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# Effects of information delay on the apple sapling supply chain performance in Iran

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**Abstract:** Sapling supply chain management (SCM) is a major component of competitive strategy, with direct implications on organizational productivity and profitability. Beside, sapling supply chain (SC) delay is a critical factor in SC optimization. Of the several types of delay, this paper focuses on information delay, which depends on the flow of intangible assets. Firstly, determining the minimum delay in a SC is determined by linear programming is described. Then, SC performance is optimized by a genetic algorithm based on minimum of delay. Finally, a dynamic model of the interaction between delay and performance is developed. A case study is presented where this model was simulated and validated at apple sapling supply chain in the ministry of Agriculture (Iran) from 2011 to 2013.

**Key words:** *Sapling supply chain Management (SCM); Performance; Information delay; Genetic algorithm*

## 1. Introduction

Sapling supply chain management (SCM) is a major component of competitive strategy, with direct implications on organizational productivity and profitability (Beamon, 1999). Why some firms outperform others has long been a central question within the organizational literature (Bechtel et al., 2004). Recent years have seen an acceleration of interest in the analysis, management, and control of sapling supply chains (SCs). The success of any SCM system depends on its developer's and adopter's capabilities. These include capabilities in developing a flexible organization, building strong relationships with suppliers Achieving these capabilities requires innovative personnel Such a team will reduce delays in project implementation with their fast and appropriate decision making, and this will lead to optimization of the production chain. Companies define the effectiveness of SCM activities in terms of the emphasis placed on developing human resources and re-training of staff (Bowersox, 2000). This includes development in the following four skill areas: problem solving, leadership, group making, and job-related skill. All four skills determine staff capabilities and their development leads to a faster and more flexible SC with fewer delays. In addition, an effective SCM activity relies on team work and constant improvement, which can also reduce delays. We know little about the intangible aspects of why some SCs excel while others struggle (Brewer and Speh, 2000), although much attention is focused on understanding performance differences between firms. Given the role of a SC in attaining core competency, it is necessary to study the factors that determine SC performance. In current competitive environment, time is one such critical factor: corporations that can quickly respond to environmental changes have a higher probability of success.

In the literature of SC, we confront many issues. One of them is buffer management. In a SC, two types of transformations occur: physical transformation and information transformation. These transformations apply to both tangible and intangible assets, respectively. Consequently, we can also divide the buffer into two categories: intangible buffer and tangible buffer. Many researchers have studied the tangible buffer and the transformation of tangible assets in a SC (Chunhua et al., 2003). However, in this paper, the intangible buffer and scrutinize its effect on the productivity of a SC is addressed. Followed by a proposing a method for improving this productivity. To this end, the effects of delay on the intangible buffer and propose a method for optimizing this delay has been studied. Speed being a key determiner of competitiveness and organizational survival, we seek methods to optimize the response time through optimizing delay. The delay discussed in this paper is information delay. The delay divides into two categories: information delay and material delay. Here we propose a method for optimizing this delay and consequently improving SC performance. In this manner, optimizing the response time of a firm and improve their competitiveness would be possible. An enterprise must monitor how well it, its partners, and the entire SC are faring, since "you cannot manage what you cannot measure" (Davenport and Prusak, 2000). That is, to improve SC performance, one must first measure that performance. Therefore, we first present existing models for SC performance measurement. After selecting a suitable model, the

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effect of delay on SC performance must be securitized.

## 2. Sapling Supply Chain Performance Management

SCM is a technique developed for pure production systems and is also related to such systems (Hitt et al., 2004). For most organizations, developing a pure production system is a key element of SC activities and consists of searching for cases such as improving the delivery value to customers, increasing the reliance on on-time production systems, eliminating wastage, increasing the stakeholders' focus on process value, developing close collaboration with suppliers, reducing the number of suppliers, and increasing suppliers' efficiency (Hult et al., 2006).

They recommend the use of the balanced scorecard (BSC) as a framework for SC performance measurement. A BSC provides a structure to measure organizational performance from four perspectives: financial, customer, business process, and learning and growth. Metrics are developed for each of these perspectives and are combined to measure the SC performance (Hult et al., 2004). They utilized this idea to develop the time (day), quality (σ level), cost (US dollar), and flexibility (TQCF) model for measuring SC performance. They stated that C-type measures reflect the performance of the financial perspective, Q-type measures reflect the customer perspective, and the T- and F-types reflect the performance of the business process. However, due to its fuzziness, the learning and growth perspective is not reflected in this performance system (Khadivar et al., 2007). They stated that the four perspectives, TQCF, reflect different properties of an entity. From the time dimension, C reflects past performance, T and Q reflect current performance, while F reflects the adaptability to future change (Ketchen and Guinipero, 2004). The interactions between the elements of the model are shown in Fig. 1.

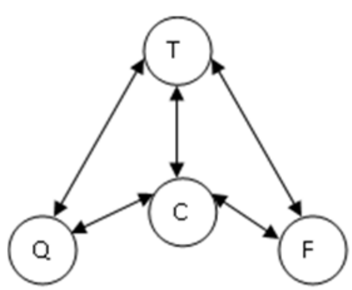


**Fig. 1:** Interaction between the elements of SC performance

There is a relationship network among the four parameters in which all affect each other. Thus, it is necessary to discover the relationship among the parameters and determine each one's effectiveness (Mabert and Venkataramanan, 1998). However, time, though in harmony with the other three, is more important. Delay, which is closely related to the time factor, is also an independent parameter by itself and a system as well. All these lead to the independent examination of delay. Hence, in this research, the parameter delay is added to the other four parameters in the model and implementation (Mikhailov and Singh, 2003). This analysis is evident in Fig. 2.

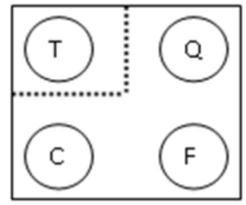


**Fig. 2:** Importance of time in model

## 3. Delay in Sapling Supply Chain Management

The essence of delay subjectivity is time. Time is a basic parameter of SC performance measurement. Though it may be initially assumed that time is the only parameter interacting with delay, this is not absolutely correct and we should consider other parameters affecting SC performance (Miller, 2001). Nevertheless, we optimize delay in terms of time: the purpose of this section is to increase the SC speed, improve performance, and decrease the total delay (Sink and Tuttle, 1984). Consider the process presented in Fig. 3.

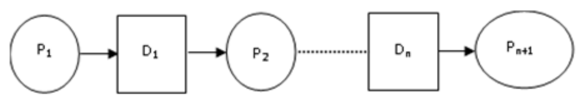


**Fig. 3:** Process framework in chain format

Fig. 3 shows delay in a SC including *n* interrelated and independent projects. In this chain, the delay among the projects is a buffer. In general these kinds of delays are information delay types. In other words, the current buffer in projects is in direct relation with the delay of the information type (Vorhies and Morgan, 2005).

Buffer creates delay in information flow, the nature of delay is not bad but it should be optimized. Is it necessary for information transfer from $P_1$ to $P_2$ with minimum delay? For example, suppose an operator must assess an instruction after completing $P_1$, a suitable motion path according to the type of letter, and finally put it in the correct path. Is the delay created by the operator in the transfer process undesirable?

No, delay is not absolutely undesirable because all of the activities performed by operators need minimum delay; therefore, the optimized delay may not be zero. For determining the optimized delay ($Di^*$), we should first define other factors affecting Di and analyse the dynamics among these factors. The buffer includes three elements (ok, watch & plan, act), and delay has the same three elements (ok, watch & plan, act) (Wernerfelt, 2005).

These three elements are defined as follows:

Ok: Necessary time for an activity acceptance; Watch & plan: necessary time for order understanding and planning of activity; Act: necessary time for plan implementation.

Di could be optimized in two ways: first, assume that Di is independent of its system and optimize it according to itself. Thus, we must analyse the Di elements and interactions that may exist among them. Second, Di can be optimized as part of a system and the focus is optimization of the total system (Wright et al., 2000).

As mentioned earlier, Di is calculated with formula 1 (it needs to sum of three elements, because of we want total delay):

$$D_i = D_{oi} + D_{wpi} + D_{ai} \quad (1)$$

The three types of delays mentioned above are as follows: $D_{oi}$ is needed when a person receives and confirms a reference topic. $D_{wpi}$ is required when a person watches and plans for the reference topic (Welden et al., 1991). And $D_{ai}$ is used when a person acts on the reference topic.

$D_{oi}$: delay of ok in iteration i ; $D_{wpi}$ delay of watch & plan in iteration i; $D_{ai}$: delay of act in iteration i.

At first, it is assumed that $D_j$ is a function of one variable—this variable is time. Then, we add other variables to this function to make it more acceptable. We then try to optimize Dj as shown in Formula 2 (Kobe and Coates, 1996).

MODEL:

$\min = D_{oi} + D_{wpi} + D_{ai}$;
$D_{oi} <= .78 * D_{wpi}$;
$D_{oi} + D_{wpi} - 0.83 * D_{ai} <= 0$;
$D_{oi} + D_{wpi} + D_{ai} <= 4.85$;
$D_{oi} > 0.29$;
$D_{oi} < 2.67$;
$D_{wpi} > 0.21$;
$D_{wpi} < 2.06$;
$D_{ai} > 0.16$;
$D_{ai} < 1.17$;
End

Therefore, we could calculate the total delay time as $D_j$ in Formula 2.

$$Dj = \min, Dt = \sum_{j=1}^{n} Dj = n * D_j \quad n: \text{number of projects } if\ j \in cp \quad (2)$$

By solving Formula 2, $D_i{}^*$ is defined. If a function of $D_i$ is not available, we can obtain $D_i^*$ using an AHP tool for ranking expert opinion on the weights and number of variables. Finally, $D_{oi}$, $D_{wpi}$, and $D_{ai}$, are calculated and $D_i^*$ is determined with Formula 1, and $D_t$ is determined with Formula 2. In the real world, the delay function cannot have just one variable; therefore, other parameters should be added on the basis of a literature review. From the literature, we find that four parameters affect delay time: these are time (t) quality (q), cost (c), and flexibility (f). Thus, delay time is a function of multiple variables. This is shown in Formula 3: $D_i = f(t, q, c, f, s)$. F and q are qualitative variables; therefore, it is necessary to use fuzzy logic for determining $D_t$.

There are several models for SC performance measurement; one is the TQCF model, which will be used here because it has four variables (t, q, c, f, s). Thus, $D_i$ depends on four variables; at first, it should be an optimum number of variables (t, q, c, f, s) and it should be validated by internal and external experts of the organization. Finally, a lower bound and upper bound should be set for all variables to define a feasibility region. Then, we should find the optimum Di in this feasibility region (Kohyama, 1980). This is explained in next section.

By obtaining the value for the minimum optimization delay using the LINGO software, attempts can be made for optimizing the SC function. LINGO is a comprehensive tool designed to make building and solving Linear, Nonlinear (convex & nonconvex/Global), and Quadratic, Quadratically Constrained, Second Order Cone, Stochastic, and Integer optimization models faster, easier and more efficient. LINGO provides a completely integrated package that includes a powerful language for expressing optimization models, a full featured environment for building and editing problems, and a set of fast built-in solvers. This is explained in the following section.

## 4. Optimization of Sc Performance Based on Delay

In the delay optimization process, several factors that influence the optimum delay are considered: time and then add other factors—quality, cost, and flexibility.

In management literature, two laws affect the optimization of activity process time. They prevented from an invaluable activity's expansion in process time and helped in corporation to have a better performance. As stated before, SC has a key role in determining the competitiveness of a firm; therefore, improving SC performance could help companies to achieve better overall performance. As mentioned earlier, in current literature, SC performance is measured in terms of four perspectives: time, quality, cost, and flexibility. If the function Di was expressed in terms of time, quality, cost, and flexibility, the problem is similar to goal programming. Thus, the goal of the problem is optimizing the SC performance subject to given constraints. The problem can be stated as below:

P(0) = output of sc/input of sc
Formula 3

**MODEL:**
MAX = $realoutput_i$ / $realinput_i$;
ti =8;
ti = processti + Deliveryti;
processti = realprocessti +d0i;
Deliveryti =realDeliverytti +d1i;
incomei = realincomei + delayincomei;

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realincomei = realci;
ci = realci + delayci;
realci =10 * 1.30 * ti / realprocessti;
delayci =10 * 1.12* 1.30 * (8-(ti / realprocessti ));
Revenue = incomei - ci;
delayincomei = 0125 * delayci + 1.341;
d0i >0.1;
d1i >0.1;
Di = d0i + d1i;
realoutputi = realincomei + delayincomei;
realinputi = realci + delayci;
End
```

In the above equation, a fuzzy range (1 = very low, 3 = low, 5 = medium, 7 = high, and 9 = very high) is used in setting the upper and lower bounds for the quality, cost, flexibility, and time parameters. To specify these bounds, a survey was conducted among senior managers and experts. Of course, quantitative parameters like cost, value, profit, and time are transformed into fuzzy numbers.

Di * was obtained by solving this problem. If for any reason, the function of Di cannot be expressed for obtaining Di*, we have to determine the limitations of the constraints and then utilize expert opinion to determine Di*.

Delay of time is more important than other parameters; therefore, this is introduced in the next section. Herein, for optimizing Di systemically, we have to consider T, Q, C, and F. By setting acceptable limits for each variable, the feasible region of solution is defined (Lei and Lechowicz, 1990).

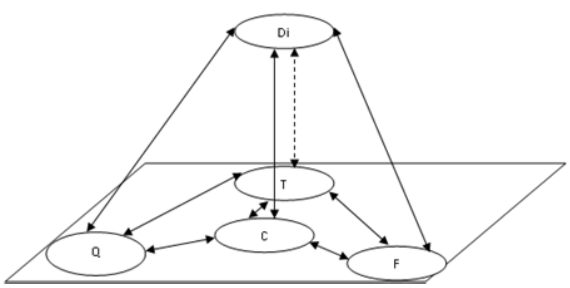


**Fig. 4:** Relation between delay and elements of SC performance

A performance variable is added to the problem and Di must be optimized to maximize it. Therefore, the closer to optimum that Di is, the better is the performance. When system runs with these delays, a problem may occur.

## 5. Research methodology

It was decided to adopt a case study approach for this paper as there is little existing research on optimization of SC based on information delay. It has been based on the descriptive Research. This descriptive research type has been carried out using the questionnaire as the research tool for gathering the required data. Data gathering involved both reference material and a questionnaire survey. Sampling was simple random sampling and the data gathering instrument was the questionnaire. In July 2011 a request for interviews and questionnaires was sent to a number of the managers (30 persons, 40% Male and 60% Female, 65% over 15 years' experience) and staff (70 persons, 35% Male and 65% Female, 65% over 20 years' experience) in the ministry of Agriculture (Iran) from 2011 to 2013. Prior to the interview and fill the questionnaire, the author explained the purpose of the research and made it clear that this information would be in the public domain, so any confidentiality concerns could be noted. The interview and questionnaire, from December 2011 to October 2013, lasted five hours per week. The interview and questionnaire was semi-structured in nature, starting off with general questions on the company background and sc optimization to put the respondent at ease. Detailed questions based on the sc and related frameworks were then used to gather information, with other questions included so as not to limit the information collected. Care was taken not to produce expected answers and flexibility was allowed in the process which enabled an effective two-way dialogue to emerge. To ensure internal validity the interview and questionnaire was transcribed and sent to and staff in the ministry of Agriculture (Iran). of Isfahan for confirmation of accuracy and to check that no commercially sensitive information had been included. Generalizability of the research has been based on Partial generalizations, it is possible to similar populations the knowledge generated by qualitative research is significant in its own right. The goal of a study has been focused on a selected contemporary phenomenon such as sc optimization based on delay. Cronbach's alpha was used in determining the questionnaire's reliability and validity. Data analysis was also performed through both descriptive and inferential statistics.

## 6. Research Algorithm

The research algorithm is presented in Fig. 5.

According to the above, a SC is first selected and then divided to independent projects. After that, the triple delay factors (i.e, $D_{oi}$, $D_{wpi}$, and $D_{ai}$) between projects are measured from the beginning to the end of the SC. Then value for the optimum delay is obtained through Formula 2. Moreafter, based on Formula 3, the primary function based on the maximizing function is determined. The results of primary delay optimization and function are entered into the genetic algorithm (GA) based on the presented specifications and codes written in MATLAB. Then the optimum delay and optimum function are obtained. The results were then revised based on the expert opinion and by repeating the algorithm.

## 6. Genetic Algorithm

According to the first reply obtained in implementation algorithm, a suitable algorithm can be presented for finding the effective optimum search. The model's steps are as follows

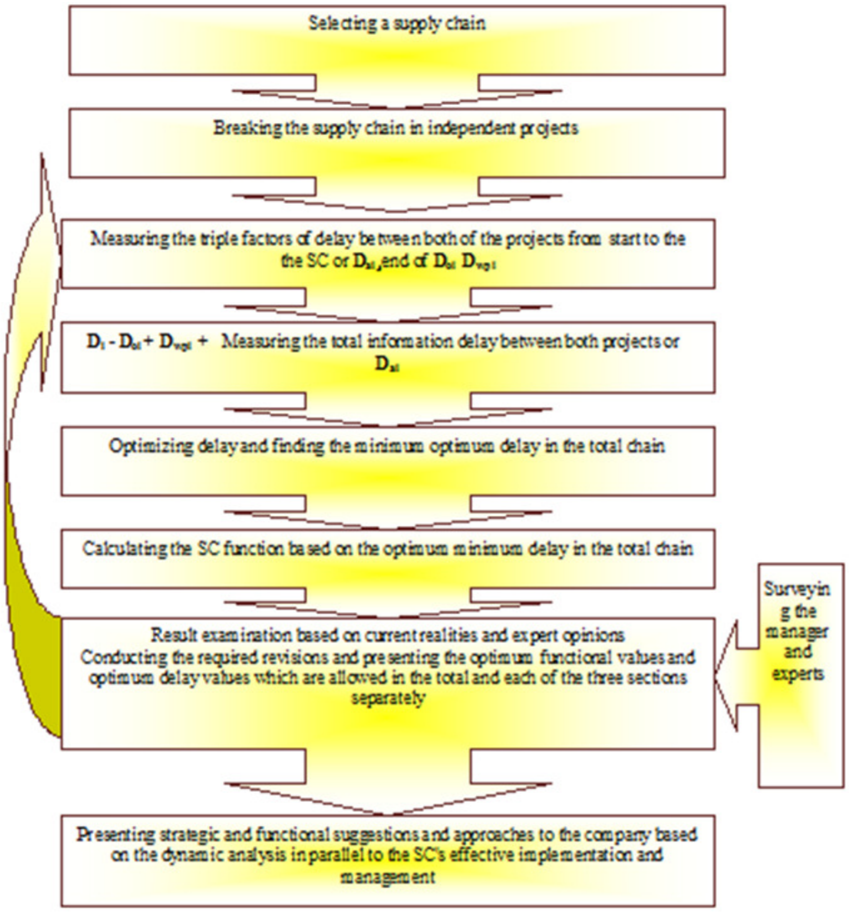


**Fig. 5:** Research Algorithm

1) Parameter determining

N=population
Pc=combination ratio
G=Repetition number
T=forbidden ratio length
N=number of replies of forbidden neighborhoods
G=forbidden repetitions

2) Primary population generation. The population is generated randomly and includes N separate individuals. The population is a collection of basic replies.
3) Calculating the separate correspond ability and correspondence likelihood
4) Comparison with the final conditions. If the answer is acceptable, the iteration will continue
5) Selection (regenerating). Selecting the separates to join the next generation based on selection likelihood.
6) Joining (combination). Selecting pairs of members based on combination likelihood and random selection of n number and finally, changing the pairs' coding chromosomes in equal places
7) Skip. Selecting the separates for random changes in their situations in each chromosome based on skip likelihood
8) Forbidden search. At first, calculate N separates separately by TS (equal separates at the calculated time). Then, the local optimum search increases in separate neighbourhoods, as the result of which is the population is optimized with several searchers. The basic answers in localized neighbourhoods are generated by skipping in the previous step.

**Key Parameters and operators are as bellow**

**Coding**

This model is implemented with the coding concept of paired-chromosomes and Characteristic qualifications (double-stranded DNA) to be possible, credited, and determined in the coding and decoding.

**Selection**

Based on correspondence likelihood, the separates in the population are selected by a roulette wheel selection operator to join in following generation. Moreover, separates better adapted to their environment have higher chances for offspring production. Thus, they leave better characteristics. Additionally, in this model, the strategy of genius separate maintenance has been used. Therefore, only separates with high correspondence can be joined with next generations.

**Joining**

The partially mapping combination method is used in this paper. First, the dual points are determined randomly. Then, crossed pairs change among the points. The genes external to the determined points are left at the main situations if they do not have any crossings with the changed pieces. Otherwise, they will be adjusted by PMX. Then, allowed acceptable separates with determined operators will be selected. If the genius pair take part in the combination and are better than the offspring, the pair will be maintained in the next generation.

**Skip**

Considering the programming characteristics of knowledge workers, the operation (INS) insert skip is done. Random points are selected and entered in the different routes. If cross answers occur, the operation is repeated until the acceptable response is found.

**Forbidden search operator**

Different search operators are applied for N separates in the population. (Equal separates in forbidden search operator are used only once.) Therefore, this method can increase the likelihood of optimum search in the neighbourhood, as a result of which the population optimization will increase.

The optional responses are usually selected in the current neighborhoods because, if there are many options, it can increase the calculation and counting. In contrast, few options can lead to unexpected convergence, although many calculations are required for general optimum searches. To decrease calculation time, it is absolutely necessary to control the optional responses in the neighborhood of each separate and also to control the number of previous repetitions.

**Search end criterion**

The search will end in two situations: reaching the number of previous generation and the optimum does not change after a certain number of steps.

## 7. Results and discussions

It was selected apple sapling supply chain in the ministry of Agriculture (Iran) from 2011 to 2013.

At first, based on the research algorithm, the delay minimizing function was implemented in LINDO software and the optimum results were obtained:

$Dj = 1.459138$

$D_t=10*1.459138=14.59138$

Based on information from the sales section, the primary function was obtained corresponding to Formula 3:

$P_0=253/458 =55.20\ \%$

Using the maximizing function, the primary optimum delay and function were obtained as following:

$P= 110.6198\%$

$D_i =0.2$

Based on the GA and presented specifications in the methodology section, the final optimized function and delay were calculated as follows:

$P=86.73\ \%$

$D_i =1.01$

The results were presented to experts, who confirmed 97.28% of the results. Additionally, they recommended the following to improve the SC productivity:

- Holding effective vocational training
- Increasing worker responsibility

This research helps to capture better information about what strategies and approaches are used to help information delay manage on the apple sapling supply chain performance in Iran. Concerns about the sustainability of the apple sapling supply chain strategies deserve continued scrutiny. Short-term responses to particular needs or crises may turn into long-term practices and, as a result, create new sets of problems. Strategies need to be vigilant about monitoring for unintended consequences related to the supply chains including information delay to accomplish core business goals. Strategies have certainly benefited from accessing needed skills through contingent employment, affording them an opportunity to avoid investments in human capital. But shifting the responsibility for human capital investment to supply chain management may not serve the longer term needs of employers or the market in general. Finally, managers should play a more active role in creating cultural environments that will optimize the benefits of flexible these strategies. Systematic research on examining causal relationships between the cultural environment and agricultural outcomes would be helpful.

The current study provides insights on how information delay manages on the apple sapling supply chains, whose tasks are inherently knowledge based. It also demonstrates that the alignment between structure, culture and HRM can be important in explaining how on the apple sapling supply chain strategies perform.

This method was validated using Cronbach's alpha (with a value above 98.3%), and its validation was confirmed scientifically and by experts (97%), managers, and company directors (98%). In this research, 40 people were directly involved. The findings at this organization indicate that SC performance is at a low level and delay is at a high level.

In parallel with the GA, the final optimum performance and delay were obtained and the algorithm continued until being confirmed by experts. The values of $R^2$ (96.49) and Cronbach's alpha (98.3) indicate the model validity. Additionally, the experts were asked about the Delphi method and 97.28% confirmed the above-mentioned values. Comparing the current situation with the optimum situation, we see that the company is behind schedule in reaching the goal of optimization by 31.53% in functionality and .44 in delay. To reach these values, strategies such as effective vocational training, increasing responsibility, creating a suitable atmosphere and healthy spaces, vocational training, and bonus awards were stated. It is worth mentioning that the questionnaire's reliability level was measured using content validation mainly based on the survey. The result showed 97.784% questionnaire validity. Cronbach Alpha was calculated to be 98.3%. These results indicate the practical reliability and validity of the proposed algorithm.

## 8. Conclusion

In this paper, the effect of delay on SC performance has been examined and then the factors that must be considered in determining the optimum delay: time (T), quality (Q), flexibility (F), and cost (C) has been identified. Using these factors, we determined the optimum delay by two methods. If the delay function could be built from the terms T, Q, Cm and F, then goal programming is sufficient to obtain the optimum delay; otherwise, we obtain the optimum delay from expert opinion.

The list of factors considered in this paper may not be complete, and the inclusion of other factors may afford a better solution. We assumed that the information buffer is independent from other buffers. However, it would be interesting to consider the interactions that may exist between the information buffer and the other elements in SC and determine the effects of this on the optimum delay.

This model has a systematic fit with the defined procedures and known inputs. The criteria and sub-criteria, which have been used as a basis to evaluate projects in this model, were extracted from the balanced scorecard that has high integration and high interaction with the decision maker. Since the weights of criteria and sub-criteria are calculated from the experts' opinions, the weights obtained are more realistic and are more acceptable to decision makers. In addition, since these weights are not fixed and may vary from one organization to another organization, the calculation method is of higher validity.

Although the proposed methods were implemented at an organization and the results were validating by top managers and experts. The future extension of this research can be conducted to improve SC performance and delay with developing of neural networks models. Also other methods can be fuzzy multi-criteria decision: fuzzy ELECTRE combined with fuzzy ANP and fuzzy TOPSIS methods used to weighting and ranking of factors of model.

## 9. Competing Interests

Authors have declared that no competing interests exist.

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