Cost-benefit sharing in healthcare supply chain collaboration

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Abstract: This paper proposes a framework for the cost-benefit sharing in healthcare supply chain collaborations. Collaboration in a supply chain can lead to cost reductions, risk management and performance improvements. The key to a successful collaboration is that the costs and benefits are shared by all, in that the costs are taken from the entire system and mutual benefits are provided for all parties. Our literature review and interviews with experts investigated the following three processes. Firstly, the cost and benefit parameters are defined as coordinate costs and benefits by a cost-benefit analysis. Secondly, the cost-benefit sharing characteristics are classified as two-echelon, three-echelon, and multi-echelon. Thirdly, the collaboration levels are categorised into four levels: data sharing, information sharing, knowledge sharing and cost-benefit sharing. Consequently, the cost-benefit sharing scenarios are presented.

Keywords: cost-benefit sharing; CBS; healthcare supply chain; collaboration; logistics systems.

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1 Introduction

Supply chain management (SCM) involves integration, coordination and collaboration across organisations and throughout the supply chains (Stock et al., 1998). Specifically, the characteristics and complexities of SCM in the healthcare industry are different compared to those of other industries. SCM in the health care industry consists of four main components: producers, purchasers, providers (hospitals) and patients (Smith et al., 2012). Improving the supply chain processes has not been a major priority in the healthcare industry. Improvements in new technologies have focused on providing the highest possible service levels and reductions in costs (Smith, 2011a). With greater margin pressures and declining revenues in the healthcare industry, stakeholders are seeking new and effective ways to gain greater visibility for their operations, in order to lower costs and improve patient care service (Smith, 2011b). Supply chain performance

can be improved by linking the supply chain strategy to all the other business strategies, including segmentation, agility, measurement, and benchmarking, alignment, and collaboration (Ebel et al., 2012). In addition, cooperation and integration activities within an organisation and collaboration with external partners can lead to significant cost savings, such as in e-procurement, collaborative planning, replenishments and forecasting (Langabeer, 2005).

The fragmentation in the healthcare supply chain and the lack of dominant players to drive favourable changes in industry practices, investment in new technology, and changing established processes are all promising areas for collaborative efforts (MIT center for Transportation and Logistics, 2006; Everard, 2001). Supply chain collaboration systems can enhance cost reductions, risk management, and performance improvements in the supply chain (Farney, 2003). Collaboration can help by taking the costs out of the entire system and providing mutual benefits for all the involved parties. However, collaboration in the healthcare supply chain lags behind because of high investment and difficulties in assessing the benefits of its implementation for the supply chain members (Smith, 2011b). Therefore, it is important to share both costs and benefits based on a fair allocation, namely 'win-win' situation, to all the supply chain members for collaboration successful (Carey, 2010; Cruijssen et al., 2007).

Previously, the cost-benefit sharing (CBS) process was developed to evaluate benefits and costs, then distribute the costs and share the benefits (Hirthammer and Riha, 2005). A case study of the CBS process in the automotive supply chain was used as a reference (Riha and Radermacher, 2009). The CBS of radio frequency identification (RFID) implementation in across-company was presented using a case study from the fashion industry (Bensel et al., 2008). In addition, a Cost-Benefit Analysis (CBA) for implemented global standard system had been investigated in global and individual healthcare supply chain. The expected investments and potential benefits were analysed. The healthcare value chain system could achieve a positive return on investment from adopting global standards and enabling business processes. The benefits could be shared across the value chain. Nevertheless, CBS was suggested for successful collaboration in healthcare supply chain but details were not provided (Ebel et al., 2012). In 2013, the impact of customer-managed inventory (CMI) implementation in hospitals had been studied and to investigate the benefits of CMI implementation among hospitals and vendors to convince vendors to collaborate (Matopoulos and Michailidou, 2013). To our knowledge, no empirical research exists which investigates CBS in the context of healthcare supply chain collaboration.

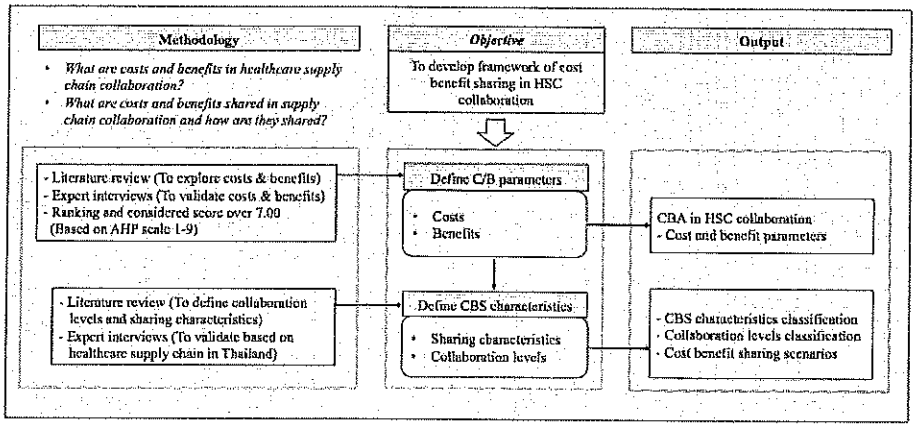
In our view, it is important to investigate CBS for collaboration in the context of healthcare supply chain. Our paper makes a valuable contribution to the existing literature as this study presents a framework that provides a global perspective of the CBS in supply chain collaborations in the healthcare industry. CBS is a viable approach for a successful collaboration (Ebel et al., 2012; Carey, 2010; Cruijssen et al., 2007; Hirthammer and Riha, 2005). The cost-benefit parameters are explored by CBA of a collaborative supply chain, which was adopted from previous studies (Ebel et al., 2012; MaLaren et al., 2002). The costs and benefits in the healthcare supply chain are categorised as 'co-costs' and 'co-benefits' and validated by the analytical hierarchy process (AHP). The sharing characteristics are classified as three types to share the cost-benefits of a collaborative healthcare supply chain. The collaboration levels of healthcare supply chain are summarised as four levels. The structure of the paper is discussed below. Section 2 presents the methods for undertaking this research, while the

results of our study are reported in Section 3. Section 4 discusses the implications of the results for cost benefit sharing in healthcare supply chains and the conclusions are stated in Section 5.

2 Methodology

The research methodologies used included a literature review and interviews with 15 experts in the healthcare supply chains in Thailand. The expert interviews were conducted by collecting a group of experts from each stage of the healthcare supply chain; manufacturing (five experts), distribution (five experts), and hospital/healthcare (five experts). The pre-conditions in selecting these experts were that they had at least five years experience in SCM and information technology and that they held the position of either a supply chain manager or an information technology manager. The research framework of the CBS in healthcare supply chain collaborations is shown in Figure 1.

Figure 1 The research framework of CBS in healthcare supply chain collaboration



2.1 First objective: exploring the costs and benefits

The literature review provided the CBA of the implementation of global standard system in either the global or in individual healthcare supply chains. The benefits could be shared across the value chain, given sufficient adoption and standardisation. A CBS approach was suggested but was not described in detail, however the cost-benefit elements of the global standard's implementation were presented (Ebel et al., 2012).

The advantages of supply chain collaborations include process efficiencies, flexibility, business synergy, quality and innovation (Cao and Zhang, 2010). The benefits to the specific supply chain's activities of collaboration were related to procurement, inventory management, product design and new product development, manufacturing and planning, order processing, transportation and distribution, sales, demand management, and customer service (Matopoulos et al., 2007).

The cost and benefit parameters are classified as the cost function and the benefit function. The cost function includes development costs, system implementation costs,

process coordination costs, and data translation costs. The benefit function consists of supply chain cost reductions and improved responsiveness to the market. The development costs include the costs of the host computer, the network equipment, middleware, and applications (Ebel et al., 2012; MaLaren et al., 2002; Matopoulos et al., 2007). The system implementation costs include maintenance costs and administration costs (Ebel et al., 2012; MaLaren et al., 2002). The process coordination cost is the cost of the installation, training, and business process reengineering (MaLaren et al., 2002; Cao and Zhang, 2010). The data translation cost is the cost function that varies with the amount of information flow (Matopoulos and Michailidou, 2013). The benefit function of the supply chain's cost reduction is the reduction in the cycle time, data cleaning, stock holding, obsolescence, product recall, and counterfeit products (Ebel et al., 2012; MaLaren et al., 2002). The benefit of the new responsiveness to the market is the gains in service levels and market intelligence (MaLaren et al., 2002). The cost and benefit parameters in healthcare supply chain collaborations were adapted from previous studies as shown in Table 1.

Table 1 Cost-benefit sharing parameters

Cost function	*Cost parameters*
Development cost	Host computer
• Hardware cost	Network equipment
• Software cost	Middleware
	Applications
System implementation cost	Maintenance cost
	Administration cost
Process coordination cost	Installation cost
	Training cost
	Business process reengineering cost
	Transaction cost
Data translation cost	Data translation cost
Benefit function	*Benefit parameters*
Supply chain cost reduction	Reduced cycle time
• Process cost reduction	Reduced data cleaning
• Inventory cost reduction	Reduced stock holdings
• Product cost reduction	Reduced obsolescence
	Reduced recall product
	Reduced counterfeit product
Responsiveness to market	Service level gains
	Market intelligence gain

The cost and benefit parameters were explored for the CBA in healthcare supply chain collaborations. In this paper, costs and benefits were defined as coordinate costs/benefits (co-cost/co-benefit) and individual costs/benefits (in-cost/in-benefit) by the CBA. Coordinate costs were defined as those that could be shared, or were a mutual investment between the supply chain's players. Coordinate benefits were defined as those that could

be shared, or were a mutual gain between the supply chain's players in the collaboration. These were confirmed and validated by the experts' interviews. In order to select the most important cost and benefit for sharing, only the costs and benefits that could possibly be shared in a supply chain, with an average score above seven (based on an AHP scale of 1–9) (Tahriri et al., 2008) were accepted. Then, they were calculated priority weight provided by the AHP analysis that is shown in Section 3.

2.2 Second objective: exploring the cost-benefit sharing characteristics

Based on the literature review, the cost or benefit sharing characteristics in supply chain collaborations have three distinct characteristics: a two-echelon sharing, three-echelon sharing and a multi-echelon sharing. The cost or benefit sharing in a two-echelon sharing has had widespread use in game-theoretic models. It was formulated for a lead-time reduction between a manufacturer and a retailer by employing a pareto-optimal Nash and Stackelberg equilibrium with a simple profit-sharing contract, which was developed to maximise the system-wide profit (Leng and Parlar, 2009). Moreover, the two-echelon supply chain sharing was modelled for collaborative knowledge creation as a Stackelberg leader-follower game, to maintain an optimal ratio between the leader's and the follower's marginal gains for the formation and continuation of the collaboration (Samaddar and Kadiyala, 2006). Furthermore, a two-echelon supply chain between the supplier and retailer was proposed as a centralised model to minimise local effects and the chain's cost based on the permissible delay in payments. A profit-sharing scenario for the distribution of generated net savings among the players in the supply chain was presented (Jaber and Osman, 2006). The two-echelon supply chain was considered to share information costs under a 'win-win' situation for the whole supply chain. A three-stage game-theoretic framework was used to decide the private cost information of the retailer for the supplier, the supplier announced the wholesale price to the retailers, and the retailers optimised their own retail prices and the values added to the product, respectively (Yao et al., 2008). The manufacturer-retailer channel had been investigated as a contract of royalty payments that were sufficient for the channel's coordination. The cost and revenue sharing via a revenue sharing rate and marketing effort participation rate on both the manufacturer's and the retailer's echelons found out the efficiency requirements of the retailer's participation, and of the manufacturer's cost of his/her marketing efforts (Kunter, 2012). Moreover, the benefit sharing model for the supplier and manufacturer was developed from a stochastic benefit sharing rule (Pibernik et al., 2011).

The cost or benefit sharing in the three-echelon and multi-echelon sharing had been investigated as shown in some of the literature. The benefit sharing gained by the manufacturer and multi-retailer collaborating was conducted using the optimisation methods to minimise inventory costs (Yang et al., 2013). A cost sharing ratio for each supply chain member was proposed to calculate cost distributions, based on the benefits of an automated data collection system, such as RFID. A simulation-based was a decision-support tool to model the current manual and automated phases (Demiralp et al., 2012). In a multi-echelon policy coordination, the inventory management part of the supply chain coordination had been studied based on integrated enterprise resource planning (ERP). The results from this were used in enterprise software to measure the potential monetary value of the policy coordination, to promote cooperation, and to

minimise the total supply chain system costs. The quantitative tools were combined with organisational and management factors (Kelle and Akbulut, 2005). The profit sharing for the supply chain's participants (multi-echelon, a cooperative game theory and a linear production game (LPG) had been used to investigate a fair profit allocation (Hennet and Mahjoub, 2010).

The supply chain's players include the supplier (S), manufacturer (M), distributor (D) and customer (C). The sharing characteristics in healthcare supply chain collaborations can be classified into 11 patterns based on the literature review as shown in the above paragraph. The six patterns of sharing between two-echelons consist of S-M, S-D, S-C, M-D, M-C, D-C (Leng and Parlar, 2009; Samaddar and Kadiyala, 2006; Jaber and Osman 2006; Kunter, 2012; Pibernik et al., 2011). The four patterns of sharing between the three echelons are S-M-D, S-M-C, S-D-C, M-D-C (Yao, et al., 2008; Yang et al., 2013). The pattern for the multi echelon is S-M-D-C (Demiralp et al., 2012; Kelle and Akbulut, 2005; Hennet and Mahjoub, 2010). The sharing characteristics can be adapted as shown in Table 2.

Table 2 Cost benefit sharing characteristics

	Sharing characteristics										
Cost/benefit	S M	S D	S C	M D	M C	D C	S M D	S M C	S D C	M D C	S M D C
Co-cost	√	×	×	√	×	√	√	×	×	√	√
Co-benefit	√	×	×	√	×	√	√	×	×	√	√

Notes: S = supplier; M = manufacturer; D = distributor/retailer; C = customer.
General supply chain: supplier → manufacturer → distributor → customer; HSC: manufacturer → distributor → hospital → patient/payer.

The CBS in healthcare supply chain collaborations by a co-cost and co-benefit has not been investigated. The sharing characteristics in a general supply chain are different from those in healthcare supply chain collaborations (Smith et al., 2012). Therefore, the CBS should be explored to classify the sharing characteristics.

The CBS characteristics were explored in the literature review as shown above and through the expert interviews based on the co-costs and co-benefits. The sharing characteristics can be classified as two-echelon sharing (S-M, S-D, S-C, M-D, M-C, D-C), three-echelon sharing (S-M-D, S-M-C, S-D-C, M-D-C) and multi-echelon sharing (S-M-D-C).

2.3 Third objective: exploring the collaboration level

Supply chain collaboration focuses on joint planning, coordination, and process integration between suppliers, customers, and other partners in the supply chain (MaLaren et al., 2002). In addition, the cooperation and integration activities within an organisation, in collaboration with external partners in the healthcare supply chain, could

lead to significant cost savings. The ability to efficiently manage business processes with vendors or key suppliers such as e-procurement, collaborative planning, replenishment, and forecasting is a characteristic of more mature supply chains (Langabeer, 2005). Supply chain collaborations have been defined as any kind of joint, coordinated effort between two parties in a supply chain to achieve a common goal (MaLaren et al., 2002). Different terms such as co-ordination, cooperation, collaboration and integration are considered to have similar meaning in a supply chain (Arshinder and Deshmukh, 2008). However, supply chain collaborations are considered to be a sequence of business initiatives carried out by like-minded collaborating partners and are divided into four levels (Kampstra et al., 2006).

Level 1 'Communication' – the goal of the partners is to achieve an improvement in productivity and the sharing of information through simple IT applications.

Level 2 'Coordination' – this involves the intra and inter entity coordination of processes to synchronise flows and routine decision making processes.

Level 3 'Intensive collaboration' – the collaborative members improve the strategic decision-making and enhance the innovations in the supply chain.

Level 4 'Partnerships' – the financial linkages are extended into such things as the sharing of investments and also profits.

The collaboration levels in healthcare supply chains were categorised for their CBS upon the co-cost and co-benefit and their different sharing characteristics. This process was validated to classify the healthcare collaboration levels by our interviews with the experts.

3 Results

On the basis of the methods used for each outcome, the results relative to each point of the analysis (parameters, features, levels and scenarios) of the case study are discussed below.

3.1 Cost-benefit analysis in HSC collaboration

The CBA was defined as the coordinate cost and coordinate benefit (co-cost/co-benefit) and individual cost/benefit (in-cost/in-benefit) as shown in Figure 2.

Interviews were conducted with four experts of the healthcare supply chain in Thailand; two supply chain managers and two information technology managers (E1, E2, E3 and E4) were interviewed to evaluate the priority weight of costs and benefits that can be shared in the supply chain as shown in Table 3. This process was carried out for up-grading the decision-making accuracy in the AHP analysis. In order to select the most important cost-benefit for sharing (co-cost/co-benefit), with average score above seven, the selected co-cost and co-benefit as well as priority weights by AHP analysis were shown in Table 4.

According to the selected cost-benefit, the 15 experts were interviewed to evaluate priority weight and obtain the pair-wise judgments of costs and benefits. Then, AHP

analysis was conducted by MS Excel to determine the priority weight of each co-cost and co-benefit. The consistency ratio (CR) was used to justify the inconsistency in the pair-wise comparison from the respondents; C.R. ≤ 0.10 is acceptable (Saaty, 1980).

Figure 2 CBA in healthcare supply chain collaboration

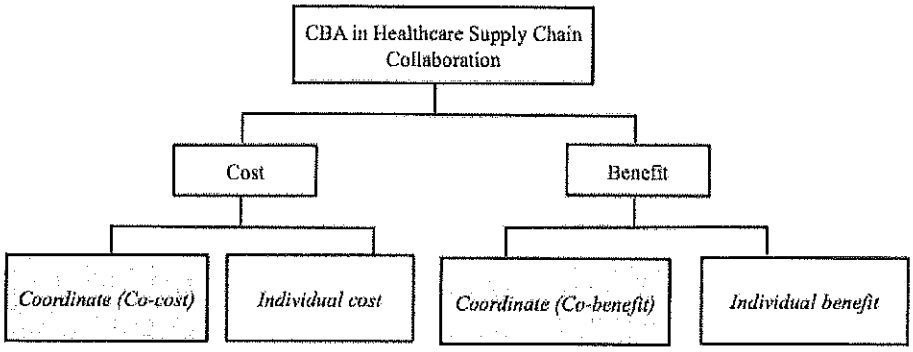


Table 3 Cost and benefit parameters (preliminary for AHP)

Cost function	*Cost parameters*	*E1*	*E2*	*E3*	*E4*	*Average*
Development cost	Host computer	8	9	8	8	*8.25*
• Hardware cost	Network equipment	8	9	8	7	*8.00*
• Software cost	Middleware	9	9	9	9	*9.00*
	Applications	8	7	8	7	*7.50*
System implementation cost	Maintenance cost	1	2	1	3	1.75
	Administration cost	1	2	1	1	1.25
Process coordination cost	Installation cost	6	5	7	4	5.50
	Training cost	6	4	5	5	5.00
	Business process reengineering cost	1	3	2	1	1.75
	Transaction cost	1	1	1	1	1.00
Data translation cost	Data translation cost	1	1	1	1	1.00
Benefit function	*Benefit parameters*					
Supply chain cost reduction	Reduced cycle time	9	8	8	9	*8.50*
	Reduced data cleaning	1	2	1	1	1.25
• Process cost reduction	Reduced stock holdings	8	9	9	9	*8.75*
• Inventory cost reduction	Reduced obsolescence	8	9	9	9	*8.75*
• Product cost reduction	Reduced recall product	8	9	8	7	*8.00*
	Reduced counterfeit product	9	8	8	7	*8.00*
Responsiveness to market	Service level gains	1	2	1	1	1.25
	Market intelligence gain	1	1	1	1	1.00

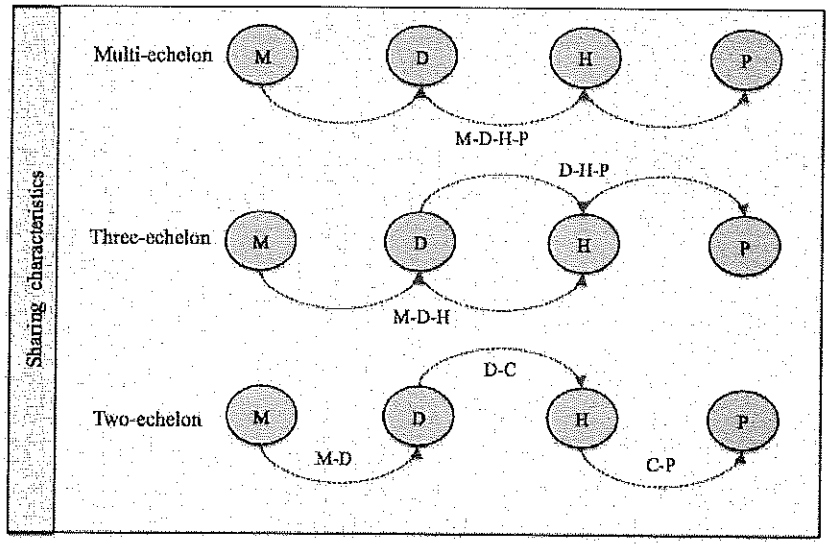
Table 4 AHP results: priority weight of selected co-costs and co-benefits

Co-cost/co-benefit	*Priority weight*	*Rank*	*C.R.*
Hardware cost			
Host computer	0.121	4	
Network equipment	0.119	6	
Software cost			
Middleware	0.143	1	
Applications	0.080	8	0.08
Reduced cycle time	0.120	5	
Reduced stock holdings	0.123	3	
Reduced obsolescence	0.115	7	
Reduced recall product	0.052	9	
Reduced counterfeit product	0.127	2	

3.2 Cost-benefit sharing characteristics in healthcare supply chain collaborations

The characteristics of sharing values in healthcare supply chain collaborations were sorted based on their level or limb position in the supply chain collaboration. For example, the CBS was seen between the manufacturer and distributor (M-D) or between the distributor and hospital (D-H). The features of CBS for healthcare supply chain collaborations can be classified as sharing two echelons (M-D, D-H, H-P), sharing three echelons (M-D-H, M-D-P) and sharing a multi echelon (M-D-H-P) as shown in Figure 3.

Figure 3 CBS characteristics in healthcare supply chain collaborations (see online version for colours)



M = Manufacturer D = Distributor H = Hospital P = Patient/Payer

3.3 Healthcare supply chain collaboration levels

The levels of the supply chain's collaboration were categorised into 4 levels of 'co-costs', 'co-benefits' and the different characteristics shared as levels of data sharing, information sharing, knowledge sharing and CBS as shown in Table 5.

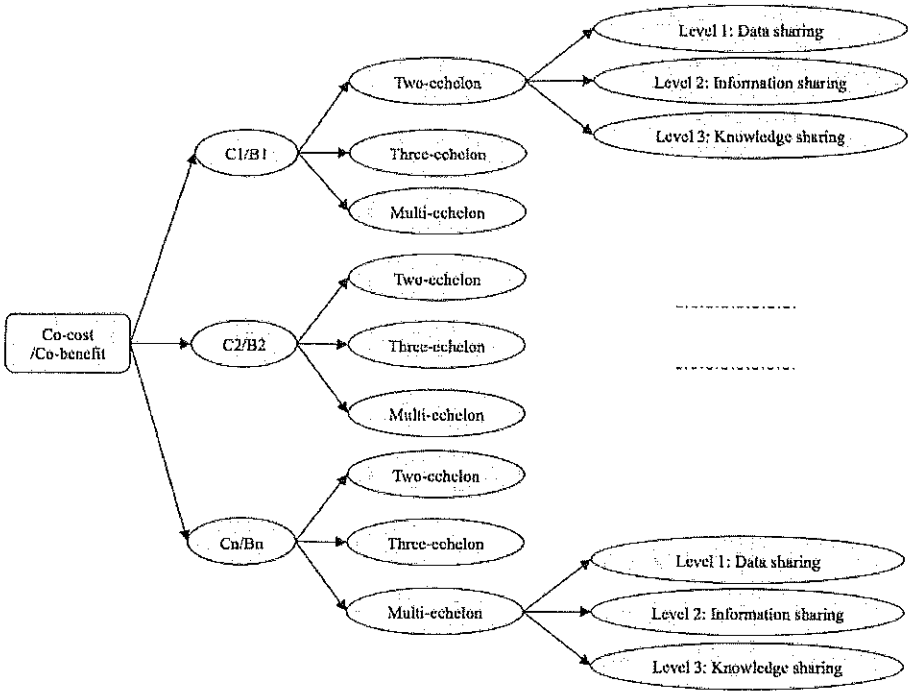
Table 5 Healthcare supply chain collaboration levels

General supply chain		*Collaboration system*	*Healthcare supply chain*
Level 1	Communication	EDI, VMI, etc.	Data sharing
Level 2	Coordination	CPFR, CRP, etc.	Information sharing
Level 3	Intensive collaboration	Innovation, competitive intelligence	Knowledge sharing
Level 4	Partnerships	Financial linkages	Cost benefit sharing

3.4 Cost-benefit sharing scenarios

From the above exercises we obtained 81 CBS scenarios on four costs, five benefits, three sharing characteristics and three collaboration levels, as shown in Figure 4.

Figure 4 CBS scenarios in healthcare supply chain collaborations



4 Discussion

CBS can lead to a successful supply chain collaboration and enhance the collaborative initiatives in the healthcare supply chain, with high stakeholder outcomes for a 'win-win' situation. The CBS of the collaboration's implementation should be based on different implementation periods and sharing characteristics Moreover, based on the expert interviews, the decision-making in the CBS for collaboration were concerned upon the influencing factors. They should be identified to gain knowledge of the influencing factors that can affect the willingness to share the costs and benefits of collaborations. Furthermore, the CBS should be optimised to allocate costs and benefits for the supply chain's members.

However, no empirical research exists which puts CBS into the context of healthcare supply chain collaborations. Two previous studies have identified CBS in supply chain collaborations: a RFID implementation in the fashion industry and in an automotive industry supply chain. The influencing factor analysis and CBS optimisation models previously investigated must be developed to enhance the success of supply chain collaborations. However, CBS optimisation models have not yet been investigated for either general supply chains or healthcare supply chain collaborations.

CBS is an incentive-system in business-networks to motivate cooperative decision-making and create 'win-win' situations. The costs and benefits should be allocated fairly. CBS models using quantitative approaches should be developed to optimise benefits for all the supply chains' participants. The driver for research into the next stage is to maximise the mutual benefits for stakeholders in healthcare supply chain collaborations, and enhance the collaborations success by using a cost benefit sharing modelling approach. The influencing factors will be identified for the CBS model's development.

5 Conclusions

This paper has presented a framework for CBS in healthcare supply chain collaborations. The findings of this study suggest that collaboration in the supply chain can lead to cost reductions, risk management and performance improvements. The key successes of the collaboration are that the costs are taken from the entire system and mutual benefits are gained by all the parties involved. As for the future, the influencing factors of CBS will be identified for the CBS model's development. The mutual costs and benefits of healthcare supply chain collaborations will be analysed to maximise the return on investment (ROI) in healthcare supply chain collaborations by using the optimisation model.

This research's contributions are aimed at enhancing collaboration in healthcare supply chains. The CBS models have been developed for use as a decision-making tool for healthcare supply chain collaborations. A review of the related literature revealed a lack of studies into this area, as the topic has not been investigated for healthcare supply chains.

The first phase of this research was to identify the CBS influencing factors that enhance successful collaborations. The contribution of the first phase was to gain knowledge of the influencing factors that affect the willingness to share the costs and

benefits of healthcare supply chain collaborations. This information can be used as a framework for a collaborative initiative or to make improvements to healthcare supply chain collaborations.

The second phase was to develop the CBS models. They are the new optimisation models to allocate the costs and benefits of supply chain collaborations, based on the willingness to share influencing factors while maximising the ROI in the supply chain. The results can be used as decision-making tools for future successful healthcare supply chain collaborative implementations.

The third phase was to develop collaboration strategies and a CBS plan for healthcare supply chain collaborations, with information from cases in the literature, and an actual case whose sensitivity towards certain parameters in the CBS models would be analysed. This can be used as the roadmap and tools for future healthcare supply chain collaborations.

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Scope	IJLSM proposes and fosters discussion on the development of logistics resources, with emphasis on the implications that logistics strategies and systems have on organisational productivity and competitiveness in the global and electronic markets. Globalisation of markets and logistics services are closely related to the success of a company. This perspective indicates the importance of effective logistics systems and their management for organisational effectiveness and competitiveness. (source)

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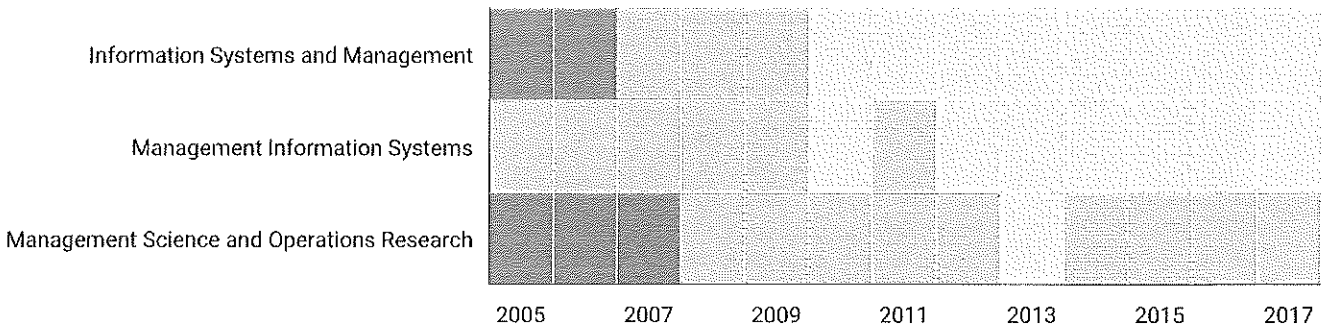

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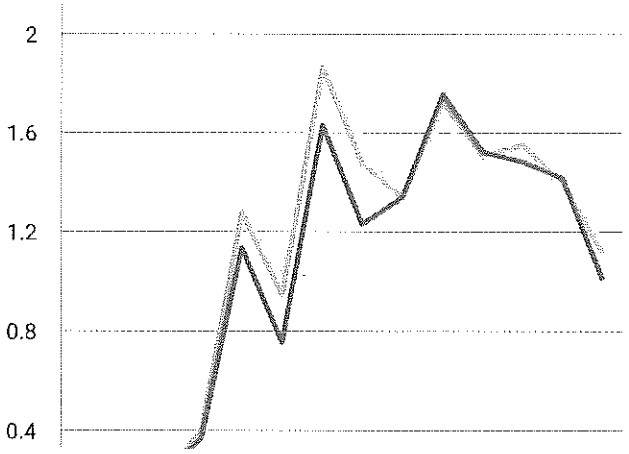

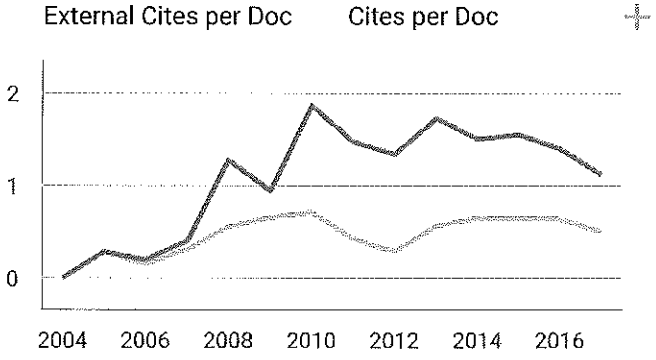

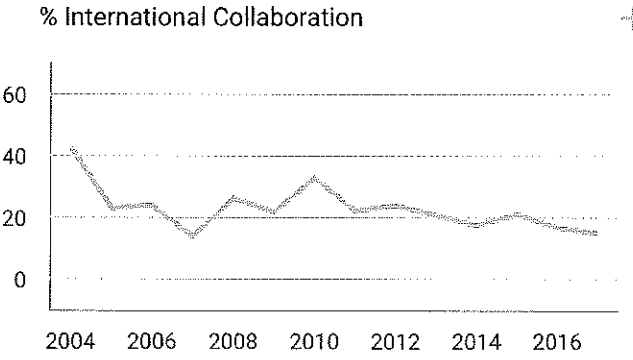

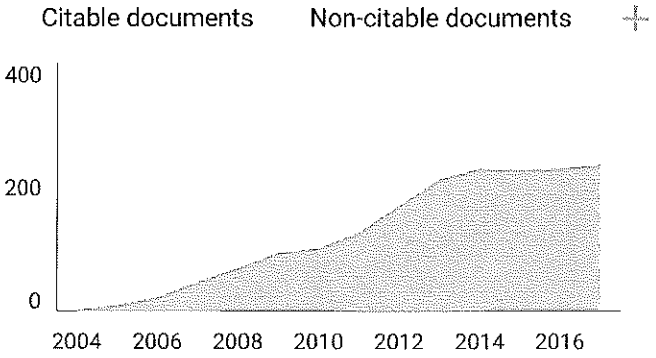

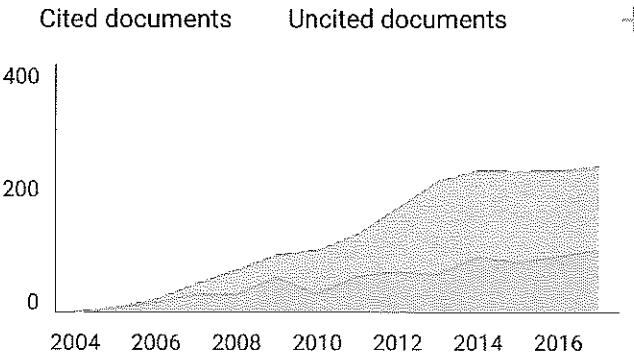

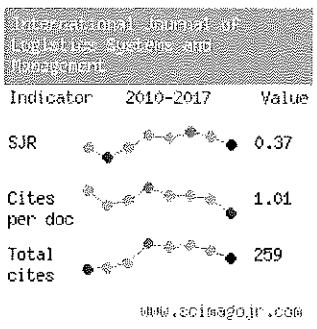

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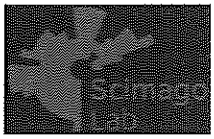

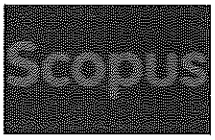

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