choice of formula (3), (4) or (5) is important since the distribution of the test statistic under the null hypothesis differs among these three cases.

When the errors in (3), (4) or (5) are serially correlated, (3), (4) or (5) result in the following regression with p-order augmentation (ADF):

$$\Delta y_t = \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-i} + u_t \tag{6}$$

$$\Delta y_t = \beta_1 + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-i} + u_t \tag{7}$$

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-i} + u_t \tag{8}$$

3. The Nonlinear Unit Root Test (ESTAR) [11, 12, 13]

The traditional unit root tests only assume linear adjustment, but the term structure of interest rates often has the characteristics of inherent nonlinear adjustment because of market frictions. Thus sometimes, wrong conclusions will be drawn if using the traditional unit root tests for term structure. In order to take into account such nonlinear adjustment, this paper employs the unit root test in the

[1] To know whether the DF model should include the intercept, the intercept and the time trend or neither in the test regression, see [14].

nonlinear exponential STAR framework developed by Kapetanios, G., Y. Shin, and A. Snell (2003) [11].

$$y_t = \beta y_{t-1} + \gamma y_{t-1}\Theta(\theta; y_{t-d}) + \varepsilon_t, t = 1, \cdots, T \quad (9)$$

where ε_t i.i.d.(0, σ^2), and β and γ are unknown parameters. The ESTAR model defines different regimes in terms of small and large absolute deviations of the transition variable values from the threshold parameter value. Hence, this model has a 'sandwich' structure with the outer regime that is contrasted with the inner regime (Boriss Siliverstovs, 2005) [10]. The transition function of the exponential form is as follows:

$$\Theta(\theta; y_{t-d}) = 1 - \exp(-\theta y_{t-d}^2) \quad (10)$$

where it is assumed that $\theta \geq 0$, and $d \geq 1$ is the delay parameter. The exponential transition function is bounded between zero and 1; *i.e.* $\Theta : \mathrm{R} \to [0, 1]$ has the properties:

$$\Theta(0) = 0; \lim_{x \to \pm\infty} \Theta(x) = 1$$

and is symmetrically U-shaped around zero.

Substituting (6) into (5) Kapetanios, G., Y. Shin, and A. Snell [11] obtain an exponential STAR (ESTAR) model,

$$y_t = \beta y_{t-1} + \gamma y_{t-1}[1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_t \quad (11)$$

Both sides of equation (11) subtract y_{t-1} :

$$\Delta y_t = \phi y_{t-1} + \gamma y_{t-1}[1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_t \quad (12)$$

where $\phi = \beta - 1$.

The application that motivates the model is that of Sercu *et al*. (1995) [17] and of Michael*et al.* (1997) [1].These authors analyse nonlinearities in the PPP relationship. They adopt a null of a unit root for real exchange rates and have an alternative hypothesis of stationarity, namely the long run PPP. Their theory suggests that the larger the deviation from PPP, the stronger the tendency to move back to equilibrium. In the context of the model, this would imply that while $\varphi \geq 0$ is possible, we must have $\gamma < 0$ and $\varphi + \gamma < 0$ for the process to be globally stationary. They claim that the ADF test may lack power against such stationary alternatives and one of the contributions of this paper is to provide an alternative test designed to have a power against such an ESTAR processes.

More formally, geometric ergodicity and the associated asymptotic stationarity can be established by the drift condition of Tweedie (1975). A variant of the condition states that an irreducible aperiodic Markov chain y_t is geometrically ergodic if there exists constants $\delta < 1$,B,L $< \infty$ and a small set C such that

$$E[\|y_t\| / y_{t-1} = y] < \delta \|y\| + L, \forall y \notin c,$$

$$E[\|y_t\| / y_{t-1} = y] \leq B, \forall y \in c,$$

The concept of the small set is the equivalent of a discrete Markov chain state in a continuous context. For more details see Tweedie (1975) [10], Balke and Fomby (1997) [20] and Kapetanios (1999) [11].

Following the practice in the literature (e.g. Balke and Fomby, (1997) [20], in the context of TAR models and Michael *et al.*, 1997 in the context of ESTAR models), Kapetanios (2003) [11] and Daiki Maki (2005, 2006) [12] [13] impose $\varphi = 0$ in [12], implying that y_t follows a unit root process in the middle regime. Kapetanios (2003) [11] and Daiki Maki (2005,2006) [12] [13] consider a null hypothesis that is a special case of a linear unit root which in terms of the above model implies that $\varphi = 0$ and $\theta = 0$ .Under the alternative hypothesis ($\varphi = 0$ but $\theta > 0$), then y_t follows a nonlinear but globally stationary process provided that $-2 < \gamma < 0$, which we assume holds. In practice, there is likely to be little theoretical or prior guidance as to the value of the delay parameter d. We would suggest that d be chosen to maximise goodness of fit over d = $\{1, 2, \cdots, d_{\max}\}$ .In what follows, to clarify ideas and in keeping with empirical practice to date (as in for example Michael *et al.*), Kapetanios (2003) [11] and Daiki Maki (2005, 2006) [12] [13] set d = 1.

Imposing φ = 0 and d = 1 gives their specific ESTAR model (12) as

$$\Delta y_t = \gamma y_{t-1}[1 - \exp(-\theta y_{t-1}^2)] + u_t, \quad (13)$$

Hence we test

$$H_0 : \theta = 0, \quad (14)$$

Against the alternative

$$H_1 : \theta > 0 . \quad (15)$$

Obviously, testing the null hypothesis (14) directly is not feasible, since γ is not identified under the null. If we compute a first-order Talyor series approximation to the ESTAR model under the null we get the auxiliary regression

$$\Delta y_t = \delta y_{t-1}^3 + error, \quad (16)$$

This suggests that we could obtain the t-statistic for δ = 0 against δ < 0 as

$$t_{NL} = \hat{\delta} / s.e.(\hat{\delta}), \quad (17)$$

Where $\hat{\delta}$ is the OLS estimate of δ and $s.e.(\hat{\delta})$ is the standard error of $\hat{\delta}$. Their test is motivated by the fact that the auxiliary regression is testing the significance of the score vector from the quasi-likelihood function of the ESTAR model, evaluated at θ = 0. Unlike the case of

testing linearity against nonlinearity for the stationary process, the t_{NL} test does not have an asymptotic standard normal distribution.

When the errors in (13) and (16) are serially correlated, (13) and (16) result in the following regression with *p*-order augmentation:

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \gamma y_{t-1}[1-\exp(-\theta y_{t-1}^2)] + u_t, \quad (18)$$

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \delta y_{t-1}^3 + error \quad (19)$$

We can test the unit root via (18) instead of (13) and (19) instead of (16).

4. Data and Empirical Results

In this paper, we employ the monthly interest rates of treasury bonds repurchase trading of national interbank market as long-term interest rates, expressed as R1M, daily interest rates as short-term interest rates, expressed as R1. It is because of the following reason to choose repurchase interest rate data [15]. First, repurchase interest rate of interbank market is the main variety of interest rate in China's money market. In regards to the trading structure of money market, the amount of repurchase trade has a larger proportion in total transaction amount than that of trade in the Offered Market and Bond Market. Second, repurchase interest rate of interbank market is not only the tool of controlling and adjusting economics to every country's central bank, but also one of important standards to decide the loan and deposit rate to commercial banks. The daily data obtained from *www.ChinaMoney.com.cn* consists of 572 periods between 2004:8-2006:1. Fig. 1 provides the change situations of R1, R1M and profit spread (R1M-R1). According to Fig. 1 and footnote$^{\Phi}$, it can be confirmed: Empirical tests to R1 and R1M should include the intercept without the time trend, and empirical test to profit spread=R1M-R1 should not include the constant or the time trend. Tab.1 gives the simple statistics characteristics of them.

4.1. Tests for nonlinear of interest rates

For simplicity, we estimate the nonlinear effect θ imposing $\gamma = -1$ on equation (12), similar to Kapetanios(2003) [11]、Daiki Maki (2005,2006) [12] [13]. From Table 2, we can know that R1M does not have θ at a significant level, and R1 and the yield spread has a significant θ. This estimation shows that R1M do not have nonlinear adjustment, but R1 and the yield spread have nonlinear adjustment.

As for the criteria to determine the appropriate length of the distributed lag, we use the Akaike info criterion (AIC), Schwarz criterion (SC) and t-sig. As to the Akaike info criterion (AIC) and Schwarz criterion (SC), we select the model with the smallest information criterion. As to t-ing, we set the maximum *lag=12*. t-ing selects the lag order k via top-down testing. To begin with, we estimate the equation with the maximum lag (here, the maximum lag k_{max}=12). We use the lag order if the t-statistic of the parameter of the maximum lag is significant. If the t-statistic is not significant, we estimate the equation with the $lag = k_{\max} - 1$. That is, when the t-statistic of the parameter of the $lag = k_{\max} - q$ is significant at a conventional level, we employ the lag order [13].

4.2. Unit root tests

ADF and ESTAR denote the unit root tests by Dickey and Fuller (1979) [17] and Kapetanios *et al.* (2003) [11], respectively. As shown in Table 3, all of the tests do not reject the unit root of interest rates at the level, but reject the unit root of interest rates at first-order difference. Therefore, the results show that interest rates is integrated of order 1, namely I (1) process.

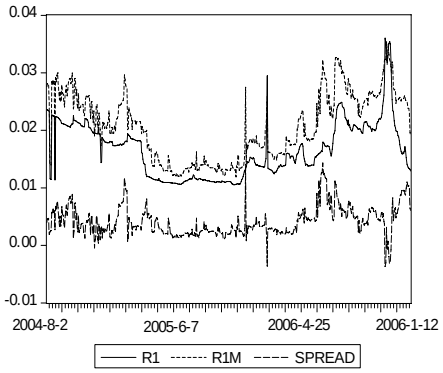

Figure 1. Interest rates of repurchase trading

4.3. Cointegration tests

According to the expectation theory, if different term interest rates are all integrated of order 1 :I(1),the yield spread between different term interest rates are stationary, or different term interest rates have the cointegration relationship with cointegrating vector (-1,1)'. Table 4 shows the results of the unit root tests of the yield spread. The results of ADF test fail to reject a unit root at a 1% significance level according to either criterion, even at a 5% according to AIC and t-ing criterions. In contrast, the test by Kapetanios *et al*. (2003) [11] provides strong evidence against the unit root of the yield spread at a 1% significance level, even when different lag criterions are employed. This finding asserts that the long-run equilibrium relationship between different term interest rates is stable with nonlinear adjustment.

5. Conclusion

The paper has researched the characteristics of Chinese interbank repo interest rates, and the relation between Chinese interbank repo interest rates with different maturities. The traditional unit root test ADF and the unit root

test in the exponential nonlinear smooth transition autoregressive (ESTAR) framework are introduced and applied to the reality of Chinese financial market. Main conclusions are as follows:

First, the monthly interest rates R1M do not have the characteristic of nonlinear adjustment, but R1 and the yield spread have the characteristic of nonlinear adjustment.

Second, both lists of monthly interest rates R1M and daily interest rates R1 are integrated of order 1 :I(1), whatever tested by ADF test or tested by ESTAR proposed by Kapetanios *et al*. (2003) [11].

Third, if we test the spread R1M-R1 by use of ADF, No matter use AIC, sc information standard or t-sig criterion, it will not refuse unit root at at a 1% level (AIC information standard and t-sig criterion even at a5% level).Thus we can get the wrong conclusion that the spread R1M-R1 is not a stationary list and the expectation theory can not come into existence.

Forth, if we test the spread R1M-R1 by use of ESTAR, after considering non-linear adjustment, No matter use AIC, sc information standard or t-ing criterion, it will refuse unit root at a 1% level. Thus the spread R1M-R1 have the cointegration relationship with cointegrating ve ctor(-1, 1)', and then we can get the conclusion to support the expectation theory.

The results provide strong evidence against the unit root of the yield spread between daily interest rates and monthly interest rates. The findings show that the long-run

Table 1. Sample descriptive statistics

Variables	Observations	Mean	Max	Min	Std. Dev	Skewness	Kurtosis
R1	605	1.650762	3.602900	1.053000	0.482511	0.903755	4.232855
R1M	572	2.071604	3.534700	1.190400	0.589263	0.190826	1.879266

Table 2. Tests for nonlinearity[A]

	R1		R1M		sperad	
	θ	t_θ	θ	t_θ	θ	t_θ
AIC	16.64400(9)	2.676826**	8.271662(9)	1.647177	517.3570(5)	2.889583**
sc	17.08785(8)	2.759931**	7.379115(8)	1.470843	660.7691(2)	3.725535**
t-sig	17.08785(8)	2.759931**	5.405781(5)	1.026662	517.3570(5)	2.889583**

Annotate: [A] Parentheses show lag length.
*(**) Significant at a 5 %(1%) level to refuse.

Table 3. Unit root tests for repo rates[B]

methods	ADF		STAR	
variables	R1	R1M	R1	R1M
level:				
AIC	-2.724232(9)	-2.273499(9)	-2.706878(9)	-1.654935(9)
sc	-2.845593(8)	-2.147877(8)	-2.793031(8)	-1.477065(8)
t-sig	-2.845593(8)	-1.801322(5)	-2.793031(8)	-1.029404(5)
first difference:				
AIC	-7.520771**(12)	-8.221985**(12)	-3.460175**(12)	-6.318140**(12)
sc	-7.520771**(12)	-8.221985**(12)	-3.460175**(12)	-6.318140**(12)
t-sig	-7.176747**(7)	-16.14545(12)	-3.397295* (9)	-6.293071** (8)

Annotate:
[B] Unit root tests are sensitive to lag length, we determine lag length using three lag criterions: the Akaike Information Criterion and Schwarz Criterion *and t-sig* introduced by Ng and Perron(1995).see[1].
*(**) Significant at 5 %(1%) level to refuse.

Table 4. Unit root tests for the yield spread

	ADF	ESTAR
AIC	-1.571899(5)	-3.035473** (5)
sc	-2.340362* (2)	-3.939495** (2)
t-sig	-1.571899(5)	-3.939495** (2)

Annotate :*(**) Significant at a 5 %(1%) level to refuse.

equilibrium relationship between different term interest rates is stable with nonlinear adjustment. Moreover, the applied cointegration tests with non-linear adjustment have multidimensional generalizations, and can be used to many other variables. For example, the number of observations of most macroeconomic variables, measuring the business cycle, is small, because those variables are sampled only quarterly or annually. Thus, there are also nonlinear properties in those macroeconomic variables with a small number of observations. We can also apply the ESTAR model to research the relation between the variables.

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A Critical Evaluation of Telecommunication Act 1996

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ABSTRACT

Telecommunication Act 1996 was considered as a milestone in the history of US telecommunication sector, as it aimed at breaking monopoly in local telecommunication market and creating competition. During last 10 years, the pace of competition in local telephony market has been very slow. Baby Bells still hold a strong dominance and a near monopoly position. They have even spread their monopoly to long distance market by mergers and acquisitions. This shows the failure of the Act. Local monopoly breaking policy, vertical reintegration, universal service and UNE pricing are the major reasons of this failure. Local loop is a natural monopoly and further investment by multiple companies is not efficient. Idea of universal service should be dropped.

***Keywords**: telecom act 1996, Vertical Integration, Universal Service.*

1. Introduction

The local telephone industry was thought to be naturally prone to monopoly as a consequence of massive scale and scope economies in provision of services over wire line networks [1-3]. Until the last quarter of 20th century, in USA, telecom sector was a regulated one with a single monopoly company American Telephone and Telegraph (AT&T). In 1945 AT&T had an almost monopoly over the sector, owning more than 80% of the lines and equipment used in USA [4, 5]. In 1934 the first Telecommunication Act was passed by Congress [6], which crystallized the regulatory superstructure and created the Federal Communication Commission (FCC) [7]. In 1969, Microwave Communication Inc. (MCI) was granted permission to provide leased line services [8]. The divestiture of AT&T in 1984 [9] led to the creation of seven independent Regional Bell Operating Companies (RBOCs) and one long distance company AT&T [10,11]. RBOCs were regional monopolies in their areas while AT&T faced competition mainly from MCI and Sprint [12]. As a result of divestiture RBOCs were not allowed to enter the long distance market and AT&T lost its direct access to consumers.

Until 1996, digitization, mobile communication and convergence of information, video and communication technologies had been understood by the government [13, 14]. The government decided to introduce competition in the local telephony market and Congress passed an Act which is known as Telecommunication Act 1996. The Act proposed changes to convert monopoly in local telephony market into competition. The preamble clearly and succinctly articulates the goal of the Act [15].

"An Act To promote competition and reduce regulation in order to secure lower prices and higher quality services for American telecommunications consumers and encourage the rapid deployment of new telecommunications technologies."

The rest of paper is organized as follows: Section II documents the goals of Telecom Act and the strategy it used to achieve its goals. In Section III, an analysis based on data collected from FCC is provided. The objective is to find out the present condition of the market. Some fallouts of the act are given is section IV. An analysis of 14 point check list is done in section V. In section VI results of section III, IV and V are summarized. Section VII discusses the reasons of the failure. Section VIII provides a summary and the conclusion of the study. Finally, references are given at the end.

2. Goals of Telecom ACT 1996

The Telecommunication Act of 1996 was a second major restructuring of the US Telecommunication sector after 1934 Act. Congress took radical steps to restructure US Telecommunication markets by passing the Act [16]. Three major goals of the Act can be stated as follows.

- The prime goal of the Act was the creation of competition in the local telephony market.
- The second goal of the Act was to increase investment in local infrastructure by creating competition.
- The third goal was to achieve of universal service.

Strategy of the Act

The Act tries to create competition in three ways.
(i) Reselling
(ii) Unbundled Access
(iii) New Entry (full facilities based)

Reselling eases entry in the retail business, by requir-

ing Incumbent Local Exchange Carriers (ILECs) to sell services to new entrants at wholesale prices. Such entry is limited only to the retailing side of the market. The most significant means of entry is through leasing of unbundled network elements from incumbents. It mandates interconnection, unbundling and non discrimination to boost competition and reduce artificial barriers to entry. Competitors can enter easily by purchasing Unbundled Network Element (UNEs) or by constructing their own infrastructure. In this way they can compete component by component and service by service.

The Act imposes conditions to ensure de facto monopoly power is not exported to vertically related markets. Thus the Act tries to ensure the competition is created in local market before allowing RBOCs to enter in the long distance market. The Act allows RBOCs to enter in the long distance market segment only after fulfilling a list of 14 requirements.

3. Analysis of the Present Market Situation

To judge the success of Telecom Act 1996, it is necessary to find the success of different strategies used. To analyze the effects of these strategies, following questions are analyzed here.

1. What portion of the market is captured by Competitive Local Exchange Carriers (CLECs)?
2. What technologies are used by CLECs?
3. How an average consumer is affected by the Act?

First question will provide the status of competition in local market. Second question will decide about the success of approaches used by FCC to introduce competition. Third question will throw light whether subscribers have gained benefits of the rapid technological advancements. Data used in this analysis is primarily taken from FCC.

3.1. Market Share

Figure 1 [16] shows the number of ILEC and CLEC end-user switched access lines from December 1999 to December 2005. CLECs provided only 31.5 million (or 18%) of the approximately 215 million nationwide switched access lines in service to end user customers at the end of December 2005. Figure 3 [16] is the graphical representation of percentage CLEC share over the years. The increase in lines shows the slow pace of competition in the market. It is also evident from this figure that major share of market is still held by ILECs.

Figure 2 [17] shows the market share of CLECs and ILECs. This is based on ILEC and CLEC share of local service revenues from 1998 to 2003. CLECs could increase their share of revenue to only 15% of the total revenue. This is really a small portion as compared to the revenue of ILECs.

Figure 4 [16] gives an account of the popularity of three different techniques used by FCC to attain competition. As evident that owned capacity by CLECs has been almost the same, thus showing that no serious investment in infrastructure has been made. Resale has decreased dramatically where as Unbundled Network Element (UNEs) purchase has increased a lot. This show with the time negotiations between companies about unbundled access is easing out making it most successful approach. Also resale has not gained popularity.

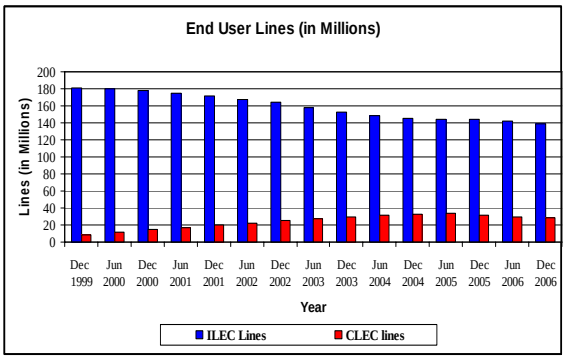

Figure 1. CLEC Vs. ILEC Share

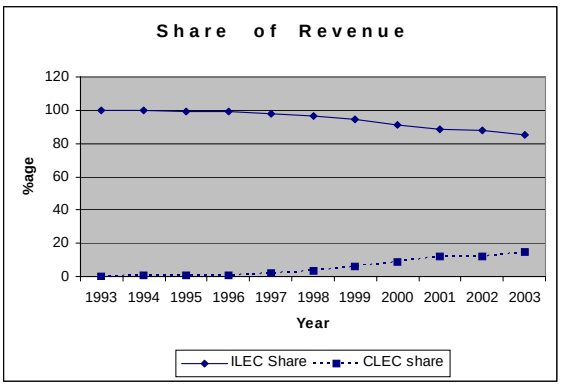

Figure 2. CLEC Vs. ILEC Share of Revenue

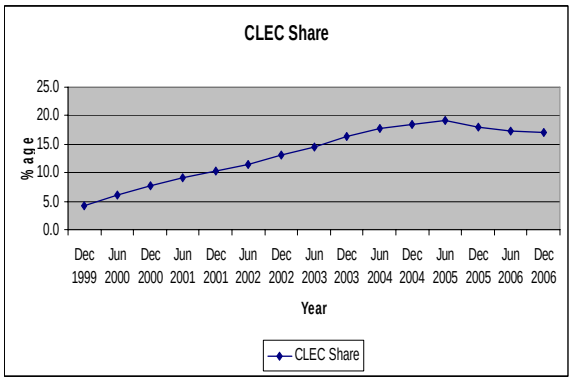

Figure 3. Percentage CLEC share of lines

3.2. Comparison of technologies

Figure 5 [16] shows that FCC's approach of enticing coaxial companies has also failed as only 16% of CLEC's

network is coaxial based. Coaxial cable has failed as a substitute to copper pair in local loop. Figure 6 [16] show the distribution of lines of CLECs and ILECs. In the beginning CLECs only concentrated on business lines but now slowly they are moving their direction towards the bigger portion of the society, that is, the residential subscriber. Slowly their percentage share of residential subscribers has increased.

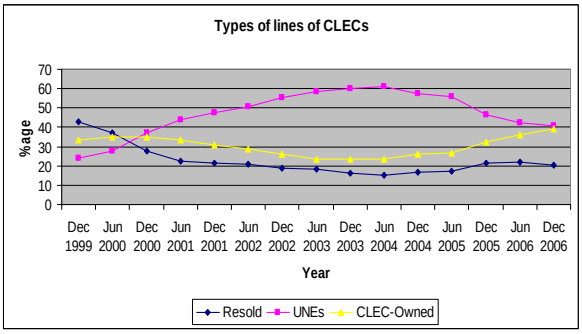

Figure 4. Types of lines of CLECs

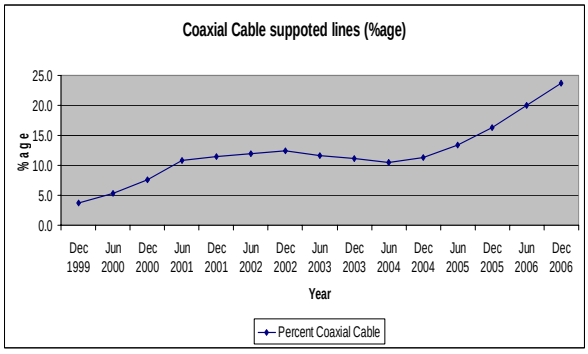

Figure 5. Percentage of coaxial supported lines

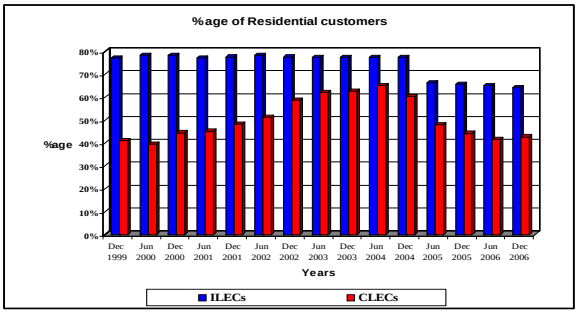

Figure 6. Percentage of residential customers

3.3. Consumer expenditure

Figure7 [17] presents an average household spending on telecom services. As evident that the expenditure of local services has increased where as the international service expenditure has decreased quite a bit. In international market there is quite a bit competition giving the benefits directly to consumers.

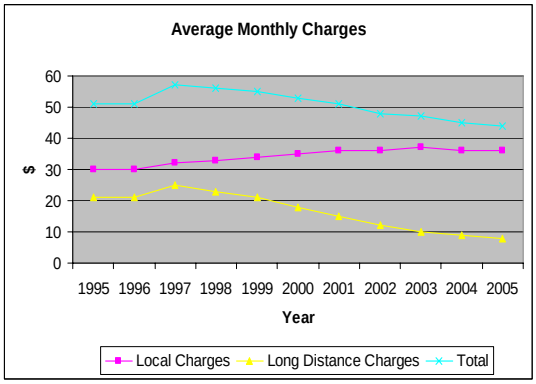

Figure 7. Average Monthly Charges

4. Fallouts of the ACT

Following fallouts of the Act are evident from today's market.

Vertical reintegration

The Act allowed local telephone companies to offer long distance service but to provide such service in their area they have to fulfill their commitment of creating competition in the area. The Act included a checklist of 14 points for RBOCs to fulfill before their entry into Inter LATA services [18]. The opportunity of allowing RBOCs an entry in long distance market was not a successful strategy. This allowed RBOCs to again enter in the long distance markets. Problems arise, when a telecommunication carrier with monopoly or near monopoly power in the provision of a particular facility also offers a competitive service that is dependent upon the use of the monopoly facility. These problems are cross subsidization and discrimination. The Act allowed RBOCs to monopolize using these methods. They acted in the same direction. The result was a wave of mergers and acquisitions.

Mergers and Acquisitions

Mergers especially vertical ones are enemies of the competition as they kill the concept of co-operation. Vertical Mergers can squeeze other companies and create monopoly in the market. Earlier, in the absence of entry in the local exchange market as envisioned by the Act, the major long distance companies bought companies that gave them some access to the local market.

For example, MCI merged with WorldCom, which had just merged with Brooks Fiber and MFS, which in turn also own some infrastructure in local exchange markets. AT&T unveiled an ambitious strategy of reaching consumer homes by using cable TV wires for the last mile. With this purpose in mind, AT&T bought TCI and in April 1999 AT&T outbid Comcast and acquired MediaOne, the cable spin-off of US West. AT&T also acquired TCG, which owned local exchange infrastructure

that reached business customers. All such mergers and acquisitions tarnished the image of a fully competitive telecom market.

Re-monopolization by RBOCs

Attempts by the RBOCs to maximize their foothold include SBC's acquisition of Pacific Bell and Ameritech, and Bell Atlantic's merger with NYNEX. SBC also bought Southern New England Telephone (SNET). Bell Atlantic has merged with GTE, creating Verizon.

Thus, the 8 large local exchange carriers of 1996 (7 RBOCs and GTE) are reduced to only 4: Verizon, Bell South, SBC, and US West. US West recently merged with Qwest. SBC first bought AT&T in 2005 and then recently it has merged with Bell South leaving just three major companies in local telephony.

Twenty years after the government broke up the long-standing MA Bell monopoly, the re-monopolization of telecommunication is almost done. This is the worst consequence of the Act. Telecom market is facing the same position as it faced twenty years back. The companies have regained their vertical structure and are edging the whole market towards a monopolistic state.

5. Section 271 Checklist

In return for opening their markets to competition, the Telecom Act allowed RBOCs to enter interstate long-distance markets, which had been prohibited since the 1984 breakup of AT&T. The Telecom Act's Section 271 provided a 14-point checklist incumbent RBOCs must satisfy before they are allowed into interstate markets. The checklist consisted of specific market-opening actions, such as providing non-discriminatory access to UNEs. The approval process requires that RBOCs apply for 271 approval on a state-by-state basis, and begins by receiving state-regulator certification that section 271's checklist has been satisfied.

Following are the major points of the checklist.

1. The BOC must allow requesting carriers to physically link their communications networks to its network for the mutual exchange of traffic. To do so, the BOC must permit carriers to use any available method of interconnection at any available point in the BOC's network. Interconnection between networks must be equal in quality whether the interconnection is between the BOC and an affiliate, or the BOC and competing local carrier.

2. The BOC must provide a connection to network elements at any technically feasible point under rates, terms, and conditions that are just, reasonable and nondiscriminatory. Non-discriminatory access to OSS (systems, databases, and personnel) is required to facilitate nondiscriminatory access to network elements.

3. The BOC must show that competitors can obtain access to poles, ducts, conduits, and rights-of-way within reasonable time frames and on reasonable terms and conditions, with a minimum of administrative costs, and consistent with fair and efficient practices.

4. The BOC must demonstrate that it has a concrete and specific legal obligation to furnish loops on an unbundled basis and that it is currently doing so in the quantities that competitors reasonably demand and at an acceptable level of quality.

5. The BOC must provide competitors with the transmission links on an unbundled basis that are dedicated to the use of that competitor as well as links that are shared with other carriers, including the BOC.

6. The BOC must provide Unbundled Local Switching to the competitors.

7. The BOC must provide competing carriers with accurate and nondiscriminatory access to 911 and E911 so that competitors' customers are able to reach emergency assistance, directory assistance and operator services.

8. White pages listings for customers of different carriers are comparable, in terms of accuracy and reliability, notwithstanding the identity of the customer's telephone service provider.

9. The BOC must provide other carriers with the same access to new NXX codes within an area code that the BOC enjoys.

10. The BOC must demonstrate that it provides competitors with the same access to the call-related databases and associated signaling that it provides itself.

11. The BOC must demonstrate that it provides number portability to competing carriers in a reasonable time frame.

12. The BOC must establish that customers of another carrier are able to dial the same number of digits to make a local telephone call. In addition, the dialing delay experienced by the customers of another carrier should not be greater than that experienced by customers of the BOC.

13. The BOC must compensate other local carriers for the cost of transporting and terminating a local call from the BOC. Alternatively, the BOC and competing carrier may enter into an arrangement whereby neither of the two carriers charges the other for terminating local traffic that originates on the other carrier's network.

14. The BOC must offer other carriers all of its retail services at wholesale rates without unreasonable or discriminatory condition or limitations such that other carriers may resell those services to an end user.

Role of FCC

FCC approved the first 271 application, Verizon's New York application, in December 1999, nearly four years after the Act's passage.

As July 1, 2002, the FCC had approved 271 applications in Arkansas, Connecticut, Georgia, Kansas, Louisiana, Massachusetts, Maine, Missouri, New Jersey, New York, Oklahoma, Pennsylvania, Rhode Island, Texas and Vermont. The FCC was in the process of reviewing applications from Alabama, Kentucky, Mississippi, North Carolina, South Carolina, New Hampshire and Delaware. RBOCs received 271 approvals for all of their states by December 2003 [19].

There was a vast difference between what the fourteen-point checklist says FCC should do, and what it allows the FCC to do. The opinion of FCC was that the Commission must apply the terms of the competitive checklist strictly as they were written, as the FCC did not write the law. Still FCC's Local Competition Order contains hundreds of pages of binding law on the meaning of 11 of the 14 checklist items. For example the Local Competition Order contains no less than 20 paragraphs discussing what it means to provide unbundled local loops. The whole situation was severely troubled by the extent of detail in which FCC had immersed itself in administering the fourteen-point checklist. The Commission vastly expanded the fourteen-point statutory checklist to include a plethora of new sub elements. All this happened because Section 271 permitted an incredible degree of FCC micromanagement.

Role of RBOCs

RBOCs always insisted that each rulemaking and decision added to or altered the compliance requirements, sometimes very significantly. The continually evolving nature of these requirements was a major problem. The costs associated with meeting these requirements constituted a significant barrier to RBOC entry into the inter-LATA market. This was like a never receding finish line for their entry into the long distance market.

RBOCs refused to accept the performance standards and performance penalties that the Department of Justice identified as necessary to ensure non-discrimination on an ongoing basis and continued a legal battle. Once RBOCs got the permissions they started mergers and acquisitions. Eight large carriers of 1996 have reduced to just four now.

Role of AT&T and other long distance companies

The long distance carriers – AT&T, MCI and Sprint were thought to be the most likely entrants into local services but they were very slow to move. They used this slow progress to argue against any attempt by RBOBs to enter the long distance market, and they did this successfully in every case filed. FCC refused to approve RBOCs applications for inter LATA services on the grounds that they have failed to comply with some aspects of the required competitive checklist.

Long distance companies used every tactic to stop RBOCs from entering the lucrative long distance services. They did not make any crucial investments in local infrastructure just to stop RBOCs from entering their market.

6. Results

Following are the results of section III, IV and V.

1. Since the approval of Act in 1996, CLECs have not been able to increase their share of the market. They have tried to enter the market but still their part is limited and most of the network is still held by ILECs.

2. The market of local telephony has moved to little bit of competition but at very slow pace.

3. RBOCs still hold a monopoly or near monopoly positions in their areas.

4. As evident from graph 4, percentage of CLEC owned infrastructure based lines remains the same, thus showing that CLECs have not made any crucial investment.

5. RBOCs have extended their monopoly to the long distance markets.

6. There is a wave of mergers and acquisitions as a result of Telecom Act distorting the whole market.

7. RBOCs have re monopolized and re grouped.

8. Residential Area is mostly neglected by CLECs.

9. Coaxial cable has failed as substitute for twisted pair based infrastructure.

10. The subscribers are unable to receive the benefits of technological advances due to unregulated monopolization in local market.

11. Congress intended to write a pro competitive, deregulatory law but did not do so. Telecom Act's proponents did not understand the realities of the telecom market and the incentives of the multibillion-dollar corporations in it. A law that seemed simple and spare when Congress wrote it became impossibly complicated and over regulatory when the FCC implemented it.

12. Each of the14 points on the checklist became a point of contention, friction, and delay.

13. This list helped the long distance carriers and clearly slowed entry of RBOCs into long distance market for a number of years. Once RBOCs got entry, they jeopardized the whole market by mergers and acquisitions.

We can say that

The telecommunication Act 1996 has failed to achieve its goal of achieving full competition in all markets even

after 10 years. It has been able to induce very little competition especially in the last mile at very slow pace. RBOCs still hold a monopoly or near monopoly positions in their areas. As a result of mergers and acquisitions they have re monopolized and vertically re integrated. FCC, RBOCs and long distance companies all were responsible for the failure of the 14-point checklist. Hence it is hard for the subscribers to receive the full advantages of technology developments.

In the next section we shall take a detailed look at the reasons of failure of telecom Act.

7. Reasons for Failure

Following are the major reasons for failure of Telecom Act 1996.

Local loop is a natural monopoly

Telecom Act failed because it took the wrong direction. The intentions were right to provide fruits of technology development to the consumers but the approach was wrong.

In local loop duplication does not bring additional utility whereas additional cost is tremendous. The local loop is a natural monopoly just like water companies. Monopoly in local telephony segment is very difficult to break due to high economies of scale.

The basic error was the breaking of local monopoly as even after 10 years, Bell companies are still monopolies in their regions. In most of the regions they have consolidated their positions.

Investments in local loop is not required

There is no need of more investment in local loop as it will only create duplication.

In 1996 about 95% of houses had the access to telephone service [20]. As the access rate is so high, creating competition simply means duplication of infrastructure or reselling of the same facilities.

Most of the subscribers don't need more than one line in their houses. Hence the Act has created unregulated monopolies in the local Telephony market. Unregulated local monopolies are worse than regulated monopolies as they pose a threat for numerous information and communication technology markets that might otherwise be deemed to be effectively competitive.

UNE pricing with TELRIC

The Act required the incumbent operators to provide competitors access to parts of their network.

FCC was assigned the responsibility to decide exactly which parts to be offered. From here the problem started. FCC made a comprehensive list of UNEs including switches, transport lines and local loop. The list included all the facilities of incumbent operator to be provided to the competitors at price set by regulators. The Act called the price to be just and reasonable. FCC calculated the prices using TELRIC. TELRIC is a forward looking costing method which includes the incremental cost resulting from adding or subtracting a specific network element. TELRIC introduced low prices for UNEs.

The availability of UNEs from incumbent carriers at low regulated prices distorted the market. It created a 'make vs. buy' trade-off for competitors. They decided to lease vital equipment rather than making the expensive and risky investments in making their own infrastructure [21].

This created a second best sort of competition with competition among the firms sharing the same infrastructure at artificially low rates ordered by regulators.

This also hindered the new investment as it discouraged incumbent carriers from investing in their networks since benefits have to be shared with rivals. Overall incumbent investment had been $15 billion less than it would be without these rules [22].

Least regulatory control

The regulatory control over the monopoly has been released in the Act. The Act envisioned a totally competitive market and did not provide regulatory controls in case competition is not healthy enough. Unregulated control of the local loop bottleneck has posed a severe risk for the telecom sector.

Without regulation, the monopoly pricing always results in substantial deadweight losses and may block the emergence of innovative services. Thus absent regulation of the ILEC bottleneck has been a threat to consumer surplus and overall efficiency as deadweight losses are likely to be large. The abuse of market power has adversely impacted competition all along the value chain of information technology that depends on PSTN.

Universal Service

The most disastrous and useless section of the Act were those that dealt with the universal service.

Congress gave FCC more power to create havoc in the market in the name of social justice and expansion of social welfare. The policymakers failed to eliminate or make radical reforms in subsidization methods used for universal service.

Current subsidization policies redistribute money in highly inefficient manner to provide cheap local service to all. These subsidies flow from long distance to local users, from business to residential users and from urban to rural users. This mechanism was created to favor AT&T to strengthen its monopoly power. But in competition these subsidies have destroyed the market structure

by discouraging market entry since it is always difficult to compete with subsidized firms [23-26].

Self contradiction

On one side the Act advocates new investment but on the other side it allows UNE pricing by TELRIC which discourages both incumbents and new comers to invest. On one side the Act calls for competition but on the other side it promotes universal service which itself promotes monopolization.

8. Conclusion

The Telecommunication Act 1996 was considered as a break through in the telecom market. It has failed to achieve its goals. Vertical reintegration, mergers, acquisitions and re monopolization are major fallouts of the Act. Section 271 also proved to be regulatory mistake over the last 10 years. There are multiple reasons of this failure. Monopoly breaking, UNE pricing and universal service are some of the reasons. As a result RBOCs have consolidated their monopoly positions in most of the areas. Rapid developments in telecommunication now demand innovation in regulatory regime.

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Website Design Quality and Form Input Validation: An Empirical Study on Irish Corporate Websites

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ABSTRACT

The information maintained about products, services and customers is a most valuable organisational asset. Therefore, it is important for successful electronic business to have high quality websites. A website must however, do more than just look attractive it must be usable and present useful, usable information. Usability essentially means that the website is intuitive and allows visitors to find what they are looking for quickly and without effort. This means careful consideration of the structure of information and navigational design. According to the Open Web Applications Security Project, invalidated input is one of the top ten critical web-application security vulnerabilities. We empirically tested 21 Irish corporate websites. The findings suggested that one of the biggest problems is that many failed to use mechanisms to validate even the basic user data input at the source of collection which could potentially result in a database full of useless information.

Keywords: *Website Design Quality, Form Input Validation, Information Quality, Data Quality*

1. Introduction

The World Wide Web (WWW) is the largest available distributed dynamic repository of information, and has undergone massive and rapid growth since its inception. There are over 2,060,000 users in Ireland alone. Over the last seven years (2000 - 2007), Internet usage in Ireland has grown by 162.8%; in United Kingdom by 144.2%; in Europe by 221.5% and Worldwide by 244.7% [18].

Based on these facts, the Internet has assumed a central role in many aspects of our lives and therefore creates a greater need for businesses to design better websites in order to stay competitive and increase revenue. Interactivity is essential to engage visitors and lead them to the desired action and customers are more likely to return to a website that has useful interactivity.

The website's homepage should be a marketing tool designed as a 'billboard' for the organization. The design is critical in capturing the viewer's attention and interest [25] and should represent the company in a meaningful and positive light. Therefore, there are many web design concerns for commercial organizations when designing their website.

The most basic are as follows: content that should be included, selecting relevant and essential information, designing a secure, usable, user friendly web interface that is relatively easy to navigate, and ensuring the site is easy to find using any of the major search engines. In the drive to make the website look appealing from a visual perspective other factors are often ignored, such as validation and security, which leads to poor user experience and data quality problems.

Data in the real world is constantly changing therefore feedback is necessary in order to ensure that quality is maintained. Data is deemed of high quality if it '*correctly represents the real-world construct to which it refers so that products or decisions can be made'* [30]. One can probably find as many definitions for quality on the web as there are papers on quality. There are however, a number of theoretical frameworks for understanding data quality.

Redman [33] and Orr [27] have presented cybernetic models of information quality. The cybernetic view considers organizations as made up of closely interacting feedback systems that link quality of information to how it is used, in a feedback cycle where the actions of each system is continuously modified by the actions, changes and outputs of the others [2,29,36]. Figure 1 shows an information system in the real world context.

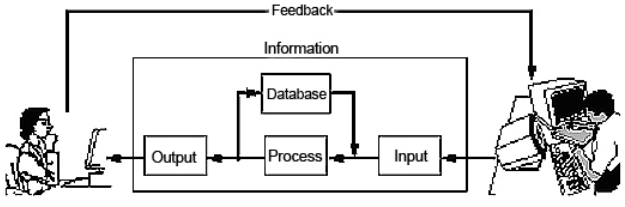

Figure 1: Information system in the realworld context [29]

Wang and Strong proposed a data quality framework that includes the categories of intrinsic data quality, accessibility data quality, contextual data quality and representational data quality outlined in table 1.

Table1. IQ dimensions [17]

DQ Category	DQ Dimensions
Intrinsic DQ	Accuracy, Objectivity, Believability, Reputation
Accessibility DQ	Accessibility, Access Security
Contextual DQ	Relevancy, Value Added Timeliness, Completeness, Amount of Data
Representational DQ	Interpretability, Ease of understanding, Concise Representation, Consistent Representation

The quality of websites may be linked to such criteria as timeliness, ease of navigation, ease of access and presentation of information. From the customer's perspective usability is the most important quality of a Web application [8].

However, even if all procedures are adhered to, errors can still arise that reduce the quality standard of the online experience. For example, a file may be moved or an image deleted, which results in broken links. The root cause that leads to web application problems is the poor approach to web design.

To remedy this several techniques exist to evaluate the quality of websites for example link checkers, accessibility checkers and code validation. To help improve the quality of a website, aspects such as structure and page layout need to be consistent and coherent. A good website must include safeguards against failure and provide simple, user friendly data entry and validation processes.

From the literature reviewed a universal definition of information quality is difficult to achieve [3, 21, 26, 29, 38, 42]. According to [25] *'Technically, information that meets all the requirements is quality information'*. Some accepted definitions of quality from the quality gurus are shown in table 2.

Table 2. Quality definitions from the quality gurus

Author	Quality Definitions
Deming	Meeting the customers needs
Juran	Fitness for use
Crosby	Conformance to requirements
Ishikawa	Continuous improvement
Feigenbaum	Customer satisfaction

One definition of quality is '*the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs*' [13, 14]. Two requirements for website evaluation emerge from this definition. 1) general valuation of all the site's characteristics and 2) how well the site meets specific needs.

1.1. Related Work

Pernici and Scannapieco [28] discuss a set of data quality dimensions such as expiration, completeness, source reliability, and accuracy to evaluate data quality in web information systems to support correct interpretation of web pages content. Cusimano Com Corp [4] declared that effective web sites must be clear, informative, concise, and graphically appealing.

Tilton [40] recommends that Web designers should present clear information that has a consistent navigation structure. Hylnka and Welsh [12] put forward the argument that the web page is a source of communication and should be analysed within communication theory.

Kelly and Vidgen [16] is concerned with the combination of a quality assessment method, E-Qual, and a lightweight quality assurance method, QA focus and states that website developers need to use standards and best practices to ensure that websites are functional, accessible and interoperable.

There are a number of ways to evaluate the quality of websites, such as competitive analysis, inspection, and online questionnaires. WebQual, developed by Barnes and Vidgen [1] is one approach to the assessment of website quality. WebQual, has 3 main dimensions: usability, information quality, and service interaction quality. According to [1], WebQual is a '*structured and disciplined process that provides a means to identify and carry the voice of the customer through each stage of product and or service development and implementation*'.

Usability is concerned with the quality associated with the site design; Information Quality is concerned with the quality of content of the site; Service Interaction quality is concerned with quality provided to the users as they enter into the site. Within these dimensions, WebQual consists of a set of 23 questions regarding the website being assessed and each question contains a rating from 1-7; 1 = strongly disagree, 7 = strongly agree.

Detailed information about evaluating websites can be found at [24, 34, 35]. Eppler & Muenzemayer [7] identifies 2 manifestations, 4 quality categories, and 16 quality dimensions. Kahn et al. [17] mapped IQ dimensions to the PSP/IQ model with 2 quality types, 4 quality classifications, and 16 quality dimensions. Zhu & Gauch [44] outlines 6 quality metrics for information retrieval on the web.

1.2. What Is a Quality Website?

Online interactivity is a valuable way of improving the

quality of business websites and web designers should be aware of how design affects the quality of the website and the image of the organization.

Good websites have a rich and intuitive link structure. A link going to the Customer Service should be named 'Customer Service' and the surfer looking for Customer Service information will know this link goes to the page they want. Therefore, 'click here' should never be used as a link.

Information managers and developers must determine how much information users need [25]. Some users will need much background on a specific topic whilst others may only need a summary or overview. A good web designer will think clearly about how each piece of data links up with the rest of the content on the website and will organize the links accordingly.

Without a clear navigation system, viewers can become disoriented. Hyperlinks are distinguished from normal text within a page by its colour. When the page pointed to by a hyperlink has been 'visited' browsers will inform the users by changing the link's colour [41].

The most vulnerable part of any web application is its forms and the most common activity of web applications is to validate the users' data. According to the Open Web Applications Security Project [27] invalidated input is in the top ten critical web application security vulnerabilities. Input validation is an important part of creating a robust technological system and securing web applications. Because of the fundamental client server nature of the web application, input validation should be done both on the client and the server.

Client side validation is used to provide input data validation at the data collection point before the form is submitted and check that the required fields are filled and conform to certain characteristics such as built in length restriction, numeric limits, email address validity, character data format etc. Incorrect data validation can lead to data corruption.

Table 3. Example validation checks

Validation check	Description
Character set	Ensure data only contain characters you expect
Data format	Ensure structure of data is consistent with what is expected
Range check	Data lies within specific range of values
Presence check	No missing / empty fields
Consistency check	If title is 'Mr' then gender is 'Male'

Input validation should be performed on all incoming data ensuring the information system stores clean, correct and useful data. Examples of invalid data are: text entered into a numeric field, numeric data entered into a text field, or a percentage entered into a currency field. Table 3 provides an example set of checks that could be performed to ensure the incoming data is valid before data is processed or used.

Having contact information available and visible on the website is a marketing plus that potential customers use in order to judge a company's trustworthiness, as it signifies respect for the customer and implies promise of good service.

Feedback mechanisms built into the website are a useful way to get meaningful feedback on the website and service quality from the people who matter most – your customers. After all, one definition of quality is *'meeting or exceeding the customer's expectations'*.

One of the most important factors for a website being successful is speed. If the website is unresponsive, with long response times the visitors will not come again. Speed or responsiveness is integral to good website design and organizational success. Web pages should be designed with speed in mind [31]. It is estimated that if a page doesn't load within 5-8 seconds you will lose 1/3 of your visitors [35]. However, many designers believe that with the recent development of broadband, visual aesthetics is now more important as download speed is not such a major concern. Nevertheless, not all users have broadband and this should be taken into consideration.

For the purpose of this study we conducted an empirical study using a data set of twenty one finalists in a recent website quality technology award. The aim of this study was to examine these websites for *Technical* quality issues from the user's perspective.

Our analysis focused on helping website owners understand the importance of certain website characteristics, quality of information and functionalities. During the analysis we tested functionalities in the website like forms, the navigation process, the relevance of all click through and the page download speed.

The rest of the paper is organized as follows: Section 2 shows our methodology, Section 3 gives a brief summary and Section 4 some conclusions.

2. Research

2.1. Methodology

We conducted an empirical study on a recent accountancy website quality technology award competition using the full data set of twenty one finalists that included (3) Charity/Not for Profit organizations, (7) Large Quoted Companies, (2) Small Quoted Companies and (9) Statutory and Unquoted Companies. The identity of websites has been concealed due to confidentiality regulations regarding

their identity.

The aim of this study was to examine these websites for *Technical* quality issues. This required validating the sites against a series of checkpoints that included: checking that legal and regulatory guidelines were adhered to (e.g. data protection and privacy), that pages conformed to Web-Accessibility standard (e.g. missing 'alt tags'), missing page titles, browser compatibility, user feedback mechanisms, applications were functioning correctly (e.g. online forms are validated for input etc.). It also included evaluation of the main characteristics and structure of the sites for example clear ordering of information, broken links, and ease of navigation. The principle used was based on the same criteria used to evaluate the participants in the 2006 award [10, 32, 39, 43]. The criteria subset used for this study is outlined in table 4.

Table 4. Set of criteria used in our study

Validation Criteria
Contrast colours support readability & understanding
Professional appearance
Do not use 'click here'
What you clicked on is title of page jumped to
Links back to home page are functional & relevant
Help features available and easy to access
Visited links change colour
Site map
Interactive form validated for input
Mailto parameters set correctly?
Web address simply a case of adding .com or .ie to
Useful search engine provided
Site search provided
FAQ
Data Protection & Privacy

2.2. Findings and Analysis

Table 5 shows the number of companies who defaulted and the number of companies who adhered to selected criteria.

Twelve websites did not include a link to their data protection and privacy policy. A help and Frequently Asked Question (FAQ) page is a general requirement for good website design. As far as navigation goes, this page should tell the user how to find products or information and how to get to the sitemap, yet, 10 companies did not have a FAQ link and 11 did not have help features available and easy to access. Seven out of the 21 sites evaluated did not have the mailto parameters set correctly.

Fifteen sites had fully functional and relevant links to other pages and back to the homepage. Thirteen sites promoted contrast colours supporting readability and understanding and 19 had a professional feel and appearance and did not have horizontal scroll bars. Twenty of the total twenty one sites adhered to the criteria of having the title of page jumped also as the label of the link connecting to it. The percentage of sites that adherence to the criteria and the percentage of sites that defaulted on the criteria are shown in figure 2.

Table 5. Criteria for website evaluation

Validation Criteria	Defaulted	Adhered
Contrast colours support readability and understanding	8	13
Professional appearance	2	19
No use of 'click here' links	12	9
What is clicked on is title of page jumped to	1	20
Links to home page functional and relevant	6	15
Help features available & easy to access	11	10
Visited links change colour	16	5
Site map available	6	15
Form validation for input	17	4
Mailto parameters set correctly	7	14
Web address is a case of adding .com or .ie to company name	4	17
Useful search engine provided	19	2
Site search provided	7	14
Frequently Asked Questions	10	11
Data Protection and Privacy	12	9

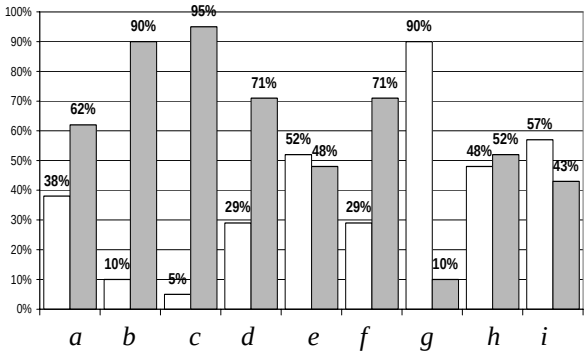

Figure 2. Percentage of sites that defaulted and percentage of sites that adhered to selected criteria (a-Colours s support readability; b-Professional appearance; c-what clicked on was title of page jumped to; d-Links functional &relevant; e-Help features available &easy to access; f-Mailto parameters set correctly. g-Use search engine; h-Frequently asked question page; i-Data protection &privacy)

Figure 3 depicts the results from the Friendly URLs

(Uniform Resource Locator). Seventeen (81%) of the 21 sites tested had good structured semantic URLs, made up of the actual name of the specific company where we could guess the URL by simply adding .com , .org or .ie to the company name. For example a company named '*Jitnu*' had a URL *http://www.jitnu.ie* or *http://www.jitnu.com* or *http://www.jitnu.org* as the web addresses which convey meaning and structure. Only 19 % of the companies examined defaulted on these criteria having a URL for example such as *http://www.jitnu.ie/?id=478* instead of *http://www.jitnu.ie/services* or had a file extension like `.php` as part of their URL.

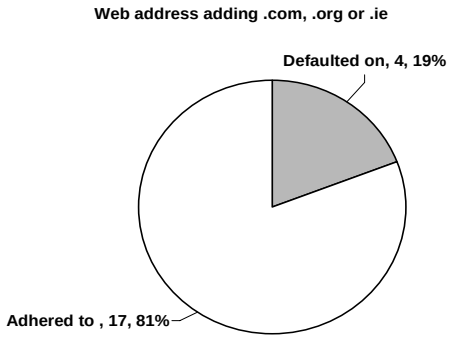

Figure 3. Results of the friendly URL's criteria

Figure 4 shows that 16 (76%) of the 21 sites examined used the same link colour for visited and unvisited pages and did not support a convention that users expect. Failing on this navigational aid could well increase navigational confusion and introduce usability problems for the user. Good practice is to let viewers see their navigation path history (i.e. pages they have already visited) by displaying links to *'visited pages'* in a different colour.

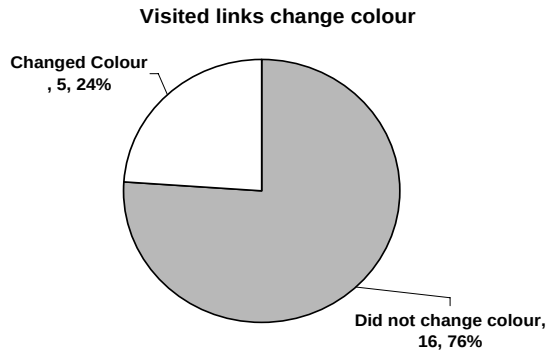

Figure 4. Visited pages changed link colour

Sitemaps are particularly beneficial when users cannot access all areas of a website through the browsing interface. Failure to provide this access option may lose potential viewers. A large website should contain a site map and search option. From analysis of our findings in figure 5, we show that six websites (29%) did not provide a site map.

Visitors appreciate search capability on sites that deals with several different products or services. In figure 6 we show that although adding a search function on a website helps visitors to quickly find information they need, seven (33%) of the 21 sites reviewed failed to provide a comprehensive site search or search interface.

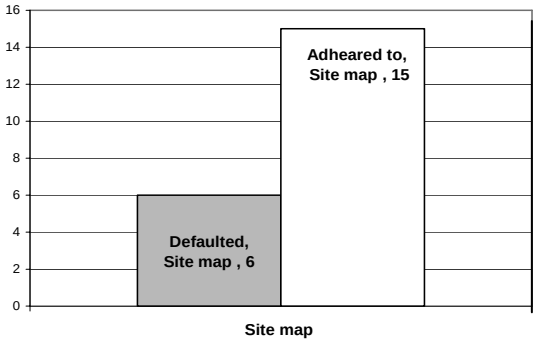

Figure 5. Site map

While creating a good navigation system will be sufficient help for many people, it won't meet the needs of everyone. It appears that these companies fail to realise the importance of providing a search capability, which not only make sites more interactive but also gives visitors more control over their browsing experience.

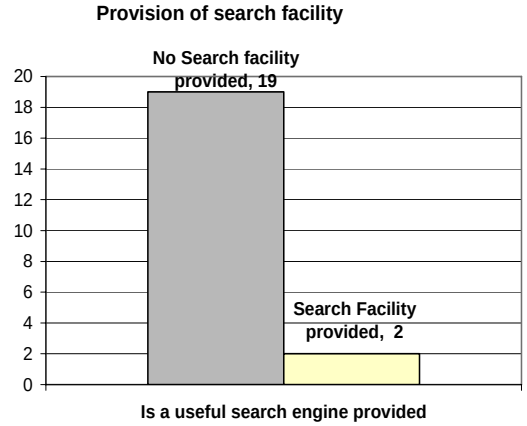

Figure 6. Search facility

Figure 7 shows the results of checking user-entered email addresses for valid input. An email address should contain one and only one (@) and also contain at least one (.). There should be no spaces or extra (@). There must be at least one (.) after the (@) for an email address to be valid. Some websites had implemented some form of email address validation but did so incorrectly. For example they correctly rejected jitnu.eircon.net and jitnu@eircom@net as invalid email addresses, however, they incorrectly accepted 'jitnu.eircom@net', as a valid email address thus allowing an invalid email address to pass to the system as a valid. While they correctly checked for the presence of the (@) and the (.), they did not however check the order in which the (@) and the (.) appeared

in the inputted email address. From the review of the sites we found that 17 (81%) had no validation process on email addresses while only 4, (19%) of the 21 sites reviewed shown in figure 7 had complete validation.

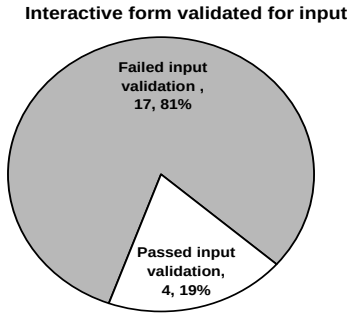

Figure 7. Email validation

Figure 8 shows that 12 (57%) of the 21 websites were careless about their link text quality by using the *'Click Here'*, which does not give indication of the content of the linked page, while nine (43%) used meaningful link text which clearly identified the target of the links.

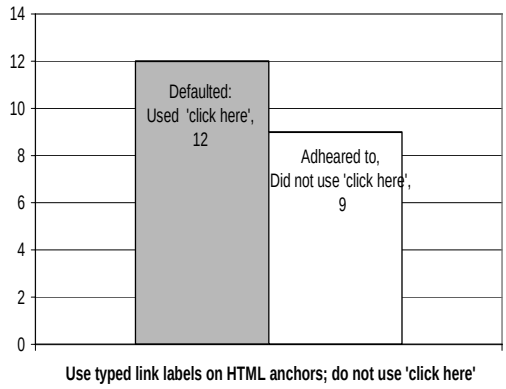

Figure 8. Click here anchors

Figure 9 shows the number of companies that observed and adhered to the quality criteria set out for this review and figure 10 shows the number that defaulted in the above criteria. It can be seen that 19 sites had a professional appearance with no annoying horizontal scroll bars and 20 sites used the page title of the page linked to as an anchor. However only 2 of the 21 sites under review had provided a site search option and 4 sites had complete validation on email addresses.

Figure 11 shows that six out of 21 sites under review did not have their 'mailto' parameter set correctly to facilitate the user with easy feedback option and none of the 21 sites provided an option for the users to view the feedback provided by other users. Providing feedback options greatly enhances the website as many errors go unnoticed until the user draws it to the attention of the organization.

From our analysis we found that all sites had good page load speed between a minimum 0.5 seconds and a maximum of 1.5 seconds and an average load speed of .89 seconds. The average download per Kb was .26 seconds with a minimum speed of .02 seconds and a maximum speed of 3.76 seconds. The minimum site size was .17kb, the maximum site size was 45.68kb and the average site size was 20.45 kb.

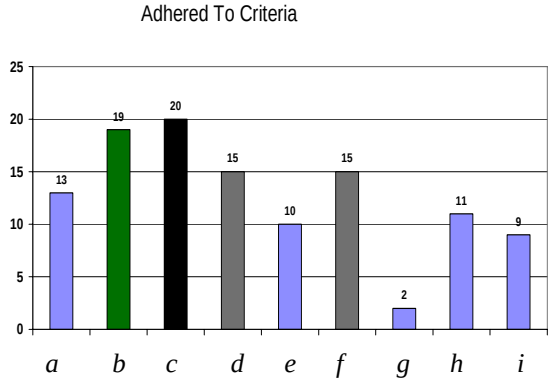

Figure 9. Adhered to selected criteria(a- Colors support readability; b-Professional appearance; c-what clicked on was title of page jumped to; d-Links functional &relevant; e-Help features available &easy to access; f-Mailto parameters set correctly. g-Use search engine; h-Frequently asked question page; i-Data protection &privacy)

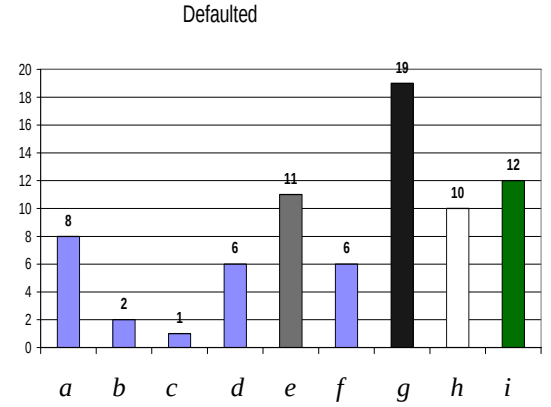

Figure 10. Defaulted on selected criteria(a- Colors support readability; b-Professional appearance;c-what clicked on was title of page jumped to; d-Links functional &relevant; e-Help features available &easy to access; f-Mailto parameters set correctly. g-Use search engine; h-Frequently asked question page; i-Data protection &privacy)

3. Summary

The Internet is an interactive channel and successful websites are those that are built on a foundation of interactivity. As the Internet's first real feedback mechanism, forms processing is still the most widely used interactivity on websites. Companies have invested vast amounts of

money and resources to make their website a strategic part of their business. But what do their customers actually experience when they perform a transaction on their site?

From our study we found that the web applications under investigation were notorious for taking practically any type of input, assuming that it's valid, and processing it further. Not validating input is one of the biggest mistakes that Web-application developers make. This can lead to database corruption. The results from our investigation of the company websites show that one of the biggest problems with online forms on the web is that many corporate companies failed to validate user input to ensure reliability and potentially resulted in a database full of useless information. (See figure 12, figure 13 and figure 14).

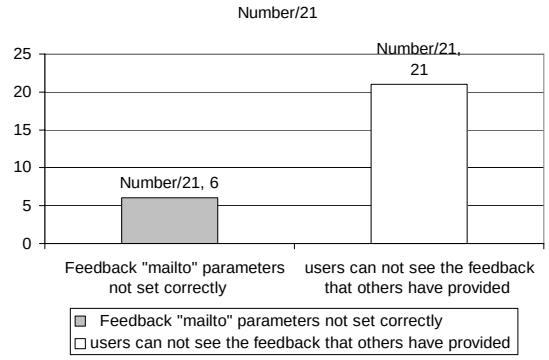

Figure 11. Feedback option and accessibility

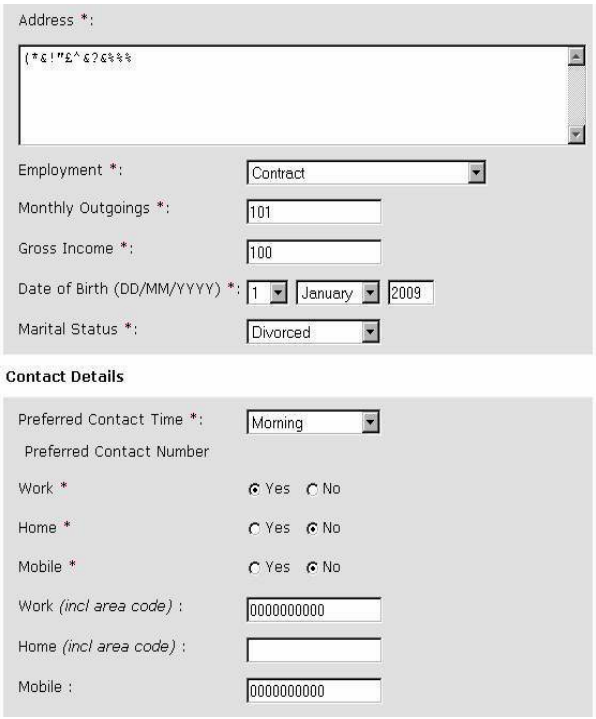

Figure: 12. Example of no date of birth validation on corporate website form

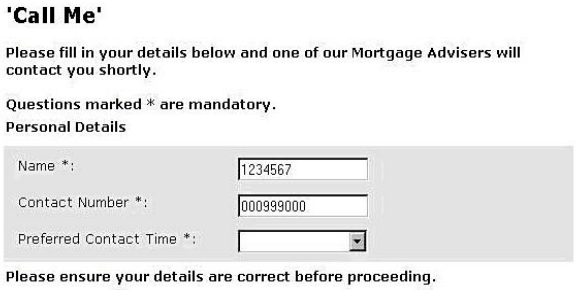

Figure 13. Example of trusting the user to enter and validate their own data

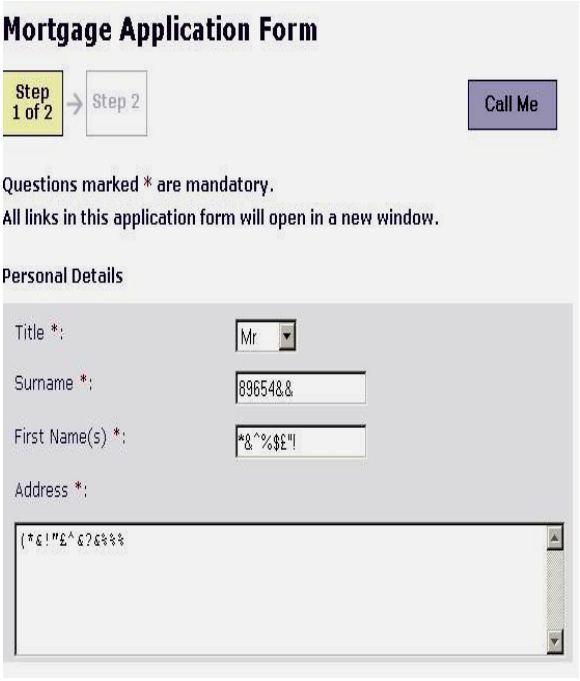

Figure 14. Example of useless information collected in one Irish corporate website

This study highlighted that to date a large number of web applications have not used mechanisms to validate even the very basic data input at the source of collection. Given that the sites under review in this study included large quoted companies, small quoted companies, charities and not for profit, statutory and unquoted organizations and that some had been recognized for excellence in financial reporting; it was surprising to find that 81% of the sites under examination failed on basic input validation. All 100% of large quoted companies and 100% small quoted companies failed in their email input validation while 67% of charities/not for profit organizations and 67% of statutory and unquoted organizations under investigation failure to validate emails. No less than 90% failed to provide a useful search engine but 71 % did provide a

site map.

Providing a site search function makes the site searchable. The sitemap should include every page on the site, categorized for easier navigation. These are the links that users look for when they cannot find what they are actually looking for on the site. However, 67% provided a site search facility and 81% had friendly URL's that were easy to remember and most sites had a good design layout that was consistent throughout. The consistency aspect of quality was closely adhered to by all sites making it easier for the user to navigate.

4. Conclusions

Today's Internet user expects to experience personalized interaction with websites. If the company fails to deliver they run the risk of losing a potential customer forever. An important aspect of creating interactive web forms to collect information from users is to be able to check that the information entered is valid, therefore; information submitted through these forms should be extensively validated. Validation could be performed using client script where errors are detected when the form is submitted to the server and if any errors are found the submission of the form to the server is cancelled and all errors displayed to the user. This allows the user to correct their input before re-submitting the form to the server. We can not underestimate the importance of input validation which ensures that the application is robust against all forms of input data obtained from the user.

Although the majority of web vulnerabilities are easy to understand and avoid many web developers are unfortunately not very security-aware. A company database needs to be of reliable quality in order to be usable. A simple check whether a website conforms to the very basic standards could have been done using the W3C HTML validation service, which is free to use.

Web developers need to become aware and trained in Information Quality Management principles, and especially in the information quality dimensions as outlined in Table 2. The only proven reliable way to deal with bad data is to prevent it from entering the system. Input can be compared against a specific value; ensure that an input field was filled and that the value falls within a certain range. Allowing bad data into the system makes the entire system unreliable and indeed unusable.

Making purchases online is all about confidence; a customer must feel assured that you are a reputable company, and the best way to project that image is through a well designed website. A consumer visiting a website that looks a little dodgy will not feel confident enough to submit their credit card information.

Slow response times and difficult navigation are the most common complaints of Internet users. After waiting past a certain 'attention threshold' users look for a faster site. Of course, exactly where that threshold is depends on many factors. How compelling is the experience? Is there effective feedback? Etc. Our analysis identified these and many other shortcomings that should have been realised and dealt with during the website test phases. Many problems could be eliminated by checking for letters (alphabet entries only); checking for numbers (numeric entries only); checking for a valid range of values ; checking for a valid date input; and checking for valid email addresses. However, it is important to keep in mind that a user could enter a valid e-mail address that does not actually exist. It is therefore, imperative that some sort of activation process needs to be done in order to confirm a valid and correct email address.

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What are the Benefits of Continued Purchasing through the Internet? A Study of South Korean Consumers

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ABSTRACT

Since keeping the customer purchasing a product/service is essential to maintaining the profitability of any business, the continuance of purchasing through the Internet is vital to online business. This study is one of the few attempts to investigate the perceived benefit factors affecting customers' intention to continue purchasing through the Internet. According to a multiple regression analysis of online questionnaires filled out by 998 online customers in South Korea, extrinsic benefits measured in terms of time and money savings as well as intrinsic benefits measured in terms of pleasure, novelty, and fashion involvement have strong effects on the repurchase intention. Our findings indicate that customer retention must be promoted in Internet shopping by guaranteeing not only extrinsic benefits but also intrinsic benefits. This study discusses the relevant techniques of providing those benefits to customers and guidelines for future research.

Keywords: *repurchase intention, benefit, Internet shopping, extrinsic benefit, intrinsic benefit*

1. Introduction

The government of South Korea is actively promoting electronic commerce (EC), in part by providing government support, and the total volume of e-commerce increased from $47.93 billion in 2000 to $99.15 billion in 2001 [21]. The growth rate of business- to-customer (B2C) EC was 252.2% in 2001. Moreover, the total EC sales during the second quarter of 2002 equaled 1.355 trillion won, an increase of 52.6% compared to that of 2001 [21]. Because of the rapid growth of the EC market and support from the government, South Korea has played an important role in the global EC market.

However, there are obstacles to B2C adoption in the area of operation of Internet stores, including high logistics costs, lack of marketing strategy, limited product range and service differentiation, and lack of features for customers on the website [21]. As these may cause online customers to stop shopping through the Internet, an investigation of the reasons that consumers choose to purchase again through the Internet is also important. Despite the need to succeed in business [23], the factors affecting the continuance of purchasing through the Internet have rarely been explored. Recent studies show that investigating such factors in an online environment can help us to create an effective customer-retention strategy and to determine the impact of the identified factors on the products and services offered by Internet shops [10, 12].

The fundamental reason for the existence of true market segments is the benefit that people derive from consuming a given product [24], and the benefits of Internet shopping for customers have been discussed in the literature. The benefits include time saving and the convenience of shopping without being restricted by store hours or location. These extrinsic benefits serve as a means to help customers achieve other outcomes, for example, to reduce the time spent shopping and to gain convenience or efficiency. Shang *et al*. [22] found that an extrinsic factor, perceived usefulness, was not an antecedent of purchasing through Internet shopping, but rather, intrinsic motivations, fashion and cognitive absorption, were more important than extrinsic ones. Considering this, the extrinsic benefit and intrinsic benefit customers get by shopping online can be used as a measure of the willingness of a customer to continue purchasing from an Internet shopping website. While prior studies have examined the benefits that encourage a customer to purchase through the Internet, this study examines the extrinsic and intrinsic benefits affecting the customer's intention to continue purchasing items through the Internet. The underlying factors among the variables can be discovered by applying exploratory factor analysis. These factors were investigated by using multiple regression analysis to determine whether they had any relationship with continuance of purchasing behavior.

In the following section, we discuss the literature that is relevant to the continuance of purchasing behavior and the benefits of Internet shopping. The methodology, measurement development, and reliability analysis are described in the third and the fourth sections. The results are discussed in the fifth section. Finally, we present our conclusions and discuss the limitations of the present research and guidelines for future research.

2. Intention to Continue Purchasing through the Internet

Many studies on customer behavior, in particular, customer satisfaction and intention to continue purchasing, have applied expectation-confirmation theory in the EC context. Kim *et al*. [4] proposed a framework combining trust, expectation, and satisfaction. Their findings showed that customer's trust and expectations are positively related with satisfaction which has a positive influence on the intention to repurchase. Lee *et al.* [12] argued that retaining customer loyalty is vital to make Internet users visit Internet shopping websites again. Trust and low transaction cost help to increase customer loyalty towards an Internet shopping website. On the other hand, Koufaris [17] used customer intention to return, not actual return visits to measure loyalty. He found that shopping enjoyment and perceived usefulness are positively significant to the customers' intention to return to visit online bookstore. Liang and Lai [27] examined the effect of design quality on consume choice of online bookstores. Their results showed that design quality is as important as product price to make customers visit and purchase again.

Chung and Lee [10] indicated that product perceptions, customer service, perceived ease of use, site image, promotion, communications environments, and overall customer satisfaction for the Internet shopping stores are positively correlated with the repurchase intention, but perceived consumer risk has a negative relationship with the repurchase intention.

In the literature, perceived benefit has not yet been examined in the context of behavior of consumers who may continue to purchase through the Internet. Hence, we believe that our study on the perceived benefits affecting continuance of purchasing through Internet shopping is unique.

Bhattacherjee [1] examined the antecedents of customers' intention to continue to use an online brokerage, which is a kind of EC service. By adding a new factor, customer loyalty, to that study's method, Atchariyachanvanich *et al.* [14] developed a model of repurchasing factors of Internet shopping and examined the key factors underlying customers' intention to continue purchasing items through the Internet. They focused on five factors including confirmation, satisfaction, perceived usefulness, perceived incentives, and customer loyalty, which accounted for 46% of the variation in the repurchase intention. This means that there must be other variables that have an influence as well. Therefore, the current study examines a new factor, perceived benefit that affects the customer's intention to continue purchasing through Internet shopping.

3. Benefits of Internet Shopping

According to Haley's study [24], the fundamental reason for the existence of true market segments is the benefit that people derive from consuming a given product. He also argued that benefits sought by consumers determine their behavior much more accurately than do demographic characteristics or volume of consumption. He pointed out that "a substantial group of people must be interested in your specific set of benefits before you can make progress in a market". This implies that online customers must be interested in Internet shopping's benefits before Internet shops can make progress in a market aspect such as customer retention. Once an online customer perceives the benefits of purchasing items through the Internet, he or she will tend to continue purchasing online. This brings us to a new factor, perceived benefit, which may affect the customer's intention to continue purchasing through the Internet.

Two kinds of benefit, extrinsic and intrinsic, were identified by previous studies in the information systems domain. Davis *et al.* [7] indicated that extrinsic motivation (usefulness) and intrinsic motivation (enjoyment) influenced a person's intention to use a computer. Hui *et al*. [15] identified seven benefits (i.e. monetary saving, time saving, self-enhancement, social adjustment, pleasure, novelty, and altruism) that could motivate customers to disclose their personal information to Internet businesses. In the domain of Internet shopping, the intrinsic factor in terms of fashion involvement was more important than extrinsic factors in explaining why customers shopped online [22]. Although the largest number of benefits has been identified in the context of online information disclosure [15], they have not been examined in the context of Internet shopping. Therefore, in the light of previous studies [7, 15, 22], we propose perceived benefits in terms of extrinsic and intrinsic benefits.

3.1. Extrinsic benefits

Extrinsic benefits offer a means with which customers can achieve other goals [15]. Since extrinsic motivation refers to the performance of an activity because it is perceived to be helpful in gaining valued outcomes that are distinct from the activity itself [7], extrinsic benefits pertain to the benefits obtained from the outcome of performing the activity, but are distinct from the activity itself. Such benefits can motivate a consumer's intention to perform an action to gain benefits that serve as a means to reach other outcomes. Four types of extrinsic benefit classified in Hui *et al*.'s study [15] were adapted to the domain of consumer behavior in Internet shopping.

Time saving refers to benefits that provide better efficiency or convenience. The benefits of saving time are to reduce time spent on and to achieve convenience in shopping. Time saving may affect online customers because it allows them to carry out more activities. As Internet shopping reduces the customers' time needed to obtain information about product prices and product offerings [2, 13], it may encourage them to shop online again. Thus,

we propose that:

H1: Time saving positively affects a customer's continuance of purchasing behavior in Internet shopping.

Money saving includes means for customers to reduce money spent on shopping and to gain free gifts such as discounts, vouchers, loyalty points, etc.. Perceived incentives in terms of free gifts, free coupons, and points were found to significantly influence the intention to repurchase in Internet shopping [14]. Customers are generally concerned about the cost of purchasing a product or service. If Internet shopping can help them save money in purchasing items, they may come back to purchase again. Therefore, we propose that:

H2: Money saving positively affects a customer's continuance of purchasing behavior in Internet shopping.

Social adjustment refers to the customers' need to establish social identities by assimilating into desired social groups. In general, customers have a desire to align with others who are like-minded [15]. Internet shopping provides additional services to satisfy such a desire. For example, a beauty club webpage is made for online customers who like purchasing beauty products and also to exchange and share knowledge about those products. This may motivate online customers to visit the Internet stores and purchase from them again. Thus, we propose that:

H3: Social adjustment positively effects a customer's continuance of purchasing behavior in Internet shopping.

Self-enhancement refers to means for customers to assert their self-concept or to maintain self-esteem in relation to others. Hui *et al*. [15] asserted that Internet businesses can possibly make use of such characteristics by bundling self-enhancement benefits with requests for personal information. In addition, the consumer behavior of an individual will be directed toward enhancing self-concept through the consumption of goods as symbols [16]. For example, online customers will be recognized by the Internet store on their next purchase after they have registered as members of the Internet store. We posit that:

H4: Self-enhancement positively affects a customer's continuance of purchasing behavior in Internet shopping.

3.2. Intrinsic Benefits

Intrinsic benefits refer to the benefits gained from purchasing through Internet shopping, apart from any purchase consequences that may be anticipated, and are ends in themselves to customers [7, 15]. When a customer considers the intrinsic benefits, they perform a task simply because the performance of the task offers them benefits. Previous studies [15, 22] indicate that online customers seek out consumption experiences obtainable from purchasing (pleasure, novelty, and fashion involvement) as ends in themselves.

Pleasure is defined as the extent to which the activity of purchasing in Internet shopping is enjoyable and pleasant in its own right, apart from any purchase consequences that may be anticipated [7, 15, 17]. Jarvenpaa and Todd [25] show that Internet customers miss the fun and atmosphere of shopping in traditional stores. In response to this problem, Aberg and Shahmehri [11] developed the Human Web Assistant to provide efficient user support to make a website more fun to use, to increase the customers' trust in the website, and to improve the website's atmosphere. In addition, virtual reality storefronts offer online customers additional ways to find enjoyment through Internet shopping. This perception of pleasure may make customers more likely to purchase again in Internet shopping. Thus, we hypothesize that:

H5: Pleasure positively affects a customer's continuance of purchasing behavior in Internet shopping.

Novelty focuses on means that help customers fulfill their innate needs for exploration or information. Hui *et al*. [15] indicated that the curiosity of customers can be stimulated by an appropriate level of information complexity. As Internet shopping websites provide plenty of information about products, support, payment methods, and delivery channels, these benefits may make customers visit Internet shopping websites again. This leads to the hypothesis that:

H6: Novelty positively affects a customer's continuance of purchasing behavior in Internet shopping.

Fashion involvement is defined as the degree to which the activity of purchasing in Internet shopping enables customers to make purchases according to their own fashionable behavior. Shang *et al*. [22] assumed that shopping is a fashionable behavior and used fashion involvement to conceptualize the effects of social influence. Their study found that fashion involvement was more important than extrinsic factors in explaining the behavior of online customers. Therefore, we propose that:

H7: Fashion involvement positively affects a customer's continuance of purchasing behavior in Internet shopping.

4. Methodology

Based on the well-established framework for developing measures of a construct [8], this study specifies the domain of the construct (i.e., Internet shopping benefits), generates items from literature reviews, collects data, purifies items, assesses reliability and validity, and develops norms.

4.1 Data collection

This study targeted potential online users who have pur-

chased a product or service through Internet shopping and intend to continue purchasing through it. The percentages of Internet users' survey conducted in 2006 by the National Internet Development Agency of Korea [19] were first used as a condition to screen our potential online customers or potential respondents. Then the percentages of age groups and gender of our respondents were set equal to those of the Internet users. Doing so avoids an excess of answers from highly educated respondents or young respondents and ensures that the respondents will be selected randomly.

As the web-based survey was conducted in South Korea, a Korean version of the questionnaire was used. The questionnaire, originally written in English, was translated into Korean by bilingual speakers whose native language was Korean and whose background was IT-oriented. The questionnaire was then translated back into English by another bilingual speaker whose native language was English and whose background was also IT-oriented. The English versions were then compared, and no item was found to pertain to a specific cultural context in terms of language or to a specific IT-related context in terms of background translation.

The survey process consisted of four steps. First, the percentages of age groups and gender were set equal to those of the Internet users of the computer and Internet usage survey [19]. The segments of respondents in the database were set to these percentages. Then an invitation to fill out an online questionnaire was electronically mailed to registered opt-in-mail members of the partner of 'goo Research' of NTT Resonant Inc., Japan on March 19, 2007. Secondly, the respondents answered a pre-test questionnaire posted on the website during March 20-23, 2007. This pre-test was to screen online users who had purchased a product or service through Internet shopping and might intend to continue purchasing through it. Thirdly, if the percentage of pre-test respondents in each age group and gender was higher than the segments set in step 1, the system would randomly select the respondents from among each segment. The potential respondents, who were randomly selected, were sent the opt-in-mail with the invitation for the post-test questionnaire attached. Lastly, they answered the questionnaire during March 24-28, 2007. The percentages of target respondents were recorded until they reached the segments set in step 1. Hence, the system automatically stopped gathering the online questionnaire when the segments were completed. After completing all steps, 998 target responses had been completed and matched target respondent segments set in step 1. The respondents received a point as a reward if they completed the online questionnaire.

To replicate the distribution of online customers of Internet shopping in South Korea [20], sample weighting* was applied to assign a weighted variable to each response.

The weighted variable was based on the percentages of gender and age group [20]. Then each response in the dataset was weighted by their weighted variables. As a result, the distribution of the dataset became applicable to the distribution of online customers of Internet shopping in South Korea. Table 1 presents the respondents demographic data.

Table 1. Demographic data of respondents (*N* = 998)

Category		Percentage(%)
Gender	Male	54.1
	Female	45.9
Marital Status	Single	56.7
	Married	43.3
Age	15-19	27.3
	20-29	22.3
	30-39	23.9
	40-49	11.1
	50-59	8.6
	>=60	6.7
Annual income (1Mllion KRW= 1,078 USD)	≤2,156 USD	18.2
	2,157-5,390 USD	42.3
	5,391-8,624 USD	14.3
	≥8,625 USD	3.3
	Missing value	21.9
Education level	Secondary School	16.2
	High School	30.8
	Vocational School	0.3
	College	10.0
	Bachelor Degree	37.3
	Master Degree	4.3
	Doctoral Degree	1.1

4.2. Measures

The post-test questionnaire consisted of two sections. The first section was designed to gather demographic characteristics including age, gender, education level, personal monthly income, and Internet activities. In the second section, the measurement items were developed from previous studies on EC benefits for customers [26] and the literature discussed in Section 3. In addition, new measurement items were adapted from Hui et al.'s study [15]. The items were modified to fit the domain of Internet shopping when necessary. A 19-item scale measuring perceived benefits and one item measuring overall customers' continuance of purchasing behavior in Internet shopping were developed (see Appendix A). The scale items of perceived benefits were classified into two major

*Sample weighting is used to correct disproportional sample sizes and adjust the collected data to represent the population from which the sample was drawn [3]. During a period of data collection, the population of online customers [20] is the newest one that is suitable for doing sample weighting.

categories: extrinsic benefits and intrinsic benefits. The respondents were requested to evaluate the level of their agreement with each scale item on a five-point Likert scale ranging from (1) "strongly disagree" to (5) "strongly agree". Table 2 represents the descriptive statistics of all scale items. Each item's mean values ranged between 3.14 and 4.26, while the standard deviation values were between 0.70 and 1.05. The dependent variable representing the intention to continue purchasing through the Internet could be scaled by three items identified in [14].

4.3. Exploratory Factor Analysis

Before performing an exploratory factor analysis (EFA), one needs a strong conceptual foundation to support the assumption that a structure does exist [9]. Hence, it must be certain that the data matrix has sufficient correlations to justify the application of factor analysis. Kaiser's measure of sampling adequacy (MSA) was used to quantify the degree of intercorrelations among the variables and the appropriateness of factor analysis. The overall MSA was 0.90. In addition, all individual variables' MSAs ranged from 0.500 to 0.845. This clearly suggests that factor analysis can be used to extract research factors [9].

EFA was applied to the 19 benefit items by using the principle component extraction method and an oblimin with Kaiser Normalization rotation. The criteria used in this analysis are outlined as follows [9]:

1. Factors with eigenvalues or latent roots of all components should be greater than 1.0,
2. Communalities of all items should be more than 0.5;
3. The factor loadings of ± 0.50 or greater are considered necessary for practical significance; and
4. Cronbach's alpha values of each factor extracted and overall measure should be greater than 0.7.

The EFA extracted items into four factors that passed all criteria. To justify the extracted factors from the factor analysis, a reliability analysis was performed on items classified under each extracted factor as well as the overall scale. Only the alpha of the fourth factor was lower than 0.7. Consequently, these factors provide a reliable and consistent measure of the intended dimensions and no further elimination of items appears necessary. Table 3 shows the final factors with meaningful factor names, loadings, communality, Cronbach's alpha, eigenvalues, and percentage of trace. Factor 1 with six items, factor 2 with five items, factor 3 with six items, and factor 4 with two items were loaded. Each factor was subjectively named from the nature of the grouped items with significant loadings:

1. Factor 1 Intrinsic factor: *I*1, *I*2, and *I*3— Pleasure; *I*4 and *I*5—Novelty; *I*8—Fashion involvement. *I*6 and *I*7 were dropped from this factor because their factor loadings were less than the accepted level.
2. Factor 2 Extrinsic factor: *E*1, *E*2, and *E*4—Time saving. *E*3 was dropped from this factor because of its unaccepted factor loading.
3. Factor 3 Extrinsic factor: *E*7, *E*8, *E*9, and *E*10—Social adjustment and self-enhancement. *E*11 was dropped from this factor because of its unaccepted factor loading.
4. Factor 4 Extrinsic factor: *E*5 and *E*6—Money saving.

Table 2. Descriptive Statistics of Data (*N* = 998) (E1-Convenience; E2-Save time; E3- Shop/find information easier; E4- Shop/find information more quickly; E5- Save money; E6- Offer lower prices; E7- Interact with other customers in EC communities; E8-Interact with like-minded people; E9- Recommendation from like-minded people; E10-Exchange idea and compare experience; E11-To be recognized when purchasing again; I1-Enjoy using Internet shopping; I2-Be happy when using Internet shopping; I3-Be delighted with experience of Internet shopping; I4-Stimulate curiosity; I5-Provide customers with the product/supplemental information that they are interested in; I6- Offers options to perform task in different ways; I7- Opportunity to make oneself appear fashionable; I8-Boast of being the first one who possess a product)

Items	Mean	Std. Deviation
E1	4.26	0.70
E2	4.07	0.85
E3	3.77	0.75
E4	4.04	0.73
E5	3.68	0.88
E6	3.94	0.76
E7	3.49	0.83
E8	3.62	0.80
E9	3.65	0.76
E10	3.63	0.76
E11	3.43	0.81
I1	3.73	0.84
I2	3.36	0.76
I3	3.55	0.75
I4	3.36	0.85
I5	3.50	0.75
I6	3.33	0.76
I7	3.61	0.75
I8	3.14	1.05

Discriminant validity is the extent to which a factor is truly distinct from other factors. Indeed, Hair, *et al*. [9] suggested that average variance extracted can be used to evaluate discriminant validity. To demonstrate the discriminant validity of the constructs in this study, the square root of average variance extracted for each factor should be greater than the correlations between that factor and all other factors. Table 4 shows the correlation matrix

of the factors. The assessment of discriminant validity indicates that the square root of average variance extracted of all factors is greater than the correlations between that factor and all other factors.

Overall, these results provide empirical support for the reliability and convergent validity of the items of our research model.

Table 3. Component Matrix of Exploratory Factor Analysis (N = 998)

Items	Factor Loadings				Communality
	1	2	3	4	
E1: Convenience	0.169	0.718	0.027	-0.012	0.610
E2: Save time	0.064	0.781	-0.032	0.038	0.644
E3: Shop/find information easier	-0.037	0.435	0.195	0.283	0.424
E4: Shop/find information more quickly	0.033	0.662	0.074	0.109	0.537
E5: Save money	-0.143	0.221	-0.024	0.697	0.565
E6: Offer lower prices	0.009	0.229	0.092	0.549	0.470
E7: Interact with other customers in EC communities	-0.007	0.041	0.800	-0.040	0.638
E8: Interact with like-minded people	-0.086	0.149	0.761	-0.123	0.565
E9: Recommendation from like-minded people	0.000	0.094	0.747	-0.013	0.594
E10: Exchange idea and compare experience	0.132	-0.186	0.710	0.094	0.598
E11: To be recognized when purchasing again	0.201	-0.178	0.385	0.365	0.440
I1: Enjoy using Internet shopping	0.596	0.342	-0.003	-0.047	0.548
I2: Be happy when using Internet shopping	0.581	-0.016	-0.086	0.495	0.666
I3: Be delighted with experience of Internet shopping	0.551	0.010	-0.048	0.478	0.641
I4: Stimulate curiosity	0.690	0.145	0.102	-0.061	0.596
I5: Provide customers with the product /supplemental information that they are interested in	0.534	0.061	0.134	0.169	0.477
I6: Offers options to perform task in different ways	0.464	0.061	0.196	0.137	0.421
I7: Opportunity to make oneself appear fashionable	0.390	-0.072	0.376	0.092	0.435
I8: Boast of being the first one who possess a product	0.683	0.017	0.027	-0.276	0.462
					Total
Sum of squares (eigenvalues)	6.238	1.779	1.288	1.027	10.332
Percentage of trace	32.83	9.36	6.78	5.41	54.38
Cronbach's alpha (Overall = 0.880)	0.820	0.739	0.774	0.584	

Table 4. Correlation matrix of the factors

Factors	Intrinsic factor	Time Saving	Social adjustment & self-enhancement	Money Saving
Intrinsic factor	0.680			
Time Saving	0.251	0.692		
Social adjustment & self-enhancement	0.419	0.254	0.689	
Money Saving	0.257	0.267	0.261	0.648

Table 5. Results of Multiple Regression Analysis

	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
	B	Beta		
Intrinsic factor	0.351	0.353	13.416	0.000
Time Saving	0.259	0.258	10.330	0.000
Social adjustment & self-enhancement	0.050	0.050	1.906	0.057
Money Saving	0.312	0.304	12.144	0.000

5. Results of Multiple Regression Analysis

A multiple regression analysis was conducted to investigate the impact of perceived benefits on the intention to continue purchasing in Internet shopping. Table 5 shows the results of the multiple regression analysis for continuance of purchasing ($R2$ = 0.458). According to the beta coefficients, the factor that has the highest impact on the continuance of purchasing behavior is intrinsic factor ($\beta = 0.35$; $p < 0.01$), followed by money saving ($\beta = 0.30$; $p < 0.01$), and time saving ($\beta = 0.26$; $p < 0.01$). Social adjustment and self-enhancement ($\beta = 0.05$; $p > 0.05$) is statistically insignificant to the continuance of purchasing behavior in Internet shopping. As a result, the hypotheses H1, H2, H5, H6, and H7 were supported, and H3 and H4 were rejected.

The results showed that not only extrinsic benefits but also intrinsic benefits influenced the online customers' intention to continue shopping online. Surprisingly, intrinsic benefits have the most significant effect on intention to continue shopping online. Internet shopping impressed online customers by arousing their curiosity and offering enhanced shopping experiences. The Internet shopping website gives consumers a different shopping experience because the interaction between the merchant and the consumer is more engaging and enjoyable [5]. Although Koufaris *et al*. [18] argued that enjoyment in internet shopping seemingly does not influence repeat customers to return, our positive significance of the intrinsic factor confirmed that online customers have an intrinsically enjoyable experience on-line that makes them continue purchasing through the Internet. The seond most significant factor is extrinsic benefits in terms of saving money. Saving time is the least significant factor. Purchasing items through Internet shopping saved customers' time in shopping and finding information and saved them money, because online prices are lower than offline prices of the same products. This indicated that online customers intend to continue purchasing in Internet shopping because it can solve their problems i.e., lack of time and lack of finances. The results also suggest that offline customers may turn to purchasing through the Internet to solve these problems.

Extrinsic benefits in terms of social adjustment and self-enhancement are insignificantly related with the intention to continue purchasing through the Internet. This result suggested that it is unnecessary for online customers to interact and exchange ideas with other customers who have similar interests or attitudes when they purchased through the Internet. It seemed that support in purchasing the items recommended by like-minded customers did not make them purchase again through the Internet. In addition, giving an acknowledgement to online customers who come back to purchase again is unlikely to be a reason for them to do so. This may be because Internet shopping websites do not provide enough services promoting social adjustment and self-enhancement benefits to online customers. For example, although they want a recommendation from like-minded customers before making a purchase, this option is not always provided by Internet shopping websites.

It is interesting that online customers continued purchasing through the Internet because they were given opportunities to boast of being the first one who possessed the product. These perceptions were regarded as intrinsic benefits that are abstract and difficult to evaluate in terms of fashion involvement.

Figure 1 presents the research model and the results of multiple regression analysis.

6. Conclusion and Implications

This paper is one of the first studies to try to determine whether perceived benefits affect customers' intention to continue purchasing through the Internet. 998 samples collected from online customers in the EC market of South Korea were analyzed by using multiple regression analysis. The results confirm that not only extrinsic benefits (savings time and money) but also intrinsic benefits (pleasure, novelty, and fashion involvement) have significant positive effects on customers' intention to continue purchasing through the Internet. The findings show that people who consider both extrinsic and intrinsic benefits of online purchasing were more likely to purchase again in Internet shopping. Therefore, we call for technological development to provide techniques and services for ensuring online customer's benefits that minimize time and cost of purchasing, improve enjoyment and pleasantness of online purchasing, and provide means to help customers arouse their curiosity when coming back to purchase again through Internet shopping.

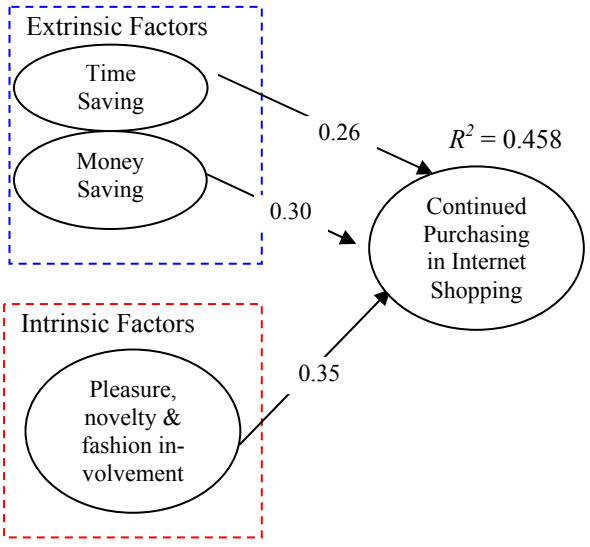

Figure 1. Research results

Our findings imply that the perceived intrinsic benefits in terms of pleasure and novelty are important for encouraging online customers to continue purchasing in Internet shopping. Thus, it seems that these benefits should be offered to online customers.

Customers found that they were delighted with their experience of Internet shopping and their interacting with Internet shopping stimulated their curiosity. Internet shopping websites need to satisfy customers' curiosity by, for example, offering several options of payment, enhancing interactive and attractive interface, offering promotions to customers, and displaying specific products or content to a certain type of customer.

Online customers would come back to purchase again if they got product or supplemental information. For online customers who want to get product instructions, the Internet shopping website should provide another webpage. For example, a cosmetics online shopping website could provide another webpage to instruct their customers on how to use and apply make-up.

7. Limitations and Directions for Future Research

Despite several significant findings, we acknowledge three limitations in our study. First, our study did not focus on any products, services, or Internet shopping websites. The empirical results for continuance intention may be biased or awry. For example, the respondents may have focused only on particular products/services or products that are not sold on the Internet. The perceived benefits factor influencing continuance intention in purchasing through Internet shopping for a particular product, service or Internet shopping website may be different from those we asserted in this study. We should be cautious in applying these results to an Internet shopping website selling a particular product and service. Second, the scope of this study is to focus on benefits in terms of extrinsic and intrinsic benefits. There may be other factors that affect the continuance intention such as payment modes and delivering time. Finally, the measures of perceived benefits developed in this study are the first step in exploring how customers' intention to continue purchasing in Internet shopping are influenced by their perceptions of benefits gained from purchasing through Internet shopping. The measurement of social adjustment, self-enhancement, and fashion involvement should be further refined.

Future researchers may pursue a number of different options. First, a longitudinal study may apply to study developmental trends across the life span of consumer perceptions and to observe the differences in their perceptions. The longitudinal study involves repeated studies and observations of the same items over long periods of time. Unlike cross-sectional data used in this study, longitudinal study can track the same people, and therefore the differences observed in those people are less likely to be the result of cultural differences across generations. Second, data mining technique may apply to both cross-sectional and longitudinal data in order to do customer profiling, to predict customer preferences, and to do trends analysis. Third, our model has been validated

by and well explains South Korean online customers' intention to continue purchasing through the Internet. To generalize this model, it should be validated with respondents from the bigger EC markets such as the USA and China. Moreover, a comparative study of the repurchasing intentions of online customers from different nationalities should be done on the basis of the same model. The differences regarding the customers' intention to continue purchasing in Internet shopping will yield insights that can help Internet shopping websites better retain customers in different world market segments.

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Appendix A

Extrinsic benefits:

E1* Using Internet shopping is convenient.
E2* Using Internet shopping saves me time.
E3 Using Internet shopping would make it easier for me to shop or find information.
E4* Using Internet shopping would enable me to shop or find information more quickly than using traditional stores.
E5* Using Internet shopping saves me money.
E6* Internet shopping offers lower prices than traditional stores for the same products.
E7* Internet shopping allows me to interact with other customers in EC communities.
E8* I should be given chances to interact with other like-minded people when I purchase through the Internet.
E9* Internet shopping recommends other things to purchase that other like-minded people appreciate.
E10* Internet shopping allows me to exchange ideas as well as compare experiences.
E11 Internet shopping recognizes me when I purchase through the Internet again.

Intrinsic benefits:

I1* I enjoy using Internet shopping.
I2* I am very happy to purchase products through Internet shopping.
I3* I am delighted with my experience of Internet shopping.
I4* Interacting with Internet shopping stimulates my curiosity.
I5* Internet shopping provides me with the products and supplemental information that I am interested in.
I6 When I purchase through the Internet, Internet shopping websites offer me options to perform tasks in different ways.
I7 When I purchase through the Internet, it gives me opportunities to make myself appear fashionable.
I8* I like to boast of being the first one who possesses a product.

* Scales remained in exploratory factor analysis.

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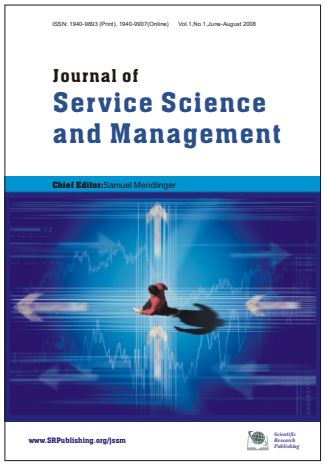

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