Pricing Heterogeneous Content Distribution Channels: Efficiency and Profitability

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Abstract

The paper considers the pricing and allocation issues of distributing digital contents via dedicated websites (Web channel) and peer-to-peer networks (P2P channel). We examine the allocation equilibrium between these two channels, and present an incentive scheme to achieve an efficient channel configuration for an organization. We further analyze these two distribution channels in a competitive market. A business environment with asymmetric decision information will push the price and profit of both channels higher. Particularly, the second mover enjoys both higher price and market share. When both channels are integrated, the price of Web channel will be lower than P2P channel's price, on the contrary to socially optimal pricing scheme. Consequently, the demand of P2P channel shrinks, and more customers experience worse service quality from Web channel.

Keywords: content distribution channels, competition and integration, network pricing, peer-to-peer, client server.

1. Introduction

The Internet provides a low-cost channel to distribute a wide variety of information goods. The digitally stored products transferred over the Internet include computer software, music, video clips, artworks, books, sport scores, and news. Today, it is common that people download the products through two important types of distribution channels: a dedicated Internet website that specializes in storing these products (such as iTune for music) and a variety of Peer-to-Peer (P2P) networks in which products are downloaded from other participating peer nodes (such as KaZaA, Gnutella, and Grokster). While extensive studies have been conducted on the technological dimension of different content delivery systems, this paper focuses on the economic analysis of the coexisting content distribution channels.

A P2P network is a social network for pooling resources, such as computing cycle, hard disk storage, network bandwidth, and contents, at numerous edge nodes. Among the various P2P applications to exchange resources and to share information, the most popular and prevalent one might be file sharing, which accounted for five of the top ten downloads from the web site, download.com, in the last week of June 2002. The number of P2P file sharing Web pages combined with the number of 4.5 million downloads has increased more than 300 percent in the last 12 months (Lee 2003). According to file sharing research firm BigChampagne, despite the lawsuit against developers and consumers, P2P activity continued to rise throughout 2005 hitting record levels in December. Worldwide there were an average 9.5 million simultaneous users, two million more than a year earlier (PC Pro News, January 12, 2006).

A Website channel provides higher capacity (bandwidth) and security environments, however, its delivery performance deteriorates as the number of the customers increases, because of its centralized client server architecture. On the other hand, while P2P channel provides a more scalable distribution infrastructure, pooling the bandwidth of the peer nodes, P2P participants face extra sharing costs from security uncertainty because of its inherent decentralized structure. Therefore, in addition to the price, a customer should take into account these factors (opportunity cost), and choose his preferable channel to download the product.

Considering the characteristics of the technological differentiation between the distribution channels and heterogeneity of consumer's preference on these two channels, we analyze the allocation and pricing problems from the perspectives of an organization and a market. We examine the self-selected equilibrium of the channel allocation and propose a pricing scheme to enforce an efficient allocation configuration within an organization. The pricing scheme shows that Web channel should be charged more to recover the efficiency loss due to over-allocation phenomena.

Utilizing game theoretic model, we further investigate pricing strategies of these two distribution channels in a competitive market. We find the equilibrium pricing decision and allocation is quite sensitive to the market power of the channel providers. A business environment with asymmetric decision information will push the price and profit of both channels higher. The leader channel loses market share because of charging higher price, however, the follower channel has the second-mover advantage to raise its price and enjoy higher demand. When both channels are integrated, the monopoly set the price of Web channel to be lower than P2P channel's price, on the contrary to socially optimal pricing scheme. This pricing strategy induces P2P-channel customers to switch to Web-channel, and finally results in worse service quality of Web-channel.

The remaining sections are organized as follows. Sections 2 lists previous literatures related to digital content distribution. Section 3 introduces the model setting. In Section 4, we examine the channel allocation and pricing scheme in an organization. We analyze the competition and integration of channels in the market in Section 5. Section 6 concludes our findings and presents future research directions.

2. Literature Review

The economic aspects of the digital content distribution channels are closely related to network pricing, distributed content distribution, and channel management. There are numerous studies on network pricing. For example, MacKie-Mason and Varian (1995) propose a congestion-based pricing model for Internet services. Medelson and Whang (1990) derive an incentive-compatible and socially optimal pricing scheme for an M/M/1 queue with multiple user classes. Considering the delay cost, Dewan and Mendelson (1990) examine the issue of budgetary balance and find that net-value maximization entails a budget deficit for the service facility. Konana et al. (2000) propose priority pricing for delay sensitive users as an on-line adaptive resource scheduling mechanism to manage real-time databases within organizations.

Recently, studies on economic incentive mechanism design of P2P networks have emerged. Golle et al. (2001) construct a formal game theoretic model to analyze the behavior of a user and suggest payment mechanisms to encourage the file exchanges activities. Antoniadis and Courcoubetis (2002) propose a market model in which peers buy and sell contents competitively within the community, considering variable content transport costs and asymmetric information. In a later study, Antoniadis et al. (2004) compare several incentive mechanisms, and suggest that a fixed scheme, where each peer shares a standard number of files, can achieve a high level of efficiency. Feldman et al. (2004) develop a model to study the phenomenon of free-riding, in which a P2P user's decision to contribute depends on her type. They suggest that a penalization mechanism for free-riding is effective when the social generality is low. Li et al. (2004) propose multiple levels of formation dynamics to investigate the self-organized sharing and grouping and linking behaviors. They find stable (self-organized) P2P network is always not efficient, and provide several incentive mechanisms to enforce a stable network become efficient.

Regarding digital channel management, Oh and Chang (2000) examine the economic situation where one network provider and one content provider can compete or collude on price and quality investment and show that the incentive of strategic vertical alliance depends on the relative market power. Lee (2002) analyzes an online information market in which one network provider and two content providers compete over both prices and content quality. He shows that sequential price choice of network providers reduces content differentiation. Gayer and Shy (2003) analyze the profit incentives of publishers to utilize the Internet and P2P for distributing versions of digital product that compete with the product sold in stores, and suggest if the externality of digital version is significant, it will increase the sales in stores. Recently, Lan and Vargov (2005) develop monopolistic pricing model to compare the profitability between P2P and client server architecture.

Previous literature covers efficient allocation and pricing, competition or monopoly within the same type of distribution channels. The main objective of this paper differs by attempting to look at those allocation and pricing dynamics between both Website and P2P distribution channels.

3. The Model

We consider a digital supply chain in which consumers (or employees in an organization) can download the digital content (or information good) from two heterogeneous distribution channels: a dedicated website (referred as Web-channel) or a Peer-to-Peer (P2P) network (referred as P2P channel). Assume the total number of customers in this market is η_0 and the total number of customers of Web channel and P2P channel are η_1 and η_2 respectively ($\eta_0 = \eta_1 + \eta_2$). The capacity (bandwidth) of the Web-channel is b_1 bytes per second and the expected bandwidth of a typical peer node in the P2P networks is b_2 bytes per second. We assume Web-channel has higher capacity than peer nodes participating in the P2P-channel ($b_1 > b_2$). For the sake of analytical convenience, the size of a content file is assumed to be f bytes.

3.1. Customer utility functions

In the model, we assume a customer downloads only a file, and the contents downloaded from either channel are homogeneous. However, the customers face different opportunity costs (delay and security uncertainty), depending on the channel chosen. A typical customer i faces heterogeneous sharing cost $\theta_i\delta$ (security uncertainty) if he/she download files through P2P-channel, where variable θ_i stands for the individual sensitivity on the sharing cost, and is uniformly distributed with an interval $[0,1]$. A customer with higher value of θ_i is more sensitive to this disutility. Parameter δ reflects the service quality level (i.e. security level) of a P2P channel. A higher value of δ indicates a higher security uncertainty may occur in file-sharing activity. Let β denote the customers' valuation for the content; p_1 and p_2 the price of content downloaded from the Web-channel and P2P-channel respectively. (Notice that the price could be zero in an organization context). The utility of each customer with δ_i is defined by

$$U_i = \begin{cases} \beta - \eta_1 w_1 - p_1 & \text{if download through Web channel} \\ \beta - w_2 - \theta_i\delta - p_2 & \text{if download through P2P channel,} \end{cases} \tag{1}$$

where $\eta_1 w_1 = \gamma\eta_1 f / b_1$, and $w_2 = \gamma f / b_2$ are the cost of waiting time in Web-channel and P2P-channel, in which parameter γ is the value of time. The delay cost functions catch the congestion externality faced by the customers of client/server based Web-channel, and the scalability of P2P-channel on the download delay. We assume that content value β is large enough, relative to consumers' reservation utilities, so in equilibrium, everyone buys (downloads) a unit. Since sharing cost (security quality) is an important factor for deciding whether to choose P2P network as the distribution channel, we also assume that $\delta > w_2$ to reflect that the security concern is significantly important, relative to the file transfer performance between two peer nodes. We also assume market size is sufficiently large ($\eta_0 w_1 \geq w_2$) to ensure coexisting of two channels.

3.2. Channel demand functions

Let $\hat{\theta}$ denote a customer type who, given prices and service levels (delays and sharing risk), is indifferent between purchasing (and downloading) from website channel and P2P channel. The utility function implies that

$$\hat{\theta} = \frac{\eta_1 w_1 - w_2 + p_1 - p_2}{\delta}. \tag{2}$$

Therefore, all customer types indexed by $\theta_i \in [0, \hat{\theta}]$ download from the P2P channel and all customers indexed by $\theta_i \in [\hat{\theta}, 1]$ download from the website channel. Further, value of $\hat{\theta}$ reveals that website channel can increase its market share by increasing its bandwidth capacity b_1 since it reduces the expected delay, whereas P2P channel can increase its market share by reducing δ to improve the sharing security. Consequently, according to conditions $\eta_2 = \hat{\theta}\eta_0$ and $\eta_1 + \eta_2 = \eta_0$, the demand functions of the Web-channel and P2P-channel are written as

$$\eta_1 = \frac{\eta_0 \left(w_2 + \delta - p_1 + p_2 \right)}{\eta_0 w_1 + \delta}, \eta_2 = \frac{\eta_0 \left(\eta_0 w_1 - w_2 + p_1 - p_2 \right)}{\eta_0 w_1 + \delta}. \tag{3}$$

4. Channels in the Organization

We consider an organization in which both website and P2P channels are installed for distributing digital content. The workers select one of the two channels to get the content. We first investigate the equilibrium channel allocation without any price scheme. Then, we compare them with the socially optimal results.

4.1. Self-Selection Equilibrium

In the absence of any pricing schemes on the channel services ($p_1 = p_2 = 0$), the users self-select a channel so as to maximize his individual utility. The resulting equilibrium demand for each channel is given by

$$\eta_1^e = \frac{\eta_0 \left(w_2 + \delta \right)}{\eta_0 w_1 + \delta}, \eta_2^e = \frac{\eta_0 \left(\eta_0 w_1 - w_2 \right)}{\eta_0 w_1 + \delta}. \tag{4}$$

The market share of each channel is

$$s_1^e = \frac{\eta_1^e}{\eta_0} = \frac{w_2 + \delta}{\eta_0 w_1 + \delta}, s_2^e = \frac{\eta_2^e}{\eta_0} = \frac{\eta_0 w_1 - w_2}{\eta_0 w_1 + \delta}. \tag{5}$$

Proposition 1. (Self-selected Equilibrium) Without any pricing scheme on the channels, (a) The P2P-channel sustains only if the total number of the users is sufficiently large ($\eta_0 > b_1 / b_2$); (b) The market share of P2P- (Web-) channel increases (decreases) as the total market size increase, whereas both market sizes of the P2P and Web channels increase as the total market size increases.

4.2. Efficient Channel Allocation

In this section, we compare the self-selected equilibrium of channel allocation with the efficient channel allocation. The efficiency of channel allocation is measured by its social welfare, which is the sum of individual utilities. In the following, we first investigate the characteristics of an efficient (or social welfare maximizing) channel allocation, which is the objective of a value-maximizing organization. The social welfare of the network is given by $W = \sum_{i=1}^{n} U_i$. The socially optimal choices can be found by solving optimization problem

$$\max_{\eta_1, \eta_2} \ W = \eta_1 \left(\beta - \eta_1 w_1 \right) + \eta_2 \left(\beta - w_2 - E\left(\theta_i \delta \right) \right) \text{ s.t. } \theta_i < \hat{\theta} \text{ and } \eta_1 + \eta_2 = \eta_0 , \quad (6)$$

and the resulting efficient allocation for each channel is written as

$$\eta_1^w = \frac{\eta_0 \left(w_2 + \delta \right)}{2\eta_0 w_1 + \delta}, \eta_2^w = \frac{\eta_0 \left(2\eta_0 w_1 - w_2 \right)}{2\eta_0 w_1 + \delta} . \quad (7)$$

Proposition 2. (Efficient Channel Allocation) (a) Self-selected equilibrium results in over-usage (under-usage) of the Web- (P2P-) channel, comparing with efficient channel allocation.(b) Closing the P2P channel is efficient if the total number of users is too small ($\eta_0 \le b_1 / 2b_2$).

To induce an efficient channel allocation, the organization can charge customers downloading content from Web channel with a price p_1^w , while keeping the P2P channel free-access. p_1^w is obtained by solving

$$\frac{\eta_0 \left(w_2 + \delta \right)}{2\eta_0 w_1 + \delta} = \frac{\eta_0 \left(\delta + w_2 - p_1 \right)}{\eta_0 w_1 + \delta} . \quad (8)$$

Thus, we have the efficient (socially optimal) pricing schemes

$$p_1^w = \frac{\eta_0 w_1 \left(w_2 + \delta \right)}{2\eta_0 w_1 + \delta} , \ p_2^w = 0 . \quad (9)$$

The pricing scheme shows that $\partial p_1^w / \partial y > 0$, $y \in \{ \eta_0, w_1, w_2, \delta \}$; in addition to the total number of users, socially optimal price increase with not only the delay in Web-channel, but also the delay and sharing cost in P2P channel.

5. Channels in the Market

In this section, we examine the pricing scheme of content distribution channels operated by profit-seeking firms. We first investigate pricing competition between these two channels owned and operated by independent firms, and then we analyze the pricing strategy and profitability when both channels are integrated.

5.1 Pricing in competitive channels

The business environment for the Web and P2P channel is largely determined by the relative market power between these two players. We consider three cases of market power distribution in non-cooperative pricing dynamics. In the first case, both channels, with symmetric market power, participate in simultaneous Bertrand pricing competition game. The next two cases consider the market structure that one of them has the leadership of pricing decision and these two channels participate in a Stackelberg (leader-follower) pricing competition game.

5.1.1. Simultaneous pricing competition

Let us first examine a simultaneous price competition between the Web-channel and the P2P-channel. Denote π_1^c (π_2^c) and p_1^c (p_2^c) be the profit function and the price of the Web (P2P) channel respectively. We have the following profit functions.

$$\pi_1^c = p_1^c \eta_1^c = p_1^c \cdot \frac{\eta_0 \left(\delta + w_2 - p_1^c + p_2^c \right)}{\eta_0 w_1 + \delta} , \quad (10)$$

$$\pi_2^c = p_2^c \eta_2^c = p_2^c \cdot \frac{\eta_0 \left(\eta_0 w_1 - w_2 + p_1^c - p_2^c\right)}{\eta_0 w_1 + \delta}. \tag{11}$$

From first order conditions, $\partial \pi_1^c / \partial p_1^c = 0$, and $\partial \pi_2^c / \partial p_2^c = 0$, we get the price response function of the Web- (P2P-) channel to the P2P- (Web-) channel's pricing decision.

$$p_1^c = \frac{w_2 + \delta + p_2^c}{2},\ p_2^c = \frac{\eta_0 w_1 - w_2 + p_1^c}{2}. \tag{12}$$

Solving both equations simultaneously, we have the Nash equilibrium,

$$p_1^c = \frac{\eta_0 w_1 + w_2 + 2\delta}{3}, p_2^c = \frac{2\eta_0 w_1 - w_2 + \delta}{3}. \tag{13}$$

Consequently, the demand functions are written as,

$$\eta_1^c = \frac{\eta_0 \left(\eta_0 w_1 + w_2 + 2\delta\right)}{3\left(\eta_0 w_1 + \delta\right)}, \eta_2^c = \frac{\eta_0 \left(2\eta_0 w_1 - w_2 + \delta\right)}{3\left(\eta_0 w_1 + \delta\right)}, \tag{14}$$

and the profit functions are

$$\pi_1^c = \frac{\eta_0 \left(\eta_0 w_1 + w_2 + 2\delta\right)^2}{9\left(\eta_0 w_1 + \delta\right)}, \pi_2^c = \frac{\eta_0 \left(2\eta_0 w_1 - w_2 + \delta\right)^2}{9\left(\eta_0 w_1 + \delta\right)}. \tag{15}$$

5.1.2. Sequential pricing competition

Suppose the Web-channel has the market power to make the pricing decision before P2P channel. P2P-channel makes pricing decision after observing the decision of the Web channel. Thus, the best response function of P2P-channel to Web-channel is the same as that from simultaneous decision, i.e. $p_2^{c_{12}} = \left(\eta_0 w_1 - w_2 + p_1^{c_{12}}\right)/2$. Utilizing backward induction approach, the profit function of Web-channel is obtained by plugging in P2P-channel's response function $p_1^{c_{12}}$, and rewritten as,

$$\pi_1^{c_{12}} = p_1^{c_{12}} \cdot \frac{\eta_0 \left(\eta_0 w_1 + w_2 + 2\delta - p_1^{c_{12}}\right)}{2\left(\eta_0 w_1 + \delta\right)}. \tag{16}$$

The first order condition for the Web channel directly yield the subgame perfect Nash equilibrium results,

$$p_1^{c_{12}} = \frac{\eta_0 w_1 + w_2 + 2\delta}{2}, p_2^{c_{12}} = \frac{3\eta_0 w_1 - w_2 + 2\delta}{4}; \tag{17}$$

$$\eta_1^{c_{12}} = \frac{\eta_0 \left(\eta_0 w_1 + w_2 + 2\delta\right)}{4\left(\eta_0 w_1 + \delta\right)}, \eta_2^{c_{12}} = \frac{\eta_0 \left(3\eta_0 w_1 - w_2 + 2\delta\right)}{4\left(\eta_0 w_1 + \delta\right)}; \tag{18}$$

$$\pi_1^{c_{12}} = \frac{\eta_0 \left(\eta_0 w_1 + w_2 + 2\delta\right)^2}{8\left(\eta_0 w_1 + \delta\right)}, \pi_2^{c_{12}} = \frac{\eta_0 \left(3\eta_0 w_1 - w_2 + 2\delta\right)^2}{16\left(\eta_0 w_1 + \delta\right)}; \tag{19}$$

Next, we examine the case in which the P2P as the first mover to decide the pricing strategy. Similarly, we have profit function of P2P-channel as

$$\pi_2^{c_{21}} = p_2^{c_{21}} \cdot \frac{\eta_0 \left(2\eta_0 w_1 - w_2 + \delta - p_2^{c_{21}}\right)}{2\left(\eta_0 w_1 + \delta\right)}, \tag{20}$$

and we get the following equilibrium results,

$$p_1^{c_{21}} = \frac{2\eta_0 w_1 + w_2 + 3\delta}{4},\ p_2^{c_{21}} = \frac{2\eta_0 w_1 - w_2 + \delta}{2}; \tag{21}$$

$$\eta_1^{c_{21}} = \frac{\eta_0 \left(2\eta_0 w_1 + w_2 + 3\delta\right)}{4\left(\eta_0 w_1 + \delta\right)},\ \eta_2^{c_{21}} = \frac{\eta_0 \left(2\eta_0 w_1 - w_2 + \delta\right)}{4\left(\eta_0 w_1 + \delta\right)}; \tag{22}$$

$$\pi_1^{c_{21}} = \frac{\eta_0\left(2\eta_0 w_1 + w_2 + 3\delta\right)^2}{16\left(\eta_0 w_1 + \delta\right)},\ \pi_2^{c_{21}} = \frac{\eta_0\left(2\eta_0 w_1 - w_2 + \delta\right)^2}{8\left(\eta_0 w_1 + \delta\right)}. \tag{23}$$

Comparing the results under various information structures (Table 1), we find that both channels' price and profit are higher in either sequential decision dynamics than in a simultaneous one. The channel with the leadership of decision has lower demand, which results in higher demand of the follower channel.

Table 1. Comparison of equilibrium results under various information structures

Leadership	Price p_i	Demand η_i	Profit π_i	Aggregate $\sum \pi_i$
Web-	$p_1^{c_{12}} > p_1^c, p_2^{c_{12}} > p_2^c$	$\eta_1^{c_{12}} < \eta_1^c, \eta_2^{c_{12}} > \eta_2^c$	$\pi_1^{c_{12}} > \pi_1^c, \pi_2^{c_{12}} > \pi_2^c$	$\pi_1^{c_{12}} + \pi_1^{c_{12}} > \pi_1^c + \pi_2^c$
P2P-	$p_1^{c_{21}} > p_1^c, p_2^{c_{21}} > p_2^c$	$\eta_1^{c_{21}} > \eta_1^c, \eta_2^{c_{21}} < \eta_2^c$	$\pi_1^{c_{21}} > \pi_1^c, \pi_2^{c_{21}} > \pi_2^c$	$\pi_1^{c_{21}} + \pi_2^{c_{21}} > \pi_1^c + \pi_2^c$

Proposition 3. (Channel price competition) In a competitive market,
(a) Both the prices of Web and P2P channels will increase as higher quality of P2P technology (lower value of δ) are provided, whereas higher uploading capacity of peer nodes (higher value of b_2) will increase the price of P2P channel but reduce the price of Web channel; (b) The price and profit levels of the player are higher in the leadership of decision than in simultaneous price competition.

5.2. Pricing in integrated channels

These two channels may be integrated as a single channel provider or form a strategic alliance to maximize joint profit. With horizontally integrated channels, price decisions of the two channels are taken simultaneously by the integrated firm. Thus, the profit-maximization problem of the monopolistic provider is written as

$$\max_{p_1^m, p_2^m} \pi^m = p_1^m\left(\frac{\eta_0\left(w_2 + \delta - p_1^m + p_2^m\right)}{\eta_0 w_1 + \delta}\right) + p_2^m\left(\frac{\eta_0\left(\eta_0 w_1 - w_2 + p_1^m - p_2^m\right)}{\eta_0 w_1 + \delta}\right). \tag{24}$$

Since Both the demand functions of Web and P2P channels are associated with the difference of these two channel price $\Delta p^m = p_1^m - p_2^m$, instead of solving the first order condition with respective to p_1^m and p_2^m, we rewrite the objective function as

$$\max_{p_1^m, \Delta p^m} \pi^m = \frac{\eta_0}{\eta_0 w_1 + \delta}\left(p_1^m\left(w_2 + \delta - \Delta p^m\right) + \left(p_1^m - \Delta p^m\right)\left(\eta_0 w_1 - w_2 + \Delta p^m\right)\right). \tag{25}$$

It can be easily observed that the joint profit is linearly increasing with p_1^m, and π^m is concave on Δp^m. Solving first order condition $\partial \pi^m / \partial \Delta p^m = 0$, we find the optimal price offset $\Delta p^m = \left(w_2 - \eta_0 w_1\right)/2$. Then, the price of Web channel p_1^m should be as high as possible such that the profit is maximized. It can be set to be a value satisfying equation $\beta - \eta_1^m w_1 - p_1^m = 0$. Hence, the pricing schemes and corresponding demand functions in an integrated channel are obtained as

$$p_1^m = \beta - \frac{\eta_0 w_1\left(\eta_0 w_1 + w_2 + 2\delta\right)}{2\left(\eta_0 w_1 + \delta\right)},\ p_2^m = \beta - \frac{2\eta_0 w_1 w_2 + \eta_0 w_1 \delta + w_2 \delta}{2\left(\eta_0 w_1 + \delta\right)}; \tag{26}$$

$$\eta_1^m = \frac{\eta_0\left(\eta_0 w_1 + w_2 + 2\delta\right)}{2\left(\eta_0 w_1 + \delta\right)},\ \eta_2^m = \frac{\eta_0\left(\eta_0 w_1 - w_2\right)}{2\left(\eta_0 w_1 + \delta\right)}. \tag{27}$$

It is noteworthy that content value β has no further impact the channel pricing schemes in an organization and competitive market whenever β sufficiently high, whereas an firm with integrated channels can set prices according to β. In our model, the market share functions of both channels are independent with the content value.

Contrary with the socially optimal price scheme ($p_1^w > p_2^w = 0$), P2P channel charges higher download fee than Web channel ($p_1^m < p_2^m$) if these two competitive channels collude. This lower price strategy will attract P2P-channel consumers to switch to Web-channel, and finally result in higher download delay in Web-channel. In a competitive market, the order is dependent on the relative disutility in these two channels (e.g. sharing cost of P2P channel and transfer delay of Web channel). If the sharing cost is relatively high then price of Web channel is higher. Price of P2P channel is higher when the number of total customers is large.

Comparing the demands of P2P channel in various business environments, we have the following relations $\eta_2^w > \eta_2^e > \eta_2^m$ and $\eta_2^{c_{12}} > \eta_2^c > \eta_2^{c_{21}} > \eta_2^m$. The integration of Web and P2P channels will result in the smallest demand of P2P downloading in a content delivery market, however, if the total number of the customers is sufficiently large, the demand of P2P channel in an efficient organization be the largest ($\eta_2^w > \eta_2^{c_{12}}$ when η_0 is sufficiently large).

Proposition 4. (Integrated channel) In an integrated channel,
(a) The price (market share) of Web-channel is lower (higher) than that of P2P- channel;
(b) Both prices of Web-channel and P2P-channel will arise as the uploading capacity of peer nodes become higher (higher value of b_2), and that will also increase(reduce) the market size of P2P channel(Web-channel).

6. Conclusion

Website and P2P networks are two important channels for distributing digital content and information good. In this paper, we have developed economic models to investigate the allocation and pricing schemes of these two channels under the business environment of an organization and competitive markets. Our analytical results show that it will be efficient to allocate more users to use the P2P channel, in the absence of any pricing scheme. In order to enforce an efficient configuration of channel allocation, a service fee on the Web channel is suggested. In competitive markets in which channels are operated by independent firms, the equilibrium pricing decisions and resulting demand distributions are significantly associated with the market power of the firm. A channel with the leadership of pricing decision can raise its service rate and generate higher profit. If these two channels are integrated as a firm, the price of P2P channel will be higher than Web channel.

In our model, we assume that valuation of the content is symmetric for all customers. Investigating the corresponding pricing strategies under heterogeneous content valuation is a planned future extension. The quality parameters, such as bandwidth capacity of Web channel and the quality of service of P2P channel, are exogenous. It will be interesting to include the quality competition between these two channels and examine how the results change according to technology investment. Besides the investigation of competition and integration between horizontal firms (channels), an interesting topic for future research is to study the business environment in which multiple content providers and channel providers participate in competition and integration game in vertical as well as horizontal dimensions.

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