A STUDY OF LEAD TIME IMPACT IN DUAL-CHANNEL SUPPLY-CHAIN FINANCIAL PERFORMANCE: AN INDONESIAN CASE

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Abstract

Dual channel supply chain(in short DCSC) has been encountering its growing phase in recent years. This concept of selling a particular product through offline/conventional store as well as through newly introduced online channel offers revenue addition and new market captive. Aside of this advantage, however, implementing DCSC also comes along with some challenges. Channel inner-competition between offline and online one is one of them. In giving a theoretical based grip for offline and online managers, this paper proposes a portray of DCSC inner-competition by exposing the effect of lead time happens in online channel to both individual channel or total supply chain financial performance. An improved model based on author's previous work series on DCSC is utilized to analyze this purpose. The improvement is done by incorporating a corresponding lead time parameter in the basic DCSC demand function. After doing numerical example based on Bertrand scheme for offline-online price setting and performing sensitivity analysis on important system parameter, a set of managerial implication is brough forward as the work result.

Keywords*:dual channel supply chain, lead time, Bertrand scheme*

1. INTRODUCTION

Dual channel supply chain (hereinafter is abbrebiated as DCSC) is a concept of offering one particular product to a volatile market in which the customers may easily switch their preference to purchase the product through either offline/conventional channel or online/internet equipped one. Some product has been distributed by employing this structure, for example books, musics, tickets, apparels, electronic appliances, etc. A number of international giant companies have also implement DCSC, such as Dell, Sony, Panasonic, etc as manufacturer examples or Wall Mart, Kmart, etc as retailer ones . In Indonesia, some business units attempt to adopt such concept into their practices. Garuda Indonesia, Jawapos, and the likes are industrial examples. In addition Gramedia, Sport Stations, and so on are the abstraction from retailers contingent.

This concept has been evoluting since the introduction of the internet for its mass usage in the early of 1990. The first brought-up terminology by DCSC proponents was "mail versus mall" by Balasubramanian (1998) in contrasting the electronic-online transaction by using the word mail and the conventional business transaction in conventional store by using the word mall.

Following this initiator, more explicit idea on DCSC concept was stated in the term of "dual channel" in the beginning of 2000. Some authors like Yao and Liu (2003) and Chiang et al. (2003) are the supporter. After this introduction, some followers tried to introduce different phrase for proposing similar concept, for example: direct versus indirect channel, retail versus online channel, and brick versus click channel were acquainted by Bendoly et al. (2007), Kumar and Ruan (2006), and Kurata et al. (2007). Since 2008, the terminology of DCSC has been becoming more frequently to be used and the beneficial insight on it has been becoming more significant and fruitful. The author such as Huang and Swaminathan (2009), Mahar et al. (2009) and Liu et al (2010) are amongst the contributors.

Author own work series are intensively devoted in the area of DCSC. The study on DCSC return and to solve this problem by proposing a new idea of buying online and return the non-conformed product to offline channel, or cross-channel mechanism was proposed in Widodo et al., (2011). In evaluating revenue and profit management to alleviate channel conflict problem in DCSC, author has proposed offline channel's profit decrease controller mechanism in Widodo et al., (2012) and adjusted-*Stackelberg* scheme for profit sharing in Widodo et al., (2013a). Furthermore, an investigation on the resale of the returned product in to initial/primary market versus to secondary market was also performed in Widodo et al., (2013b).

Nonetheless none of those works considers analytically service level in online channel side. As it is generally understood, there is no lead time in offline sale as the customer directly can receive the product directly after sales are concluded. Moreover, based on author best knowledge and own experience in observing online channel practices in Indonesia, lead time is considered as one critical indicator in determining the preference of customer either to shop offline or online. Moreover, in the customer viewpoint, lead time is essentially comparable to price in deciding whether an order is going to be placed or not. Hence, there is an imaginary trade off in customer perception prior to his or her purchase. In short, lead time is a critical parameter which may influence positively to the online sales directly and to the offline sales indirectly.

Based on this research gap, this work presents a research problem as up to what extent lead time influence the financial performance of conventional/offline channel, online channel, and the whole DCSC? What main property of DCSC structure should be anticipated attentively to maintain entire system financial performance in the desired level?

To give the solution to this problem, lead time is incorporated into previously established DCSC demand models (Widodo et al., 2011) to provide the main element of proposed analytical model. This analytical model further is utilized to evaluate the role of lead time in changing customer preference in placing his/her order under DCSC structure. The model comprises the individual channel profit, both offline and online, and the whole structure as well.

An Indonesian case of selling book under DCSC structure is utilized to exercise the models. Further complementary step of sensitivity analysis is undertaken in obtaining the inductive implication. The result is then proposed as a set of new insight in managing better DCSC.

2. SYSTEM UNDER DISCUSSION

In giving a boundary of conceptual model, the system under discussion (SUD) is elaborated. DCSC is a mixed structure of already established conventional/offline channel and newly added online channel. This structure is employed to sale one particular product from a manufacture through a central warehouse. Both offline and online channel get supplied from this central warehouse. As the decision variables, central warehouse, online, and offline channel respectively determine their prices, namely P_{cw}, P_o , and P_s. The main parameter in this work is lead time, t in online channel, which is defined as the time interval starting from an online order is placed to the product reach the customer place. Figure 1 illustrates the SUD of this work.

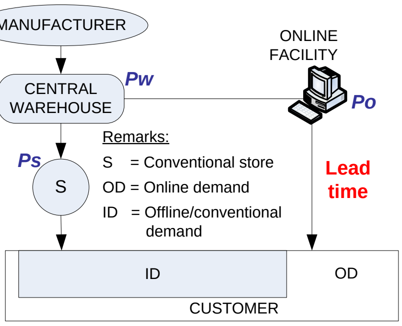

Figure 1. System under discussion: DCSC with lead time consideration

As a case study, a DCSC structure for selling books in Indonesia is selected. From this structure, system characteristic is measured to get a set of real parameters values. These parameters are:

1. Demand maksimum for one particular book as object under discussion (in short OUD), D_s^{max}.
2. Unit cost for OUD, cost per unit in obtaining OUD from its manufacturer, C_u.
3. Lead time t, a time interval from online facility dispatching to customer receiving.
4. Lead time converter ϕ, a conversion coefficient from time into unit.

5. Online customer acceptance ρ, a fraction to refer online customer valuation for OUD relative to that in offline channel.
6. Price converter β, to convert price in all channel to become unit measure.

There parameters value are collected from SUD in representing book selling under Indonesian DCSC characteristic.

2.1 MODEL DEVELOPMENT

Based on current research question and selected SUD, corresponding analytical model is developed. The main elements of measuring DCSC financial performance are offline and online demand functions. As for the initial step, offline demand function should be modified first. This function is referred from Widodo et al. (2011) as expressed in the following equation (1).

$$D_s = d_s^{max} - \beta\left(\frac{P_s - P_o}{1-\rho}\right) \tag{1}$$

To expose lead time impact on DCSC performance, lead time component is inserted into equation 1. The logic is the greater online lead time t is, the greater offline demand D_s will be (or the smaller online demand D_o will be). Hence the role of lead time in offline demand function is as an additional item. Moreover, since the unit of t is time while the unit of D_s is unit product, then a conversion parameter is necessary. In filling this need, lead time converter ϕ is introduced altogether with t. Hence the offline demand function after modification is given in the following equation (2).

$$D_s = d_s^{max} + \phi t - \beta\left(\frac{P_s - P_o}{1-\rho}\right) \tag{2}$$

By drawing basic demand function $D_s = D_s^{max} - P_s$ and equation (2) in Cartesian coordinate, we may get a shifting area between these two functions. Practically this area can be define is a part of customers who switch their preference from previously prefer online shopping to offline purchase because of the lead time consideration. Having performed this subtraction, the following online demand function is given as:

$$D_o = \frac{\rho\beta P_s - \beta P_o - (1-\rho)\phi t}{\rho(1-\rho)} \tag{3}$$

Based on equation (2) and (3) then the offline profit G_s, and online profit $G_{w,o}$ can be developed respectively in the equation (4) and (5).

$$G_s = D_s\,(P_s - P_w)$$
$$= \left(d_s^{max} + \phi t - \beta\left(\frac{P_s - P_o}{1-\rho}\right)\right)(P_s - P_w) \tag{4}$$

Note that $G_w = D_s(P_w - C_u) + D_o(P_w - C_u)$ and $G_o = D_o(P_o - P_w)$, then

$G_{w,o} = G_w + G_o$

$$= \left(\left(d_s^{max} + \phi t - \beta\left(\frac{P_s - P_o}{1-\rho}\right)\right)(P_w - C_u)\right) + \left(\left(\frac{\rho\beta P_s - \beta P_o - (1-\rho)\phi t}{\rho(1-\rho)}\right)(P_w - C_u)\right) + \left(\left(\frac{\rho\beta P_s - \beta P_o - (1-\rho)\phi t}{\rho(1-\rho)}\right)(P_o - P_w)\right) \quad (5)$$

Having constructed offline profit G_s, and online profit $G_{w,o}$ functions, then whole system profit as a representation of total system financial performance can be defined as

$$\max_{P_w, P_o, P_s} G = \max_{P_w, P_o, P_s}(G_s + G_{w,o}) \quad (6)$$

subject to the following constraints of:

1. Positive value of selling prices in all DCSC channels, including central warehouse, online and offline channel $P_w, P_o, P_s \geq C_u$. (7)
2. Threshold value for P_s so that online channel may exist $P_s \geq \frac{\beta P_o + \phi t(1-\rho))}{\rho}$. (8)
3. Positive profit margin in all channel $P_o, P_s \geq P_w$. (9)
4. Positive offline demand $d_s^{max} + \phi t - \beta\left(\frac{P_s - P_o}{1-\rho}\right) \geq 0$. (10)
5. Positive online demand $\frac{\rho\beta P_s - \beta P_o - (1-\rho)\phi t}{\rho(1-\rho)} \geq 0$. (11)

2.2 NUMERICAL EXAMPLE

Having observed the SUD, the value of necessary system parameters are collected, namely $D_s^{max} = 108\,unit$; $C_u = Rp\,35.000$; $\rho = 0.89$ $t = 5\ days$; $\phi = 4.8\,unit/day$; $\beta = 0.001\,unit/Rp$. These parameter values are substituted into equation (6) as the objective function and all constraints in equation (7) – (11). In determining optimum solution, quadratic programming is applied and *Bertrand scheme* is employed. Quadratic programming is selected to accommodate the property of price variable in constructed objective function. It can be understood because demand is basically a function of price. Revenue itself is a product of demand multiplied by price. Hence price's order is 2. Hence quadratic programming is appropriate to solve the problem. In considering the step taken by offline and online managers to determine channel price, *Bertrand scheme* is selected ahead of *Stackelberg leadership scheme*. The reason is the pragmatism aspect offered by *Bertrand scheme* in the view of achieving the optimum solution simultaneously by aggregating offline and online parameters and constraints at the same time. However, it will be a very interesting work to expose in more detail on the influence of step-by-step decision making as offered by *Stackelberg leadership scheme*.

The result of current work numerical experiment is shown in the following table (1).

Table 1. Numerical experiment result

Pw	Po	Ps	DsMax	Cu	ϕ	t	β	ρ
35,000	64,386	70,954	108	35,000	4.8	5	0.001	0.89
Ds	**Do**	**Gw**	**Go**	**Gwo**	**Gs**	**G**		
24.29	14.33	0	421,147	421,147	873,355	1,294,503		

Table (1) illustrates DCSC managers' the best decision on their channel prices, i.e. $P_w = Rp\,35.000$, $P_o = Rp\,64.386$, and $P_s = Rp\,70.954$ for central warehouse, online and offline channel respectively. With respect to aforementioned system parameter values, these prices are the local optimum solutions to guarantee the local maximum total DCSC profit $G = Rp\,1.294.503$.

This total profit can be brokendown into individual profit, namely conventional store/offline channel profit $G_s = Rp\,873.355$ and online channel profit $G_{w,o} = Rp\,421.147$. These profits are generated by offline and online demand. These demand values also indicate reasonable output. Offline demand is still greater than online one, $D_s = 24.29 > D_o = 14.33$, which is very practical for dual channel case in Indonesia.

To compare with current price in SUD, the numerical experiment result provides better total profit. In practice, the prices are intuitively set as $P_w = Rp\,35.000$, $P_o = Rp\,65.000$, and $P_s = Rp\,65.000$ for central warehouse, online and offline channel respectively. This composition yields $G = Rp\,1.137.978$ which is lower that the suggested provit at $G = Rp\,1.294.503$. Up to this point, it has been proven that the proposed model performs financially better then the current intuitive practice.

Aside of this better pricing proposal, it is understandable that the price composition is still an abstraction of local optimum solution. Something more general is necessary to make this work become more significant. Hence supplementary analysis is applied.

Since author main consideration in current DCSC work is lead time, then $t = 5$ in parameter set should be generalized by doing sensitivity analyzis of profits (G_w, G_o, G_s) to lead time. The value of default setting $t = 5$ is shifted up and down per 10%. The result is illustrated in figure (2).

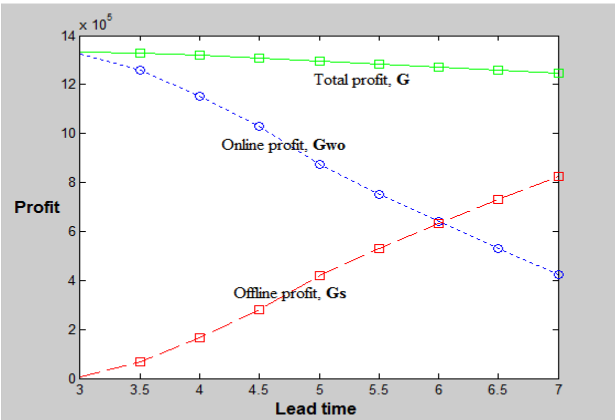

Figure 2. Offline, online and total profit sensitivity to lead time

Not only sensitivity for t, it is also necessary to consider the parameter of online customer acceptance on online sales relative to the offline sales, ρ. The author previous DCSC work series reveal the fact that this parameter has critical influence in generating online demand and suppressing offline one. The value of default setting $\rho = 0.89$ is shifted up and down per 1%. The result is illustrated in figure (3).

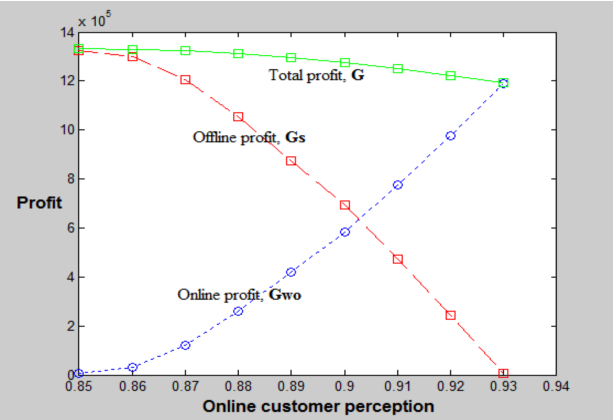

Figure 3. Offline, online and total profit sensitivity to online customer perception

From Figure (2) and (3) it can be stated that:

1. Both t and ρ have similar relationship to total system profits G. The greater t and ρ are, the smaller total profit G is. However the decrease in total profit is relatively slight.
2. In the individual channel perspective, there are some opposite effects of t and ρ to offline profit G_s and online profit G_{wo}.
   a. In offline channel perspective, the greater t is, the greater offline profit G_s is (Figure 2). Conversely, the greater ρ is, the smaller offline profit G_s will be (Figure 3).
   b. In online channel perspective, the greater t is, the smaller online profit G_o is (Figure 2). Conversely, the greater ρ is, the greater online profit G_o will be (Figure 3).
3. There is a threshold value in each figure. It means the shift of t or ρ may significantly change the profit distribution between offline and online channel.
   a. If the consideration is lead time, online channel experiences better profit distribution than offline channel when online channel can make sure its lead time is below the threshold value. As expressed in Figure (2), lead time threshold value is approximately $t_{threshold} = 6\ days$. For offline channel, opposite situation is preferred.
   b. If the main consideration is online customer perception, online channel experiences better profit distribution than offline channel when online channel can measure its corresponding online customer perception is beyond the threshold value. As expressed in Figure (3), online customer perception threshold value is approximately $\rho_{threshold} = 0.9$. For offline channel, opposite situation is preferred.

3. CONCLUSION

In this work, a DCSC model set incorporating lead time consideration has been successfully developed. The development is based on previous author work series on DCSC. This model is significantly beneficial in portraying the effect of online channel lead time in delivering the product from online facility dispatching to customer reception.

In total DCSC system perspective, the increase of lead time give a slight financial performance decrease. However, in individual perspective of offline channel this situation may become a favor. By nature, in online channel viewpoint, lead time is a drawback. It means, this internet equipped channel should be able to convey its product to its customer below one particular lead time threshold value. Moreover, to be compared to important DCSC property such as online customer perception, lead time has an opposite characteristic in term of its impact to channel financial performance. To assure its practicallity, in current work system under discussion, i.e.

Indonesian DCSC case study of offline and online book sales, aforementioned insight has been analytically proven.

Some complementing ideas are left for future work. To include products' relationship, not only one particular product will give more fruitful insight. Either complementary or subsitution products will be a challenging DCSC secret to reveal. Another idea is a more detail time-to-unit of product conversion is worth to be added. By doing this supplementary procedure, the analytical result will be more purified.

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