Impact of Accounting Methods on Supply Chain Contracts: Analysis Based on E-tailer Supply Chain Costs

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Abstract

Cost optimization is a widely discussed topic in the supply chain literature, where effective supply chain contracts are identified as essential tools that can address the strategic issues such as ineffective costs, integration, information sharing and coordination. Knowing how supply chain costs are measured is vital for all supply chain members, where different accounting methods used to derive cost information. Therefore, accenting methods have implications on supply chain cost information, thereby affecting supply chain contracts formed among various supply chain partners. However, the studies that explored the relationship of cost measurement based on accounting methods with supply chain contracts are scant in literature. Therefore, we propose propositions considering Historical cost accounting, Fair value accounting and Creative accounting in a contractual framework of an e-tailer supply chain, operating in an asymmetric informational scenario. The findings indicate that both historical and fair value-cost accounting methods affect supply chain contract outcomes when market conditions change. Furthermore, creative accounting directly impacts supply chain contracts if incentive-compatible constraints are not defined as it creates room for manipulating cost information.

Keywords

Accounting Methods, Asymmetric Information, Cost Optimization, Cost Measurement, E-tailer Supply Chain, Supply chain Contract

1. Introduction

Cost minimization is one of the critically important objectives in supply chain coordination (Dror et al. 2012). An efficient supply chain's primary goal is to fulfil customer demand with the lowest possible cost. Hence, each supply chain member must pay attention to cost savings methods, such as collaboration and effective supply chain integration (Leng and Parlar 2009). As a result, obtaining accurate cost data is vital for all supply chain activities and processes to improve productivity and profitability (Askarany et al. 2010). Also, cost data provides a clear picture of the actual situation of the supply chain than any other source (Pettersson and Segerstedt 2013). Therefore, knowing the cost structure of supply chain operations are imperative for deriving effective cost minimization strategies.

Since cost minimization is widely used as an optimization objective in the supply chain (Snyder and Shen 2011), it is imperative to identify how different supply chain members determine their cost values. In this context, cost measurement plays an essential role where accounting methods and accounting information drive cost measurement outcomes in an organization. Accounting information plays a vital role in operations management. It affects the decision-making of firms' operational aspects such as inventory management, cost of sales, management of materials, work in process and finished products (Horngren et al. 2014). Therefore, e-commerce supply chain organizations must identify appropriate accounting methods to demonstrate accurate and transparent financial information, which affect operational decisions and strategic outcomes as the correct information is the most influential asset of online supply chains.

Even though cost minimization is well studied, no attempt has been made to determine how these costs are measured when effective strategic interactions are formulated among supply chain members. Besides, the cost concepts have a significant game theory and contract theory implications for strategy formulation, information

revelation, cooperation, and contract design, as the cost management are related to the strategic decision of firms (Perloff 2014). Game theory-based optimization models have been widely adopted in the literature to formulate strategic interactions among different supply chain members where efficient contracting is one of the critical tools used in developing these models. However, no attention was paid in studying the impact of the cost measurement approach towards the outcomes of such contracting models in the literature. Therefore, the cost measurement approach, which defines the accounting methods and its effects, needs to be studied thoroughly to understand and design an effective cost-sharing approach among the main partners of an e-commerce supply chain operation. On this basis, this study addresses whether the accounting method adopted by the supply chain partners in an e-tailer supply chain operation has an impact on contract outcomes in terms of cost minimization.

A theoretical framework is developed to integrate accounting methods with the cost measurement aspects for managing supply chain costs. Accordingly, this paper develops propositions to test which accounting methods are more suitable in deriving improved outcomes based on cost minimization to resolve conflicts of interests and information asymmetry issues in an e-commerce supply chain operation. The propositions are tested using the cost-sharing contract developed in Rathnasiri et al. (2019).

This paper has the following contributions. Firstly, we integrate accounting and e-commerce supply chain operations within a contractual framework, which has not been studied in the literature according to the best of our knowledge. Secondly, the outcomes of this study derive the impact of cost measurement when formulating cost-sharing contractual framework, and hence, new knowledge is generated to the contract and supply chain literature. The outcomes of this study generate significant practical implications as well. The e-commerce supply chain members can examine their respective partners' information accuracy before entering into contractual agreements based on the accounting methods they adopt in their organizations. This analysis gives insights for the supply chain members in selecting the most appropriate cost measurement system in their organization, which can derive better outcomes in achieving competitive advantage.

2. Literature Review

We first discuss the game theory and contract modelling related to supply chain issues, followed by the accounting methods adopted to derive cost measurements in organizations. Next, we discuss the extant literature that explored the accounting information and its impact on supply chain information and contract modelling.

2.1 Game Theory and Contract Theory Issues within Supply Chain Framework

Game theory is an important tool applied in strategic decision-making and interactions among different parties (Perloff 2014). Game theory also focuses on the actions of different decision-makers, which affect each other (Rasmusen 2007). As supply chains typically operate in decentralized environments, it creates conflicting situations in decision-making and inefficiencies in operations as different players are acting towards their self-interests (Kogan and Tapiero 2007). Game theory applications have become one of the highly applied tools in resolving supply chain management issues (Simchi-Levi et al. 2014). The critical issues analyzed using game theory models in the supply chain literature are coordination issues, ineffective integration, information asymmetry issues and lack of collaboration. These issues affect organizations' strategic interactions and ultimately impact the output of the overall supply chain operations.

Game theory frequently integrates contract models to derive effective strategic interactions among supply chain members (Hjaila et al. 2017). A contract will act as an incentive for different parties, who have diverse objectives to share information and collaboratively work with each other (Cachon 2003). Supply chain contracts are used to achieve coordination and collaboration when strategic decision-making issues are discussed (Cachon and Netessine 2006, Simchi-Levi et al. 2014). A considerable number of researches on game theory and contract applications can be found relating to organizational cost aspects. The costs are incorporated in these models using different approaches such as cost allocation, cost-sharing, cost minimization and binding contacts. However, the cost measurement and its impact on the outcomes of game/contract models are still unclear in the extant literature.

2.2 Accounting Methods and Measurement Techniques

In accounting terms, cost measurement is a highly important aspect. The accounting methods are segregated mainly into three as Historical Cost Accounting (HCA), Fair Value Cost Accounting (FVA) and Creative Accounting.

2.2.1 Historical Cost Accounting and Fair Value Cost Accounting

There is a never-ending debate on adopting either historical cost accounting or fair value/ current cost accounting. Many scholars have argued the pros and cons of both these accounting methods, which have

different implications on profit generation, capital and assets, earning management and operating costs (Marra 2016). Fair value accounting generates forward-looking information while it violates the reliability of the information. These values can be manipulated where historical cost accounting data cannot be manipulated; nevertheless, the information is not so forward-looking and relevant. This scenario is the most significant trade-off between these two accounting measurement types (McDonough and Shakespeare 2015, Blecher 2019).

In historical cost accounting, accountants track the flow of costs to match them against the revenue earned (Godfrey 2010). However, they do not take the residual net value of an organization's assets when the income statements are prepared. Moreover, the historical costs accounting incorporates the conservative contractual relationship between an organization and the parties who provide the necessary resources. The authors further argue that historical cost accounting is applicable when the economic decisions are made in a company when a transaction occurs, not when it is merely possible. Above factors can mainly be identified as major benefits of adopting the historical cost accounting approach. In contrast, the historical cost could affect the efficiency levels of companies because it illustrates past behavioural efficiency of the managers and uses lesser depreciation levels for the assets, which ultimately display improved efficiency levels in financial information (Godfrey et al. 2010). Recent literature suggests that investors do not look for financial statements derived based on historical data; instead, they are interested in obtaining up-to-date information (Marra 2016, Tkachuk 2019).

In the Fair Value Accounting (FVA), assets are valued based on the current market prices, and accordingly, the profits are determined (Godfrey et al. 2010). The issues of FVA are identified as recognition principles and objectivity (Scott 2015). There is a huge debate regarding the reliability of adopting fair values accounting to determine the financial position of organizations (Tkachuk 2019). FVA violates the conservatism principle of HCA as they record non-monetary assets in the current market price, thereby including unrealized gains in the financial records. The holding gains of company profit is calculated as cost savings in FVA when these cost savings are not realized. Therefore, the costs are recorded without the actual transaction occurred. However, these theorists argue that when market prices of goods can be easily determined, the accountant can use current costs to value those items. One such item is inventories of a firm (Godfrey et al. 2010). For e-commerce supply chain organizations, inventory holding cost is a crucial component, and hence, determining which cost measurement system to be adopted can have significant implications on the supply chain costs.

2.2.2 Creative Accounting

Creative accounting is defined as a changing method use to present a company's financial outcomes to attract more investors (Fizza and Qaisar Ali 2015). It has a questionable nature with the ethical practising of financial reporting since creative accounting does not involve the business's fair situation (Fizza and Qaisar Ali 2015, Remenarić et al. 2018). Adopting creative accounting principles mean ignoring some rules and considering the most beneficial rules, which ultimately is advantageous for the organization (Bhasin 2016). The author further highlights that creative accounting is a crime, and the accounting bodies should take necessary actions to stop these unethical practices. Fizza and Qaisar Ali (2015) analyzed the causes of using creative accounting in organizations through empirical investigations. The main reason is the extreme competition in businesses followed by reasons such as benefits of manipulation, obtaining more investments and materializing accounting statement-making art.

Several areas are identified that creative accounting practices can be adopted in manipulating the information. Tangible assets related depreciation, company goodwill calculation, inventory levels, provisions allowed for liabilities and the creating of contracts are some of the main areas identified (Yadav et al. 2014). It showcases that the supply chain organizations have a clear motive to adapt the creative accounting practices. Creative accounting practices are primarily linked with agency problems (Diana and Beattrice 2010, Shahid 2016, Umobong and Ironkwe 2017). The conflicts of interest of the accounting information among different players derive creative accounting practices (Diana and Beattrice 2010). Shahid (2016) have tested the hypothesis to identify the relationship between the agency problem and creative accounting. Their analysis showcase that an agency problem is significantly related to the use of creative accounting. Therefore, the impact of creative accounting practices on contractual agreements is a critical area that needs to be explored in supply chain literature.

Looking at the pros and cons of these accounting methods, it is evident that selecting an accounting method has implications for the decisions related to valuation and determining actual earnings and expenses of firms. More importantly, there is room for manipulation with different accounting techniques, which affects the operational outcomes of supply chain organizations. E-commerce supply chain organizations depend on accurate information sharing among different supply chain partners, as their primary focus is to derive effective results

and meet customer expectations. Therefore, the supply chain members must be aware of the financial information and measurement terms, which affect their strategic decision-making.

2.3 Impact of Cost Measurement and Accounting Methods on Contracting

Accounting methods have a direct impact on efficient contracting (Scott 2015). Sellhorn and Stier (2019) describe that the financial reporting method serves to provide relevant information and measures that can be used to arrange contractual terms. When a firm encompasses a high-quality financial reporting system, it enables all parties to act with integrity and trust when forming a contractual agreement (Scott 2015). Fargher and Zhang (2019) also elaborated that providing discretion to use fair value measurement within organizations creates an environment for managers to act opportunistically, thereby generating less informative financial outcomes. They further emphasized that it negatively affects financial reporting reliability, which ultimately affects a firm's earning management.

Scott (2015) has exclusively discussed the relationship between accounting policies for efficient contracting, where the main factors are reliability, conservatism and contract rigidity. This author argues that accounting policy differences are created due to the measurement type adopted by an organization as efficient contracting leads to establishing trust. The author further elaborates that an efficient contract enables a higher level of trust at the lowest cost. Nevertheless, the contracting terms are focused on minimizing agency costs in this analysis within a Principal-agent framework (Christensen et al. 2016). However, suppose a firm uses fair value accounting. In that case, there is an opportunity to manipulate accounting information when the contract is signed, which leads to creating an un-trustful scenario among the parties who engage in the contract (Scott 2015). When information is assessed related to historical cost and fair value, historical cost maintains the reliability of information while fair value maintains the relevance of information (Blecher 2019). Christensen et al. (2016) also explain that when a firm is more focused on scoring high on accounting measurement, relevance with the fair values, reliability levels get decreased as they are challenging to verify. Scott (2015) also corroborates the same argument. This finding is an interesting fact to consider, particularly when we focus on operational aspects of e-commerce-based supply chains as information is the driving factor of the flawless operations. Therefore, the supply chain members have to give their attention to define their respective accounting methods to manage the trade-off between reliability and relevance.

Gao (2013) argues that having a conservative accounting approach benefits efficient contracting as it reduces the possibility of manipulation of earnings management. The author further verifies that it is more applicable when information asymmetry exists within an organization. Therefore, knowing the cost measurement in organizations is essential for the decision-making process and designing efficient contract models with different members. Nevertheless, this author also not discussed how it affects managing operational costs in the firm. Liao et al. (2013) have extensively analyzed how the fair value measurement affects information asymmetry within organizations. They have tested their arguments for the banking industry, considering net asset measurements. According to their findings, information asymmetry is positively correlated with fair value measurement. Further, they elaborate that investors have suspicions about the financial statements when an organization uses fair value measurements. These findings generate an important insight, which can be expanded into supply chain operations as well. However, no attempt has been made amongst the supply chain studies to identify how the accounting measurement information such as fair value accounting or historical cost accounting can affect the supply chain outcomes.

However, extant studies related to contracting and accounting information, are focused on a single organization, where mainly principal-agent relationships are considered, such as compensation contracts, debt contracts, etc. There is no evidence in testing the same argument within an e-tailer supply chain operation where different external supply chain members interact with an efficient contract to derive better operational and economic outcomes, which is discussed in this paper.

3. Theoretical Framework

As discussed in the literature, the accounting method adopted in an organization directly impacts contract formation and its outcomes (Scott 2015). As no evidence is found in relating the accounting methods adopted to measure costs towards the contract outcomes of an e-commerce-based supply chain operations, this study presents the following theoretical framework to address this issue and derive the implications.

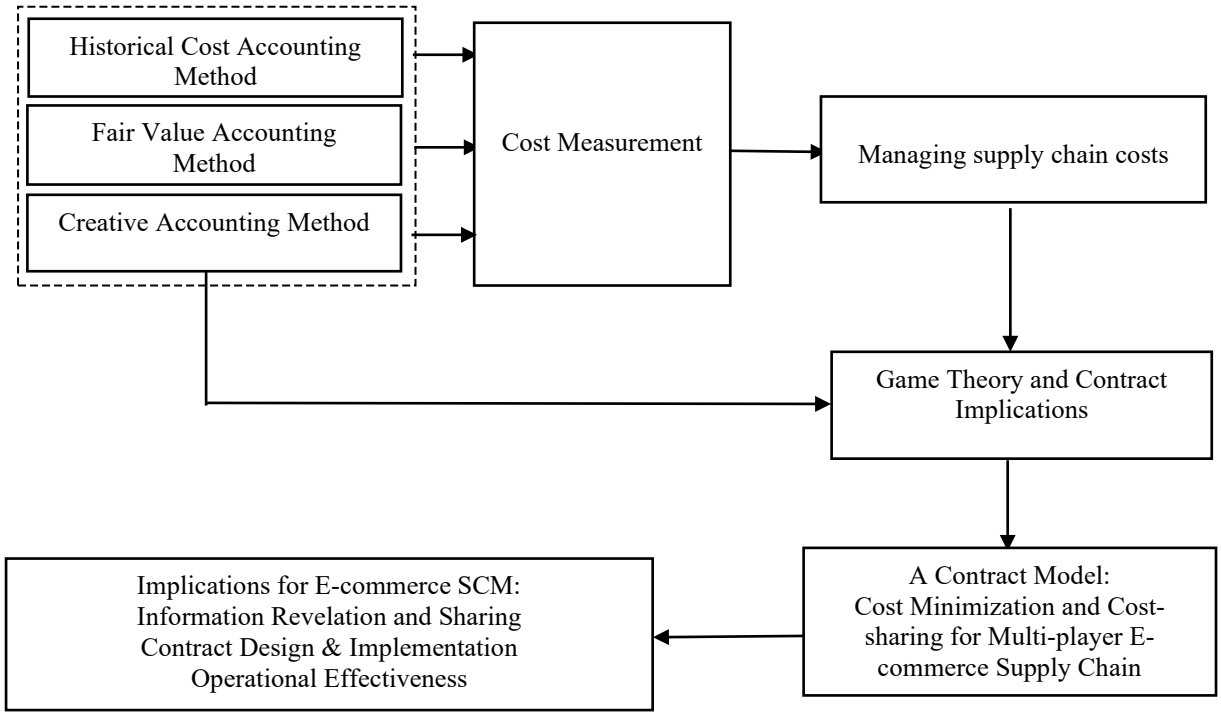

Figure 1. Theoretical framework

Cost information in the e-commerce supply chain is derived based on accounting methods. Hence, it is necessary to identify which method has more impact on deriving accurate cost information. As measuring costs in supply chain management is problematic, cost measurement has an impact on managing supply chain costs such as inventory costs, distribution costs, logistics costs, manufacturing costs, etc., which creates a direct connection between the accounting methods and supply chain costs. As accounting data derive strategic decisions within and across firms, which mutually affect each other, strategic interactions among different agents become imperative to firms (Migdalas 2002). Therefore, game-theoretical implications are generated from the accounting methods mainly focusing on the efficient contracting, incentive setting, ex-ante and ex-post data recording (Migdalas 2002, Scott 2015). Hence, accounting methods have a direct relationship in producing implications for game theory-based contract theory models.

This study examines the impact of supply chain cost information within a contractual framework among three supply chain members; e-tailer, product supplier and the 3PL operator. These supply chain members operate in a decentralized and asymmetric information scenario. So, the contract model outcomes can be different according to the accounting method employed by these players. Numerical analysis for the cost-sharing contract will be tested for each of these accounting methods to derive implications related to strategy formulation, information revelation and sharing, contract design and implementation and operational effectiveness.

Based on the above theoretical framework, we test the following propositions in this study:

Proposition 1*- The fair value accounting has a positive/negative impact for supply chain costs when integrating through a cost-sharing contract*
Proposition 2 *– The historical cost accounting method has a positive/negative impact on the supply chain costs when integrating through a cost-sharing contract.*
Proposition 3 *– Creative accounting method can manipulate the contractual outcomes in an asymmetric information environment without revelation principle-based compatible incentives*

4. Model Formulation with Proposition Analysis

We use the cost-sharing contract model developed in Rathnasiri et al. (2019) to determine the impact of accounting methods described by Proposition 1 to 3 on the contract outcomes. In the e-tailer supply chain, operational costs are the cost subjective to change according to the accounting method used. $c_{i,s}$ indicates the total cost of the product supplier in each period i, $c_{i,e}$ and $c_{i,D}$ represents the total costs of the e-tailer and the 3PL operator respectively. The demand for the supply chain is D_i, where we assume that the demand is fulfilled without any losses. MC_i, HC_i, TC_i indicate the manufacturing cost, inventory holding cost and the distribution

cost, respectively. The contract model is based on cost-sharing, where the e-tailer proposes to share a fraction of the operational costs of the product supplier and the 3PL operator. Since manufacturing costs and the distributions costs are unknown to the e-tailer, the e-tailer has a probabilistic assumption of the costs as high and low, and hence α and β describes the probability associated with high and low cost of the product supplier and 3PL operator and accordingly, we create high and low boundaries for manufacturing and distribution costs as $\overline{MC_i}, \underline{MC_i}$ and $\overline{TC_i}, \underline{TC_i}$. The operational costs of the supplier, e-tailer and the 3PL operator are related to the cost measurement in this contract.

The decision variables of the contract model are the number of units produced in each period, q_i are the inventory levels of the product supplier and the e-tailer; $s_{i,s,}$ and $s_{i,D}$;the number of units ordered in each period, Q_i. $\lambda_{i,s}$, and $\lambda_{i,D}$ represents the cost-sharing percentage by the e-tailer to the product supplier and the 3PL operator respectively. $sh_{i,s}, sh_{i,D}$ explains each player's sharing costs, which is derived based on the sharing percentages.

Cost objective of the product supplier

$$c_{i,s} = \left\{\left(\alpha(\overline{MC_i}) + (1-\alpha)(\underline{MC_i})\right)\cdot\left(q_i + \varepsilon_i \cdot (s_{i,1})\right) - \left(\alpha(\underline{sh_{i,s}}) + (1-\alpha)(\overline{sh_{i,s}})\right) - \left(\alpha(\overline{P_{i,s}})\cdot Q_i + (1-\alpha)(\underline{P_{i,s}})\cdot Q_i\right)\right\} \quad [1]$$

Cost objective of the e-tailer

$$c_{i,e} = \left[\begin{Bmatrix} HC_i(s_{i,e}) + \left(\alpha(\underline{sh_{i,s}}) + (1-\alpha)(\overline{sh_{i,s}})\right) + \left((\alpha(\overline{P_{i,s}})\cdot Q_i + (1-\alpha)(\underline{P_{i,s}}))\cdot Q_i\right) + \left(\beta(\underline{sh_{i,D}}) + (1-\beta)(\overline{sh_{i,D}})\right) \\ + \left((\beta(\overline{P_{i,D}}) + (1-\beta)(\underline{P_{i,D}}))\cdot D_i\right) \end{Bmatrix}\right] \quad [2]$$

Cost objective of the 3PL operator

$$c_{i,D} = \left[\left\{\left(\beta(\overline{TC_i}) + (1-\beta)(\underline{TC_i})\cdot D_i\right) - \left(\beta(\underline{sh_{i,D}}) + (1-\beta)(\overline{sh_{i,D}})\right) - \left(\beta(\overline{P_{i,D}}) + (1-\beta)(\underline{P_{i,D}})\right\}\cdot D_i\right\}\right] \quad [3]$$

Incentive compatibility constraints

$$\overline{MC_i}\left(q_i + \varepsilon_i\left(s_{i,s}\right)\right) - \underline{sh_{1,s}} - \overline{P_{i,s}}\cdot Q_i \geq \underline{MC}\cdot q_i + \alpha_i \cdot \underline{UC_i}\left(s_{i,s}\right) - \overline{sh_{1,s}} - \underline{P_{i,s}}\cdot Q_i; \forall_i \quad [5]$$

$$\underline{MC_i}\left(q_i + \varepsilon_i \cdot s_{i,s}\right) - \underline{sh_{i,s}} - \underline{P_{i,s}}\cdot Q_i \geq \overline{MC_i}\left(q_i + \varepsilon_i \cdot s_{i,s}\right) - \overline{sh_{i,s}} - \overline{P_{i,s}}\cdot Q_i; \forall_i \quad [6]$$

$$\overline{TC_i}\cdot D_i - \underline{sh_{i,D}} - \overline{P_{i,D}}\cdot D_i \geq \underline{TC_i}\cdot D_i - \overline{sh_{i,D}} - \underline{P_{i,D}}\cdot D_i : \forall_i \quad [7]$$

$$\underline{TC_i}\cdot D_i - \underline{sh_{i,D}} - \underline{P_{i,D}}\cdot D_i \geq \overline{TC_i}\cdot D_i - \overline{sh_{i,D}} - \overline{P_{i,D}}\cdot D_i : \forall_i \quad [8]$$

Individual rationality constraints

$$\overline{sh_{i,s}} \leq \lambda_s \left\{\left(\alpha(\overline{MC_i}) + (1-\alpha)(\underline{MC_i})\right)\cdot\left(q_i + \varepsilon_i \cdot (s_{i,s})\right)\right\} \quad [9]$$

$$\overline{sh_{i,D}} \leq \lambda_D \cdot \{\beta\cdot(\overline{TC_i}\cdot D_i) + (1-\beta)(\underline{TC_i}\cdot D_i)\} \quad [10]$$

Eq. [1] to [3] depicts the cost minimization objectives of the supplier, e-tailer and 3PL operator, which comprises of the operational costs and the sharing costs received with the cost-sharing contract., The e-tailer is the centralized decision-maker in this supply chain, considering the cooperative decision-making. Eq. [5] to [8] describes the incentive compatibility constraints, which ensure true cost revelation by each player of the contract. Eq. [9] and [10] indicates the individual rationality of the contract, where sharing costs are determined.

4.1 Propositions 1 and 2

Propositions 1 and 2 are tested using numerical analysis as below.

1. Numerical test 1 - All players of the supply chain adopt Historical Cost Accounting (HCA)
3. Numerical test 2 - E-tailer's organization uses historical cost accounting while the product supplier and the 3PL operator use fair value cost accounting.

We consider the re-valuation option in FVA to determine the changes in cost measurement under this numerical illustration. We assume a scenario where the products' market value is reduced (e.g., pandemic situation, new technology, etc.).

- In testing scenario 1, where all members adopt historical cost accounting (HCA), even though the market value gets reduced, no asset is re-valued. The costs are calculated based on the previously incurred values.
- In testing scenario 2, the product supplier and the 3PL operator re-evaluate their assets based on the current market value. Therefore, the operational costs of the product supplier and the 3PL operator will change.

According to the categorization of assets under fair value accounting, assets level is defined, which is then applied to the assets' re-valuation. In this operational setting, the finished goods and inventories are the main assets capable of producing an income by selling the goods in the future. The operational costs are inherent for each organization, which is unobservable to the market; however, the finished goods' selling prices are matched according to the market values.

4.2 Proposition 3

If any organization adopts creative accounting method, it allows the accountant to manipulate and change the information to showcase better financial information. Within an information asymmetry scenario in the e-tailer supply chain, creative accounting motivates the organizations to report false costs to obtain extra benefits from contracts. The revelation principle is adopted in the contract literature, to eliminate information asymmetry issues where incentive-compatible constraints are defined. The cost-sharing contract model described in this study also incorporates incentive compatibility constraints to ensure that all players reveal accurate information when engaged in the contract. It ensures that the supply chain members do not have the possibility of manipulating the cost data in the proposed contract. Therefore, incentive compatibility constraints affect the decision to adopt creative accounting in the product supplier and 3PL operator's organizations. Based on this argument, we test the proposition 3 to identify the impact on creative accounting on contractual outcomes.

When either the product supplier or the 3PL operator has higher operational costs, the sharing fraction is lower. The product supplier's total costs under higher operational costs scenarios are equal to or greater than the total costs under lower operational costs (Eq. [5]). Similarly, the total costs under higher operational costs of the 3PL operator are also equal to or greater than the total costs under lower operational costs as denoted by Eq. [7]. The total costs are determined after deducting the sharing fraction and the fixed payment received by the product supplier and the 3PL operator in each period. Constraints denoted by Eq. [6] and [8] ensures the true cost revelation by selecting the current menu of contracts. The product supplier's and the 3PL operator's total operational costs under lower costs when receiving a lower sharing fraction and lower payment are equal or greater than the total operational costs under higher costs when the product supplier receives a higher sharing fraction and a higher payment. Therefore, neither the product supplier nor the 3PL operator does not receive extra benefits of reporting low costs even when they have high costs. Eq. [6] and [8] compel these players to select the correct contract menu according to their operational costs.

When Eq. [6] and [8] are not included in the contract, and only Eq. [5] and [7] are included, there is no guarantee that either player reports the correct costs. They may under-report the costs to gain a higher sharing fraction from the e-tailer, allowing manipulation of information within these organizations. Therefore, Proposition 3 is tested in the numerical analysis by comparing the incentive levels with the inclusion and exclusion of incentive compatibility constraints to derive whether the effective contract outcomes are generated without the possibility of adopting creative accounting methods.

5. Numerical Analysis

The contract model is solved as a non-linear programming model using an optimization solver tool. The model is coded using GUSEK solver (Version 4.65), and numerical experiments are conducted in the NEOS server (https://neos-server.org/neos/). Due to the model's non-linear nature, the BARON solver (https://neos-server.org/neos/solvers/minco:BARON/AMPL.html) is incorporated to perform computer experiments. BARON solver derives global optima solutions for non-convex constrained optimization models using Brach and Reduction algorithms. The optimal solutions of the effective cost-sharing contract in e-tailer operations are derived in Rathnasiri et al. (2019), and therefore, we use this model to conduct the numerical analysis of cost measurement in this study.

5.1 Results Analysis of Proposition 1 and 2

We consider data from Ragsdale (2017), which has been tested for a similar operational context. We assume that the unit cost values are changed according to the accounting method adopted by the supply chain member, and the demand drop is 30%, which occurs from the third period of the model.

In the operational scenario 1, no asset re-valuation occurs as all players maintain HCA in their organizations. Therefore, the operational costs of the contract model do not change. However, as demand drops, the supply chain costs are affected. It is because of the changes in the manufacturing, order quantities and inventory levels. The results indicate a 56% overall supply chain costs reduction when the demand drops by 30% without changing the operational costs. It directly affects the cost-sharing levels, and both supply chain members receive a reduced level of incentives through cost-sharing (Figure 2)

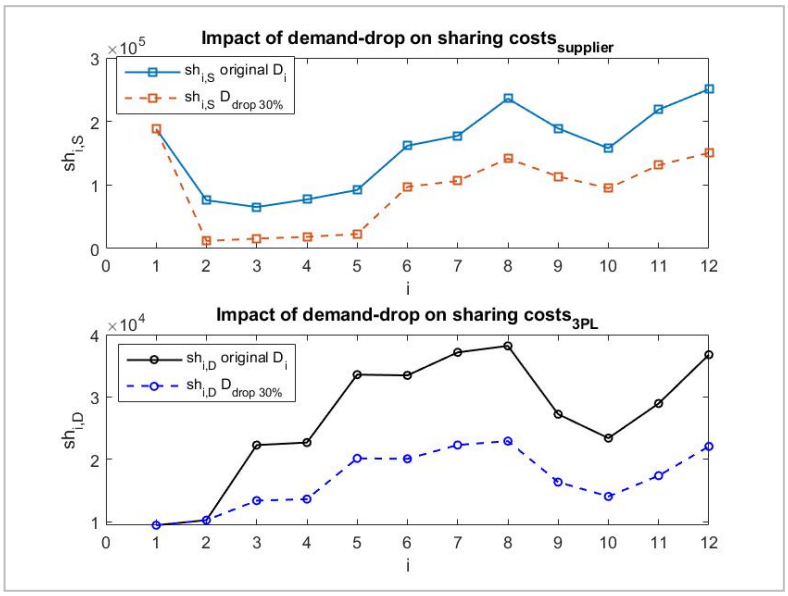

Figure 2. Impact of HCA on Sharing Costs of the product supplier and the 3PL operator

Therefore, the impact of the demand drop affects the supply chain costs as well as the incentives of the cost-sharing contract; however, operational costs do not have any impact as they remain the same.

In operational scenario 2, the product supplier and the 3PL operator re-value the assets in his organization for the current market value, where e-tailer's costs remain the same. Therefore, unit operational costs within the supplier and 3PL operator is changed. A sensitivity analysis is conducted assuming that due to the fair value accounting, the assets re-valuation results in reducing the unit costs by 5%, 10%, 15% and 20%. Figure 3 indicates the impact on the overall supply chain costs results due to the fair value accounting adoption by the supplier and the 3PL operator.

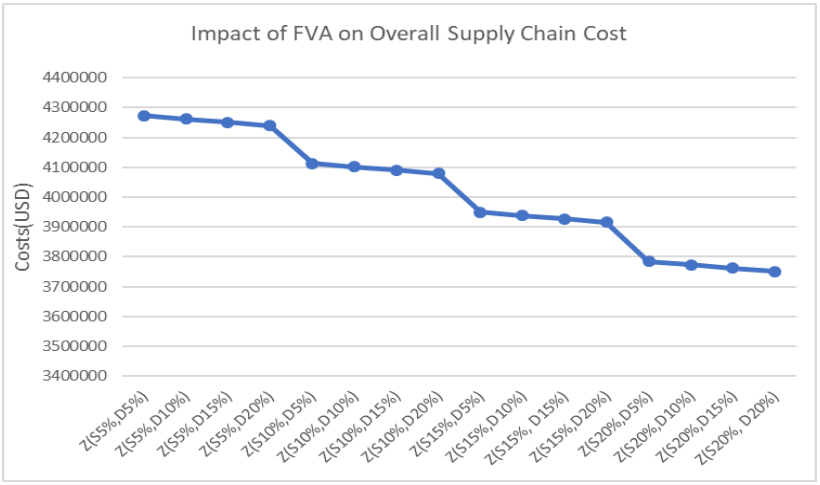

Figure 3. Impact of FVA adoption by the supplier and 3PL operator on the overall SC cost

The results showcase that the FVA affect the overall SC costs. With the market value getting reduced with demand drop, asset re-valuation generates lower operational costs for the supplier and 3PL operator. Hence, the overall supply chain cost (z) gets reduced. Then, we have compared the results with the HCA scenario

(Operational scenario 1), to illustrate the impact on FVA by two players in the contract model to the overall supply chain costs (Figure 3). The costs are varied from 4% to 18% when both supplier and the 3PL operator adopts FVA in their organizations than the HCA scenario.

Hence, it is proven that both the HCA and FVA has a positive impact on the supply chain costs and contract outcomes as tested using proposition 1 and 2.

5.2 Results Analysis of Proposition 3

To test Proposition 3, we use two numerical illustrations, which includes all constraints in the contract model and does not include constraints denoted by Eq. [6] and [8]. The numerical analysis is conducted with the same data set. The contract model results change when Eq. [6] and [8] are removed from the model. The results reveal that it mainly affects sharing costs. Accordingly, the sharing costs are reduced for the 3PL operator and become zero for the product supplier. A comparison of the sharing costs with and without the incentive compatibility constraints are indicated in Figure 4.

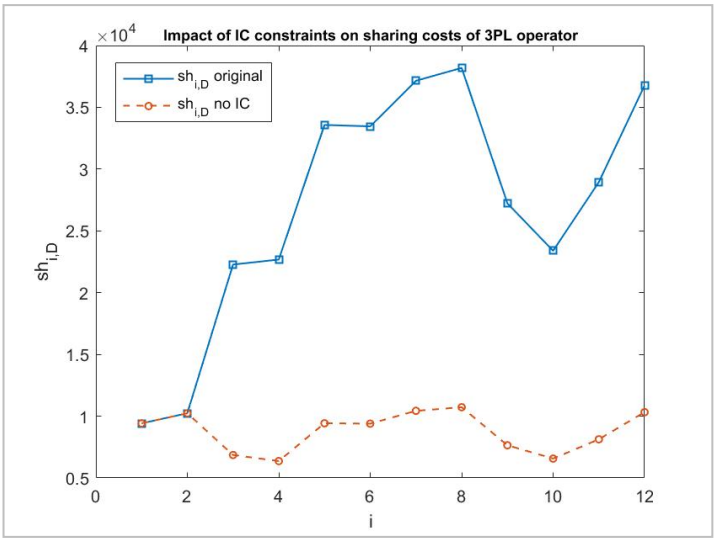

Figure 4. Comparison of sharing costs with and without incentive compatibility constraints_3PL operator

The incentive reduction proves that reporting false or modified costs does not provide benefits from the contract. The cost-sharing incentive received by the 3PL operator significantly reduces, and the product supplier gets zero benefits, which ensures that the revelation principle-based incentive compatibility motivates players to reveal true costs. Thus, it eliminates the possibility of adopting an accounting method as creative accounting, allowing accountants to manipulate costs and report modified or false costs to create an enhanced picture. Removing compatibility constraints not only reduces the but also reduces overall the supply chain costs.

The results disclose that the total costs of the product supplier and the 3PL operator also increase without the incentive compatibility constraints. Therefore, the results further emphasize that incorporating incentive compatibility constraints ensures better cost optimization for the product supplier and the 3PL operator and delivers better incentives, thus eliminating the possibility of implementing creative accounting practices within their organizations. Therefore, the results of the numerical analysis show that Proposition 3 developed in this study is accurate.

6. Conclusion

This paper analyzes the impact of cost measurement on the outcomes of the supply chain contracts. Cost measurement in supply chain organizations depends on the accounting methods adopted. Literature related to accounting information and contracts discusses the importance of accounting information and its impact on contractual outcomes. However, no clear evidence is found related to accounting information and its effect on the supply chain contracts and supply chain costs, even though cost minimization is one of the critical objectives of any supply chain operation. Therefore, this study addresses this gap and attempt to derive the relationship between the accounting information derived through different accounting methods and the supply chain costs and contracts. The study uses an e-tailer supply chain with three-player scenarios, led by an e-tailer since e-commerce supply chains are highly dependent on accurate information.

A theoretical framework is created to define the relationship of historical cost accounting (HCA), fair value cost accounting (FVA) and creative accounting methods adopted by supply chain members towards the supply chain costs, strategic decision-making, and contractual outcomes. Based on that, three propositions are tested using a multi-period cost-sharing contract model developed in Rathnasiri et al. (2019) considering asymmetric cost information. A numerical analysis is conducted for different operational scenarios, and accordingly, the results are interpreted, and model implications are derived for this study.

The findings of this study divulge that both HCA and FVA Historical affect supply chain costs. However, HCA does not create an opportunity for manipulating information as supply chain costs are affected due to the changes in operational scenarios and not due to the changes in accounting information. In contrast, FVA has a higher impact on changing cost information than the historical cost accounting method. Therefore, HCA is better than FVA for contracts, especially when asymmetric information is present. On the other hand, FVA derives better cost minimization than the HCA. Next, we have tested the motivation towards adopting creative accounting. The results reveal that the incentive compatibility adopted contracts ensure that supply chain members do not have an opportunity to adopt creative accounting in their organizations and manipulate contractual outcomes and supply chain costs.

This study can be extended in several ways in future. Even though we have considered the asset re-valuation, an in-depth cost analysis for each operational cost is not conducted in this study, which needs to be investigated to derive actual changes of assets in financial statements on supply chain contracts. Next, the implications on financial accounting methods used in the real-world e-tailer supply chain can be incorporated to test the model implications on actual business operations. Through that important practical insights can be generated to improve decision-making levels in optimizing operational performances of supply chains. Finally, it is essential to study on financial cost measurement outcomes in other types of contract models where analytical propositions can be developed.

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