A game theory approach for value co-creation systems

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This paper introduces a game theory approach to study firms’ strategic behaviours in value co-creation systems. The game theory approach not only faces a joint value optimization problem between the firm and the customer, but also faces a value allocation problem to the firms. Value co-creation system emphasizes on firm-customer interaction and value trade-off between the firm and the customer. Simulation experiments are carried out on the hypothetical system to conduct the value trade-off between the firm and the customer, and study the firms’ strategic behaviours on the market place. The experimental results indicate the value trade-off between the firm and the customer, and the strategic tension between cooperation and competition. Although the competitive action is the dominant strategy for each firm, but the firms’ cooperative action guarantee to gain a maximum joint value. This paper contributes theoretical insights on value co-creation and firms’ strategic behaviours in value co-creation systems.

Keywords: value co-creation; offering dominant logic; value concepts; strategic trade-off; game theory

1. Background

Recent developments in marketing and operations management highlight the opportunities for value co-creation, in which the firm and the customer are both collaborators and competitors – collaborators in co-creating value and competitors for extraction of economic value (Prahalad & Ramaswamy, 2004). Value co-creation occurs through coordinated efforts or related efforts of the firm and the customer (Parks et al., 1981), and with the presence of significant customer inputs in transformation processes (Sampson & Froehle, 2006). From value co-creation perspective, value becomes a joint function of actions of the firm and the customer (Grönroos & Voima, 2011), and there exists a trade-off between firm profit and customer utility (Trinh, Kachitvichyanukul, & Khang, 2014).

In literature, firm-customer interaction is becoming the locus of value co-creation. Many earlier researchers attempted to approach theory of value co-creation under various research methodologies including open innovation approach, blue ocean strategy and game theory approach. Open innovation approach recognizes the focal role of customers and their experience through the innovation (Chesbrough, 2011). Open innovation seeks to identify, access, assimilate and leverage the abundant knowledge and

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resource beyond the firm boundaries in order to co-create value with external innovators (Neyer, Bullinger, & Moeslein, 2009; Teece, 2007). The firm migrates from closed innovation to open innovation in order to co-create value with the customer (Chesbrough, 2003, 2011). Blue ocean strategy is based on the view that market structures are not given and can be reconstructed by the actions of the firm and the customer (Kim & Mauborgne, 2005a). The cornerstone of the blue ocean strategy is value innovation. A blue ocean is created when a firm achieves value innovation that creates value simultaneously for both the firm and the customer (Kim & Mauborgne, 2005b). Game theory approach deals with mathematical models of cooperation and competition in supply chain (Esmaeili, Aryanezhad, & Zeephongsekul, 2009; Esmaeili & Zeephongsekul, 2010). Moreover, contracts can be used to coordinate the activities between the firm and the customer, and achieve Pareto improvement in supply chain (Hua, Zhang, & Xu, 2011; Zhao, Wang, Cheng, Yang, & Huang, 2010). Stuart (2011) used a game theory approach to explore the tension between value-creating behaviour and value-claiming behaviour that has been viewed as fundamental to negotiation analysis.

Even value co-creation has become the most interesting topic for researchers and practitioners, the vagueness and complexity of value co-creation result in a limited understanding of value concepts and a lack of analytical models for value co-creation. So far, there have not been any studies on the firms’ strategic behaviours in value co-creation systems. From these motivations, this paper explores value concepts and develops analytical models for value co-creation. The simulation experiments are carried out on the hypothetical value co-creation system to conduct the value trade-off between the firm and the customer, and study the firms’ behaviours under cooperative and competitive strategies in value co-creation systems.

2. Value co-creation perspective

2.1. Value concept

The concept of value has a very long history in economic and philosophical thought that attempt to explain two notions of value, and the balance between value-in-exchange and value-in-use in value propositions (Kowalkowski, 2011). The nature of value-in-exchange is the negotiated evaluation that customers and firms offer and receive among themselves (Kowalkowski, 2011). The nature of value-in-use is the extent to which a customer feels better off (positive value) or worse off (negative value), where value accumulates over time through experiences during usage (Grönroos, 2011). Value proposition is recognized as central conceptual elements that required further elaboration (Vargo & Lusch, 2008). Such conceptual elaboration creates greater opportunities for value creation that benefit both the firm and the customer (Payne, Storbacka, & Frow, 2008). The firm offers a value proposition which is the value foundation to be used by customers, and the customers then add their own resources and skills, the potential of these resources is developed into value-in-use (Grönroos, 2008).

For instance, let’s take the experience from a café, what are the attributes of the café, what are the outcomes of the experience and how did the attributes of the café become the outcomes of the experience. The firm offers value propositions with the attributes of the café such as music, ambience, good coffee and nice space. The customers create value-in-use through the outcomes of the experience such as relaxed, chilled, feel good, cozy and warm. In fact, the customers realize the attributes of the café to
become the outcomes of the experience. The importance is that the customers need to add their own resources and skills to develop value propositions into value-in-use.

The difference between value-in-use and value-in-exchange is important because they form the base of value theories (Hall, Cleveland, & Kaufmann, 2008). The view of Good Dominant logic (G-D logic) is based on the value-in-exchange notion (Vargo, Maglio, & Akaka, 2008). In G-D logic, value is created (produced) by the firm and distributed in the market, usually through exchange of goods and money. This view implies that firm’s production processes create value for customers through manufacturing and delivering of a product, in which the firm embedded value in such product. The customer then consumes or destroys this value embedded in the product they have purchased. The alternative view of Service Dominant logic (S-D logic) is based on the value-in-use notion (Vargo et al., 2008). In S-D logic, customer is always the value creator while the firm is facilitator for value creation. Since customers use firm resources and add their resources and skills, the potential of these resources is developed into value-in-use. This view of value creation suggests that there is no value until goods or services are used, in which experience and perception are essential to value determination (Vargo & Lusch, 2008).

2.2. Value co-creation

The foundation of value creation is rapidly shifting from firm-centric view (G-D logic) to customer experience (S-D logic) (Prahalad & Ramaswamy, 2004), and joint value co-creation (O-D logic) (Ojasalo, 2010). In addition, a trend toward the integration of goods and services into a single offering implies that the production means the creation of a combined product of goods and services (Johansson & Olhager, 2006), in which several actors contribute by performing specific activities. The offering can provide benefits to the customers not only in the form of physical products, but also in the form of service transactions, new information and interpersonal relationships (Ramírez & Wallin, 2000).

The view of Offering Dominant logic (O-D logic) is based on value co-creation perspective that emphasizes on firm-customer interaction and value trade-off between the firm and the customer. The customer can actively participate in firm’s production process as co-producer (Grönroos, 1978; Ojasalo, 2003; Parks et al., 1981; Trinh & Kachitvichyanukul, 2013; Wikström, 1996). The level and nature of co-production is viewed as strategic decisions that must be managed by the firm (Ojasalo, 2010). The value creation process can be defined as a series of activities performed by the customer to achieve a particular goal (Payne et al., 2008). The customers determine what they value when they use the product, and the firm can only offer value propositions (Ballantyne & Varey, 2008). The firm’s opportunities for value co-creation do not only influence the customers’ value creation, but it also has an impact on customers’ future purchasing and consumption behaviour. In O-D logic, value becomes a joint function of actions of the firm and the customer, but it is always determined by the customer (Vargo & Lusch, 2006).

Let’s take Iphone as an example. The Iphone is beautifully designed with a minimum set of features that would be needed for an internet-connected phone and multimedia device. What Apple does not know is how people would use the device. Every usage pattern is contextual in nature, and the end-user is the final missing piece in completing the product. As a result, Apple created the Appstore so that people could come up with new ways for using the device.
Value co-creation emphasizes the firm-customer interaction through a dialogical, personalize interaction, enabling a joint value creation (Prahalad & Ramaswamy, 2004) as in Figure 1. In firm perspective, the firm takes on the two roles of value facilitator and value co-creator. If the system is closed for the customer, the firm only produces resources that facilitate the customer’s value creation. In customer perspective, the customer plays dual roles of value creator and co-producer. If the system is closed for the firm, the customer creates value independently from the firm. In value co-creation perspective, the system is open for both the firm and the customer. Value co-creation occurs in the firm-customer interaction process, where the customer is a co-producer of resources and processes with the firm, and the firm could take part in the customer’s experience of value-in-use and influence it as a value co-creator.

3. Game theory approach

3.1. Joint value function

Since customer is treated as co-producer in the offering process (Trinh & Kachitvichyanukul, 2013), besides firm capital ($K$) and firm employee ($H$), customer input ($L$) should be included in the following co-production function.

$$Q = f(K, H, L) = A \times K^\alpha \times H^\beta \times L^\gamma$$

(1)

where $A$ is total factor productivity, $Q$ is total output of the offering. $K$, $H$ and $L$ are firm capital, firm employee and customer input, respectively, and $\alpha$, $\beta$ and $\gamma$ are the output elasticities of input factors. The co-production function yields constant returns to scale with $\alpha + \beta + \gamma = 1$; increasing returns to scale with $\alpha + \beta + \gamma > 1$; and decreasing returns to scale with $\alpha + \beta + \gamma < 1$.

By using the least-cost combination of production inputs, cost function $F$ of the offering can be determined as follows:

$$F = w_K K + w_H H + w_L L$$

(2)

where $w_K$ and $w_H$ are unit prices of firm capital and firm employee, respectively. $w_L$ is a unit cost of customer input.

Consider a customer $i$ ($i = 1 \ldots n$) uses an offering $j$ ($j = 1 \ldots m$) with the output of $Q_{ij}$. Thus, $u_{ij}$ is utility of customer $i$ in using the offering $j$.

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Figure 1. Value co-creation perspective.
Source: Adapted from Grönroos and Voima (2011).
where $v_j$ is unit value (value-in-use) and $p_j$ is unit price (value-in-exchange) in using the offering $j$. Total utility is the sum of the utility of all customers ($i = 1 \ldots n$) obtained in all offerings ($j = 1 \ldots m$). Therefore, total utility ($U$) is given by:

$$U = \sum_{i=1}^{n} \sum_{j=1}^{m} u_{ij} = \sum_{j=1}^{m} \left( (v_j - p_j) \times Q_j - w_{Lj} \times L_j \right)$$

where $Q_j$ is total outputs received by customers in using the offering $j$, and $L_j = \sum_{i=1}^{n} L_{ij}$. The firm profit ($\pi_j$) in providing the offering $j$ is determined as follows:

$$\pi_j = p_j \times Q_j - (w_{Kj} \times K_j + w_{Hj} \times H_j)$$

Therefore, total profit ($\Pi$) is given by

$$\Pi = \sum_{j=1}^{m} \pi_j = \sum_{j=1}^{m} (p_j \times Q_j - (w_{Kj} \times K_j + w_{Hj} \times H_j))$$

Since joint value ($V$) is sum of total utility ($U$) and total profit ($\Pi$), the formula of the joint value can be expressed as:

$$\text{Joint value: } V = \sum_{j=1}^{m} v_j \times Q_j - \sum_{j=1}^{m} \left( w_{Kj} \times K_j + w_{Hj} \times H_j + w_{Lj} \times L_j \right)$$

From the above join value formulas, the process of value co-creation is driven by value-in-use ($v_j$), but monitored by value-in-exchange ($p_j$). When the firm gets access to join the customer’s value creation as value co-creator, value-in-use ($v_j$) is co-created upon firm resources and customer resources. Meanwhile, value-in-exchange ($p_j$) has an impact to levels of output ($Q_j$) and a trade-off between firm profit ($\Pi$) and customer utility ($U$).

### 3.2. Game theory model

Game theory analyses situations involving at least two interactive decision-makers (called players) with different goals (Borm, Hamers, & Hendrickx, 2001). In this paper, a game theory approach is used to explore firms’ strategic behaviours in value co-creation systems. Game theory model considers two firms (Firm A and Firm B) serving the same group of customers, each firm has a choice of only two strategies: cooperation or competition (non-cooperation). Figure 2 illustrates a game theory model for value co-creation.

For each firm, joint value ($V$) between the firm and the customers is determined from Equation (7), i.e. $V = \sum_{j=1}^{m} v_j \times Q_j - \sum_{j=1}^{m} \left( w_{Kj} \times K_j + w_{Hj} \times H_j + w_{Lj} \times L_j \right)$. Since $Q_j$ and $v_j$ are predetermined, the joint value ($V$) is maximized only when the joint cost ($F = \sum_{j=1}^{m} \left( w_{Kj} \times K_j + w_{Hj} \times H_j + w_{Lj} \times L_j \right)$) is minimized as in the following joint value model.

The joint value model:

$$\text{Max } V = \sum_{j=1}^{m} v_j \times Q_j - \sum_{j=1}^{m} \left( w_{Kj} \times K_j + w_{Hj} \times H_j + w_{Lj} \times L_j \right)$$
Subject to

\( Q_j = A_j \times K_j^{w_j} \times H_j^{b_j} \times L_j^{c_j}, \quad \forall j = 1 \ldots m \) \{Co-production function\}

\( \forall K_j, H_j, L_j, \quad \forall j = 1 \ldots m \)

From the value co-creation perspective, firms’ strategic behaviours should be subjected to the value trade-off between the firm and the customer. The following model is developed to conduct a trade-off between firm profit and customer utility in value co-creation systems.

The value trade-off model:

\[
\text{Max } U = \sum_{j=1}^{m} \left( (v_j - p_j) \times Q_j - w_{L_j} \times L_j \right) \quad \{\text{Customer utility}\}
\]

\[
\text{Max } \Pi = \sum_{j=1}^{m} \left( p_j \times Q_j - (w_{K_j} \times K_j + w_{H_j} \times H_j) \right) \quad \{\text{Firm profit}\}
\]

Subject to

\( Q_j = A_j \times K_j^{w_j} \times H_j^{b_j} \times L_j^{c_j}, \quad \forall j = 1 \ldots m \) \{Co-production function\}

\( \forall K_j, H_j, L_j, \quad \forall j = 1 \ldots m \)

The above multi-objective optimization model provides Pareto-optimal solutions (value trade-off) between firm profit and customer utility. The Multi-Objective Particle Swarm Optimization (MOPSO) algorithm from ET-Lib: Objective Library for Evolutionary Techniques (Nguyen, Ai, & Kachitvichyanukul, 2010) to identify a value trade-off (Pareto front) between firm profit and customer utility. Key parameters of MOPSO algorithm used in simulation experiments are as follows:

- Population size (number of particles) is 50 particles.
- Personal/global/local/near-neighbour acceleration constants \((c_p/c_g/c_l/c_n)\) are 1/1/1/1.
• Number of iteration is 500.
• The maximal/minimal inertia weights \( (w_{\text{max}}/w_{\text{min}}) \) are .9/.4.

4. Simulation experiment

4.1. Experiment cases

Simulation experiments are carried out on the hypothetical production system with a single offering \((j = 1)\), in which the co-production function is assumed to be a well-defined function with total factor productivity of 1 \((A_j = 1)\) and constant returns to scale \((\alpha_j + \beta_j + \gamma_j = 1)\) with \(\alpha_j = \beta_j = 2\gamma_j\). Table 1 presents parameters of the co-production system. In addition, unit value \((v_j)\) and unit price \((p_j)\) are initially assigned to be 20 and 15, respectively.

The simulation experiments are designed for two experiment cases: the first experiment (case 1) is to conduct value trade-offs between the firm and the customer, and the second experiment (case 2) is to study firms’ strategic behaviours in the value co-creation systems.

Experiment 1: ‘Value trade-offs between the firm and the customer’.

The experiment is carried out on a perfect competition market that has numerous firms and customers. Both the firm and the customer have no market control, and they are price-takers and value-takers. In order to conduct a trade-off between firm profit and customer utility, a proposed firm with a single offering has the parameters of the production system as in Table 1.

The experiment is expected to provide the following information:

• Relationship between total output and total cost.
• Trade-off between firm profit and customer utility.
• Effects of changes in price and value on the trade-off.

Experiment 2: ‘Firms’ strategic behaviours in the value co-creation systems’.

The experiment is carried out on an imperfect competition market that has only two firms (Firm A and Firm B). The firms provide the same single offering for customers. The firms’ production system is given the same parameters as in Table 1.

The experiment is expected to analyse the firms’ strategic actions of cooperation and competition. The cooperation action occurs only if Firm A and Firm B coordinate the quantity of the offering as the commitments. The competition (non-cooperation) action occurs only if Firm A or Firm B does not coordinate the quantity of the offering as the commitments. These strategic actions will affect the market quantity of the offering. In

| Parameters                  | Sign | Value |
|-----------------------------|------|-------|
| Total factor productivity   | \(A\) | 1     |
| Unit cost of firm capital   | \(w_K\) | 10    |
| Unit cost of firm employee  | \(w_H\) | 3     |
| Unit cost of customer input | \(w_L\) | 2     |
| Output elasticity of firm capital | \(\alpha\) | .4 |
| Output elasticity of firm employee | \(\beta\) | .4 |
| Output elasticity of customer input | \(\gamma\) | .2 |

Note: The co-production function is assumed with \(\alpha + \beta + \gamma = 1\).
imperfect competition market, changes in market quantity \((Q_j)\) cause changes in unit price \((p_j)\) and unit value \((v_j)\) as assumed in Table 2.

### 4.2. Experimental results

**Experiment 1:** ‘Value trade-offs between the firm and the customer’.

From the experimental results, the relationship between total cost \((F)\) and total output \((Q)\), and trade-offs between firm profit and customer utility are represented in Figure 3. There are various effective input combinations to produce different levels of desired output, in which total cost is minimized. Meanwhile, the trade-off between total utility and total profit presents effective input combinations at the certain level of output as illustrated in Figure 3 with respect to three levels of output \((Q_j = 20, Q_j = 25, Q_j = 30)\). It notes that the unit price \((p_j)\) and the unit value \((v_j)\) are still holding the constant values of 15 and 20, respectively. For the higher levels of output, the value trade-off (Pareto front) moves far from the origin.

The study on effects in price (value-in-exchange) and value (value-in-use) is important for the design of efficient value co-creation systems. Figure 4 illustrates effects in price to the trade-off between total utility and total profit. If market price changes from \(p_j = 15\) to \(p_j = 18\), this causes increases in total profit and decreases in total utility. In contrast, total profit will decrease and total utility will increase if market price is decreased from \(p_j = 15\) to \(p_j = 12\). Meanwhile, effects in value often affect to total utility rather than total profit. Figure 4 illustrates effects at different levels of value \((v_j = 18, v_j = 20, v_j = 22)\) on value trade-off.

**Experiment 2:** ‘Firms’ strategic behaviours in value co-creation systems’.

### Table 2. Demand and value for the offering.

| Demand quantity \((Q)\) | Unit price \((p)\) | Unit value \((v)\) |
|------------------------|------------------|------------------|
| 25                     | 15               | 20               |
| 30                     | 14               | 18.5             |
| 35                     | 13               | 17               |

Figure 3. Co-production function and value trade-offs.
The joint value ($V$) represents the strategic outcome that depends on the consequence of each possible pair of actions. From the result of simulation experiment, the joint value ($V$) gains a maximum value at the market quantity ($Q$) of 25 with unit price ($p$) and unit value ($v$) of 15 and 20, respectively. Cooperation action occurs only when both Firm A and Firm B commit to offer the quantity level of 12.5 to maximize total joint value. Figures 5 and 6 present the matrices of strategic actions and strategic outcomes in the game theory model.

For the pair of cooperative–cooperative actions, firms will coordinate the quantity of current production ($Q = 25$) to maximize total joint value. Each firm offers the output ($Q_A = Q_B$) of 12.5 with the unit price ($p$) of 15 and the unit value ($v$) of 20. Figure 7 illustrates strategic trade-off and outcome for the pair of these actions.

For the pair of cooperative–non-cooperative actions, one firm coordinates with the output ($Q_A$) of 12.5 and another firm does not coordinate as the commitment and offers the output ($Q_B$) of 17.5. Since total output ($Q = Q_A + Q_B$) increases to 30, the unit price ($p$) and the unit value ($v$) decrease to 14 and 18.5, respectively. The experimental result reveals that Firm B (non-cooperation) gets the joint value higher than Firm A. Strategic trade-off and outcome are illustrated as in Figure 8.

Figure 4. Effects in price and value on value trade-off.

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**Firm B’s strategic behaviours**

| Cooperation | Non-Cooperation |
|-------------|-----------------|
| $Q = 12.5$  | $Q = 17.5$      |
| $p = 15.0$  | $p = 14.0$      |
| $v = 20.0$  | $v = 18.5$      |

Figure 5. The matrix of strategic actions.
Figure 6. The matrix of strategic outcomes.

| Firm B’s strategic behaviours | Cooperation | Non-Cooperation |
|------------------------------|-------------|-----------------|
| V = 89.26                    | U = 30.35   | Π = 58.91       |
| V = 98.72                    | U = 33.74   | Π = 64.98       |
| V = 70.51                    | U = 24.10   | Π = 46.41       |

Figure 7. Trade-off and outcome under cooperative–cooperative strategies.

Figure 8. Trade-off and outcome under cooperative–non-cooperative strategies.
For the pair of non-cooperative–non-cooperative actions, both firms do not coordinate on the quantity of production as in the commitment \((Q_A = Q_B = 12.5)\). Instead of this, each firm offers the output \((Q)\) of 17.5 with the unit price \((p)\) of 13 and the unit value \((v)\) of 17 as in Table 2. As a result, non-cooperation firms get the joint value lower than cooperation firms. Figure 9 illustrates strategic trade-off and outcome for the pair of these actions.

The matrix of strategic outcomes provides the joint values \((V)\) for each pair of actions as in Figure 6. This matrix meets two identifying characteristics: each firm has a dominant strategy and the consequence of these dominant strategies is a Pareto-inferior outcome. Although non-cooperation (competition) action is the dominant strategy for each firm, but firms with cooperative actions could be better off in terms of total join value.

The strategic tension between cooperation and competition is the tension between a low risk with moderate joint value (cooperative actions) and a high risk with high joint value or low joint value (competitive actions). In addition, the coordination failure is entirely consistent with ‘common belief of rationality’ because each firm would have preferred competitive action given that the other was choosing cooperative action. However, the cooperative behaviour guarantees that the maximum value will be created in terms of total joint value, firm profit and customer utility.

5. Conclusion
The paper explores value concepts and introduces the game theory approach for value co-creation systems. The difference between value-in-exchange and value-in-use is important because they form the base of value theories that also reflect a different way of thinking about value and value creation. From the value co-creation perspective, value becomes a joint function of actions of the firm and the customer. The customer not only participates in the firm processes as co-producer, but also the firm processes are incorporated into specific customer’s value creation processes that are likely to lead to the discovery and understanding of customers’ latent needs.

The simulation experiments are carried out on the hypothetical system under the perfect and imperfect competition markets. The experimental result indicates that there exists the value trade-off between the firm and the customer. The value trade-off is
fundamental to negotiation analysis, in which price negotiation in contracts may gain the maximum joint value between the firm and the customer. The experimental result also indicates the strategic tension between cooperation and competition that is fundamental to competition analysis. Although the competitive action is the dominant strategy for each firm, but the firms’ cooperative actions guarantee to gain a maximum joint value. However, game theory approach studies the behaviours of rational players. The assumption of rationality is the main limit for the application of game theory in reality. In addition, price and value are not the main drivers of customer’s purchase, and strategic trade-offs are not the same of firms’ goals. The further research should consider the game theory model with multiple players (with different goals) and market structures. The paper contributes theoretical insights on the value co-creation and the firms’ strategic behaviours in the value co-creation systems. The challenge of linking theory and practice requires various empirical studies to test the reality of the game theory approach and support its shortcomings to further research and refinement.

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