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Optimal Distribution Strategy for Enterprise Software: Retail, SaaS, or Dual Channel?

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Abstract

While the optimal distribution channel strategy of physical goods has been extensively studied, there is a lack of research for that of enterprise software as a digital good. This research analyzes the optimal distribution strategy of enterprise software by taking into account the distinct features of enterprise software for both the short-run problem, in which the software quality is fixed, and the long-run problem, in which the software quality becomes part of the strategic decisions. Our results indicate that in the presence of high unfit cost relative to the customization cost, the dual channel strategy exists and generates the highest profit for the firm and the highest social welfare. When the unfit cost is low relative to the customization cost, the SaaS channel strategy becomes the best strategy for both the firm in terms of profitability and society in terms of social welfare. This key finding is robust in that it holds for both the short-run problem and the long-run problem.

Keywords: enterprise software, software distribution channel, software quality, SaaS, unfit cost, customization cost

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1. Introduction

Enterprise software, or enterprise application software, refers to the software intended to solve enterprise-wide problems, and it comprises a wide variety of types in different business functions, such as business intelligence, business process management, content management system, customer relationship management, enterprise resource planning (ERP), and supply chain management. The enterprise software market was estimated at $367.3 billion in constant U.S. dollars in 2016, with a growth of 6.9% throughout 2015 according to the Gartner Group. Traditionally, an enterprise software firm has value-added retailers (VAR) to market its product to its customers, a channel strategy commonly referred to as the retail or indirect channel strategy. Such a channel strategy is usually implemented under the On-Premises licensing model wherein the corporate customers (hereafter customers for short) purchase software by paying the price upfront and install the software locally. For example, SAP relies on the VAR to sell some of its products, e.g., AlertEnterprise reselling physical security and monitoring solutions for SAP. With the advent of the Internet, it is increasingly popular for enterprise software firms to provide their software to customers directly through the Internet, usually under the Software as a Service (SaaS) licensing model wherein customers pay a subscription fee on a recurring basis and access the software through the Internet, a channel strategy referred to as the SaaS or direct channel strategy. For example, Salesforce.com allows customers to access the software through the Internet without the participation of a retailer[1]. The enterprise software firm can employ a dual channel strategy to offer its product through the retail channel and SaaS channel simultaneously, allowing the customers to decide in which channel to participate. An example of the enterprise software distributed through a dual channel strategy is Microsoft Dynamics.

Which channel strategy is optimal for selling *physical* goods and under what conditions have been studied extensively in prior literature (Chiang, Chhajed, & Hess, 2003; Cattani, Gilland, Heese, & Swaminathan, 2006; Dumrongsiri, Fan, Jain, & Moinzadeh, 2008; Huang & Swaminathan, 2009; Xia, Xiao, & Zhang, 2013). However, several distinct features of enterprise software as a *digital* good make the optimal channel strategy issue an intriguing problem that has not been examined in the literature. First, the marginal production cost and distribution cost of enterprise software as a digital good are negligible. Prior literature, e.g., Chiang et al. (2003) and Dumrongsiri, et al. (2008), show that the firm's optimal channel strategy depends on the interplay of marginal production and distribution costs of various channels. This key finding may not be applicable for enterprise software as a digital good since those costs are negligible.

[1] See, http://www.salesforce.com/sales-cloud/overview/

Second, each different channel strategy of enterprise software comes with its own different licensing model. For example, software distributed through a retail channel is under the On-Premises licensing model, while software distributed through a direct channel is under the SaaS licensing model. There are intrinsic pros and cons for each software licensing model (Ma & Kauffman, 2014; Li, et al. 2017). Specifically, the customers under the On-Premises license usually customize the software and bear a customization cost (Born, 2003), while it is infeasible for the customers under the SaaS license to customize the software, and thus, they bear an unfit cost (Dillon, Wu, & Chang, 2010). As a result, the enterprise software firm's optimal choice of distribution channel strategy is decided by not only the inherent features of the distribution channel but also the customers' decisions influenced by the customization cost or the unfit cost that comes with the respective licensing model of the channel. Moreover, it is often assumed in prior literature that the wholesale price under the indirect channel cannot surpass the retail price under the direct channel; otherwise, the reseller can purchase the product from the direct channel at a cheaper price and resells it. However, this assumption is no longer needed for enterprise software since purchasing an SaaS product and reselling it as an On-Premises product is technically infeasible. While prior studies focus on the impact of the inherent features of the distribution channel on the firm's optimal channel strategy in the context of durable physical goods, the aforementioned unique features of enterprise software call for a reexamination of this critical issue in the enterprise software market. Lastly, prior literature on the optimal channel strategy of physical goods assumes that the quality of the product under consideration is fixed. In this paper, we consider both the short-run model, where the software quality is exogenously given, and the long-run model, where the enterprise software firm makes decisions on the optimal level of software quality and the optimal channel strategy simultaneously.

The objective of this research is to provide guidelines for enterprise software firms on deciding the optimal channel strategy. Specifically, we aim to address the following research questions, namely, which channel strategy (retail, SaaS, or dual) should the firm choose? Which factors are the drivers of the software firm's decision? Will the software firm's optimal channel strategy be the same or different in the short-run and the long-run problems? Lastly, will the distribution strategy that is optimal for the software firm also be the one that generates the highest social welfare for the whole supply chain?

We find that the dual channel strategy performs the best in terms of generating the highest profit for the firm and the highest social welfare, when the unfit cost is high relative to the customization cost. However, when the unfit cost is low relative to the customization cost, the SaaS channel is the best strategy for both the firm and for society. This result is robust since it holds for both the short-run and long-run problems and irrespective of whether the software firm is vertically integrated with the retailer or not. In the long-run problem where the software quality becomes part of the software firm's overall decision, the firm has the ideal situation, since to achieve the highest optimal level of software quality is in sync with that of the highest optimal profitability.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 explores the software firm's optimal distribution channel strategy and software quality decisions. In the short-run model, the software quality is exogenously given, and the software firm only makes the decision on distribution channel strategy. In the long-run model, the software firm chooses the optimal distribution channel and software quality simultaneously. Section 4 concludes the paper, discusses the implications of the results and offers directions of future research.

2. Literature Review

Two streams of literature are relevant to our study of optimal distribution strategy of enterprise software as a digital good – the literature on the optimal channel strategy of physical goods and the literature on SaaS supply chain.

Among the vast amounts of literature studying optimal channel strategy of physical goods, two papers are most relevant to our study of optimal channel and quality decisions of enterprise software. Chiang et al. (2003) investigate the optimal channel strategies under the scenario where the manufacturer vertically integrates with the retailer and the case where it is not vertically integrated with the retailer. The marginal costs of manufacturing and logistics are different under direct channel and indirect channels. In the case of vertical integration, Chiang et al. (2003) identify three different conditions involving user acceptance of the direct channel and marginal costs, and find that different channel strategy dominates under different conditions. In the case of no vertical integration, they find that the direct channel has no impact when user acceptance of the direct channel is low. Only when user acceptance of the direct channel is high does the existence of the direct channel induce the retailer to cut prices and thus lead to a profit increase for the manufacturer. They also find that there will be no sale through a direct channel in the case of no vertical integration, no matter how well the direct channel is accepted. Dumrongsiri, et al. (2008) also study the impact of marginal costs under different channels on the firm's channel strategy. They assume that the marginal costs of selling a unit of product under the direct channel and indirect channel are different. Further, there is a marginal cost of production incurred to the manufacturer. They find that the manufacturer is likely to be better off in the dual channel than in the single channel when the retailers' marginal cost is high.

Several of our key findings are substantially different than those reported in prior literature on optimal distribution strategy of physical goods due to the distinct features of the enterprise software described in the Introduction section. For example, the retail-only channel strategy is never optimal for enterprise software, while it can be an optimal strategy for physical goods. Another example is that prior literature on the channel strategy decision involving physical goods, e.g., Chiang et al. (2003) finds that there is only demand from the retail channel when the valuation discount factor for the direct channel is small enough, a result contrary to one of our key findings. A major driver for the difference between our results and those of the prior literature is that while different channels have different marginal distribution costs for physical goods, the marginal distribution cost of enterprise software as a digital good is negligible.

There is an extensive repertoire of studies on various aspects of the pricing and distribution strategies of digital goods. Little of this stream of research, however, addresses the issues in the supply chain setting. The notable exceptions are Demirkan and Cheng (2008) and Demirkan, et al. (2010). Demirkan and Cheng (2008) study an application services supply chain consisting of one application service provider (ASP) and one application infrastructure provider (AIP). The ASP buys computer capacity from the AIP and then sells the valued-added software services to the market. They examine the supply chain's performance under different coordination strategies involving risk and information sharing between the ASP and the AIP and find an effective decentralized mechanism to achieve the goal of maximizing the overall supply chain performance. Extending the work of Demirkan and Cheng (2008), Demirkan, et al. (2010) analyze the coordination mechanisms in an SaaS supply chain by explicitly taking into account the congestion cost of computing. One interesting finding of their analysis is that the congestion cost in accessing the SaaS service and computing capacity costs affect the overall surplus more severely when the supply chain partners follow coordinated strategies than when they do not.

Our research differs significantly from Demirkan and Cheng (2008) and Demirkan, et al. (2010) in several ways, although the digital goods supply chain is the common thread of our studies. First, Demirkan and Cheng (2008) and Demirkan, et al. (2010) consider SaaS the only licensing model to deliver software services in the supply chain, while the channel strategies in our study include the retail channel, the SaaS channel, and the hybrid channel strategy. Second, the emphasis of their study is on the coordination strategy between the software firm and the upstream supplier, while the focus of our research is to find the optimal channel strategy for the software firm with or without the downstream value-added reseller. In addition, we examine both the short-run problem, in which the software quality is fixed, and the long-run problem, in which the software quality becomes part of the overall decision. Lastly, the pricing model of SaaS in Demirkan and Cheng (2008) and Demirkan, et al. (2010) follows the pay-per-use or pay-per-transaction scheme, while we consider the subscription pricing model in our research since enterprise software vendors tend to implement the subscription model rather than the pay-per-use model. For example, the most popular Customer Relation Management SaaS provider, Salesforce.com, charges by the number of users per period irrespective of the transaction volumes[2].

3. The Model

In this section, we model the software firm's optimal channel strategy problem by capturing the salient features of enterprise software. The model setups are described as follows. The customers

[2] See http://www.salesforce.com/crm/editions-pricing.jsp

are heterogeneous in their valuation of the software. The customers' valuation v is uniformly distributed in the interval $[0,1]$. The price of the enterprise software under the retail channel is P_r and the price under the SaaS channel is P_s. Although customization of enterprise software is costly and thus inadvisable in principle, companies implementing enterprise software cannot avoid customization in reality.[3] While the customers under the retail channel are able to customize the software, it is infeasible for customers under the SaaS channel to do so since the software is centrally hosted at the vendor's server. We let C_m represent the customization cost. Therefore, customers under the retail channel derive utility

$$U_r = v - P_r - C_m. \tag{1}$$

Customers under the SaaS channel cannot customize the software and thus bear an unfit cost. To model the unfit cost, we let the valuation of customers under the SaaS channel be discounted by a discount factor θ ($0 < \theta < 1$) to reflect their unfit cost. Thus, the customers under the SaaS channel will realize the utility

$$U_s = \theta v - P_s. \tag{2}$$

Table 1 summarizes the notation.

--- Insert Table 1 about here ---

In the short-run model, the software firm takes the software quality as exogenously given and derives the optimal channel strategy. In the long-run model, this restriction is relaxed, and the software firm chooses the optimal channel strategy and software quality simultaneously. We

[3] See Harvard Business School case "Cisco Systems Inc., Implementing ERP" (case #: 9-699-022).

begin our analyses of the firm's strategic decisions with the short-run model and then move on to the long-run model.

3.1 The Short-Run Model

In each channel strategy (retail, SaaS, or dual), the software firm may or may not be vertically integrated with the value-added retailer (VAR). We examine both cases as follows.

3.1.1 A vertically integrated firm

We first analyze the case where the software firm adopts the retail channel and the software firm is vertically integrated with the VAR. The marginal consumer indifferent between adopting the software and doing without is derived by setting the utility U_r in Eq. (1) to zero. Then, the demand equals $(1-P_r-C_m)$, as shown in Figure 1.

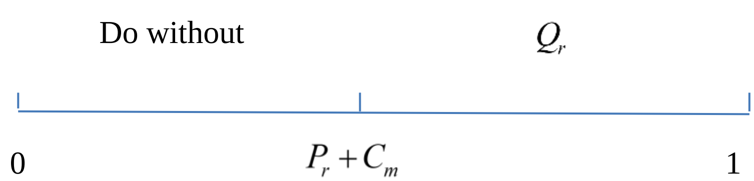

Figure 1. Market segmentation under the vertically integrated retail channel

The software firm's profit function is then described by Eq. (3).

$$\pi_r = P_r \cdot (1-P_r-C_m). \tag{3}$$

The software firm's optimal price and profit are $P_r^* = \dfrac{1-C_m}{2}$ and $\pi_r^* = \dfrac{(1-C_m)^2}{4}$.

We next study the case when the software firm adopts the SaaS channel strategy. The marginal consumer is derived by setting U_s in Eq. (2) to zero. The demand equals $1-\dfrac{P_s}{\theta}$, as shown in Figure 2.

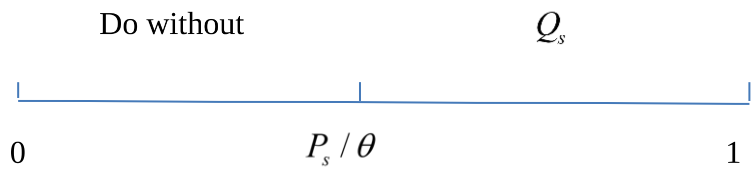

Figure 2. Market segmentation under the SaaS channel

The software firm’s profit function under the SaaS channel is defined by Eq. (4).

$$\pi_{SaaS} = P_s \cdot (1 - \frac{P_s}{\theta}) . \tag{4}$$

The software firm’s optimal price and profit are thus $P_s^* = \frac{\theta}{2}$ and $\pi_{SaaS}^* = \frac{\theta}{4}$ respectively.

When the software firm adopts the dual channel strategy, the customers have the freedom to choose the retail channel or the SaaS channel. The marginal consumer type who is indifferent between participating in the SaaS channel and not in either channel is $v_1 = \frac{P_S}{\theta}$. The marignal consumer type who is indifferent between participating in the SaaS and the retail channel equals $v_2 = \frac{P_r + C_m - P_s}{1-\theta}$. The market segmentation under the dual channel strategy is illustrated in Figure 3. For the dual channel to exist, $v_1 \le v_2$ is required; otherwise, the problem reduces to a retail channel problem if $v_1 > v_2$. The $v_1 \le v_2$ requirement leads to $\frac{P_s}{\theta} \le P_r + C_m$ and implies that it becomes a constraint in the software firm’s dual channel optimization problem.

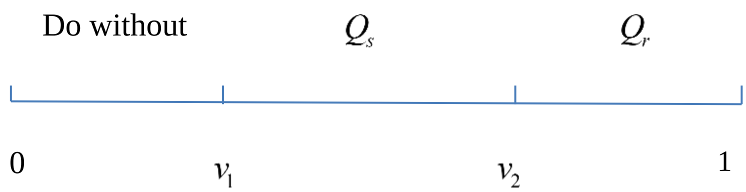

Figure 3. Market segmentation under the dual channel ($v_1 < v_2$)

We thus have $Q_s = \frac{\theta(P_r + C_m) - P_s}{\theta(1-\theta)}$, and $Q_r = 1 - \frac{P_r + C_m - P_s}{1-\theta}$. The software firm's profit function is

$$\pi_{dual} = P_r \cdot \left[1 - \frac{P_r + C_m - P_s}{1-\theta}\right] + P_s \cdot \left[\frac{\theta(P_r + C_m) - P_s}{\theta(1-\theta)}\right]. \tag{5}$$

The software firm solves the following problem.

$$\max_{P_r, P_s} \pi_{dual} = P_r \cdot \left[1 - \frac{P_r + C_m - P_s}{1-\theta}\right] + P_s \cdot \left[\frac{\theta(P_r + C_m) - P_s}{\theta(1-\theta)}\right] \tag{6}$$

Subject to: $v_1 \le v_2$

$v_2 \le 1$

where v_1 and v_2 are the marginal consumers defined above. Solving the firm's optimization problem, we obtain Lemma 1. For ease of understanding the context of each lemma and proposition, we describe whether the result is for the short-run or long-run problem, and whether the software firm is vertically integrated in the parentheses immediately after the lemma or proposition number.

Lemma 1 (Short-Run Problem, Vertically Integrated): *There are two sets of solutions for the firm's optimal prices and profit depending on the relationship between θ and C_m. When $\theta \le 1 - C_m$, the solutions are*

$$P_r^* = \frac{1-C_m}{2}, \quad (7)$$

$$P_s^* = \frac{\theta}{2}, \text{ and}$$

$$\pi_{dual}^* = \frac{(C_m - 1)^2 + \theta(2C_m - 1)}{4(1-\theta)}.$$

When $\theta > 1 - C_m$, however, the dual channel effectively reduces to an SaaS channel. The software firm's optimal price and profit become $P_s^* = \frac{\theta}{2}$ and $\pi_{SaaS}^* = \frac{\theta}{4}$ as in the pure SaaS channel case.

Proof: See the online appendix for proofs of all lemmas and propositions.

The managerial implications of the condition $\theta > 1 - C_m$ in Lemma 1 are as follows. Recall from Eq. (1) that C_m is the customization cost for customers in the retail channel, while a higher q in Eq. (2) corresponds to a lower unfit cost for SaaS customers. That is, a high customization cost and a low unfit cost will lead to no customers participating in the retail channel. The dual channel strategy will in effect reduce to the SaaS channel strategy.

Comparing the profit achieved under the dual channel strategy with those of the retail and SaaS channel strategies, we obtain Proposition 1:

Proposition 1 (Firm's Optimal Distribution Strategy, Short-Run Problem, Vertically Integrated): *When $\theta \le 1 - C_m$, the dual channel strategy exists, and it generates a higher profit than the retail and SaaS channel strategies. If $\theta > 1 - C_m$, the dual channel strategy reduces to an SaaS channel strategy, and the SaaS channel dominates the retail channel.*

A closer look at the proof of Proposition 1 shows that the condition for the dual channel to generate a higher optimal profit than the retail-only channel is for the customization cost to be positive. When the dual channel strategy degenerates to a pure SaaS strategy, the condition for this degeneration to occur is also the condition for the pure SaaS strategy to generate a higher optimal profit than the retail-only strategy.

The intuition of Proposition 1 is that the firm obtains a higher profit by offering dual channels when the unfit cost is high (corresponding to a lower θ) relative to the customization cost (i.e., $\theta \le 1 - C_m$). Otherwise, no consumer will choose the retail channel since the customization cost under the retail channel outweighs the unfit cost. Prior literature on the channel strategy decision involving physical goods, e.g., Chiang et al. (2003) find that there is only demand from the retail channel when θ is small enough, a result opposite to our Proposition 1. A key driver of the different results is that different channels have different marginal distribution costs for physical goods, while the marginal cost of digital goods (enterprise software) is negligible.

In addition to the firm's optimal profit, it is of critical interest to know which channel strategy generates the highest social welfare. Social welfare under the retail channel strategy can be derived as

$$SW_r = \pi_r + \int_{P_r + C_m}^{1} (v - P_r - C_m)dv = \frac{3(1 - C_m)^2}{8}, \tag{8}$$

while the social welfare under the SaaS channel strategy is described by

$$SW_{S_{aa}S} = \pi_{S_{aa}S} + \int_{P_s/\theta}^{1} (\theta v - P_s)dv = \frac{3\theta}{8}. \tag{9}$$

Recall that the dual channel exists when $\theta \leq 1 - C_m$ as shown in Lemma 1. In this case, social welfare under the dual channel strategy equals

$$SW_{dual} = \pi_{dual} + \int_{P_s/\theta}^{\frac{P_r + C_m - P_s}{1-\theta}} (\theta v - P_s) dv + \int_{\frac{P_r + C_m - P_s}{1-\theta}}^{1} (v - P_r - C_m) dv = \frac{3\left((1-C_m)^2 + \theta(2C_m - 1)\right)}{8(1-\theta)}. \quad (10)$$

Comparing the social welfares of all three distribution strategies leads to Lemma 2.

Lemma 2 (Optimal Social Welfare, Short-Run Problem, Vertically Integrated): *When $\theta \leq 1 - C_m$, the dual channel exists, and it leads to the highest social welfare. Otherwise, the social welfare is the highest under the SaaS channel strategy.*

We next study the firm's optimal profit and social welfare of each channel strategy where there exists a separate value-added retailer in the channel.

3.1.2 With the existence of a value-added retailer (VAR)

In this scenario, there exists a value-added retailer to sell the enterprise software firm's product to customers. We first investigate the case where the software firm adopts the dual channel strategy, which corresponds to a two-stage Stackelberg game for the software firm. In the first stage, the software firm decides the wholesale price w and the SaaS channel price P_s. In the second stage, the VAR decides its retail price P_r. In prior literature, e.g., Chiang et al. (2003), it is often required that $w \leq P_s$, since the retailer will purchase from the direct channel otherwise. However, in the context of enterprise software, it is infeasible for the VAR to purchase SaaS product and resell it as an offline product. Therefore, it is possible for $w \geq P_s$ to occur in the enterprise software supply chain, another distinct feature of enterprise software making it significantly different from the physical goods. This two-stage Stackelberg game entails first solving the second-stage problem and then the first-stage problem.

In stage two, the VAR chooses a P_r to maximize its profit $\pi_{VAR} = (P_r - w)Q_r$. As given above, the marginal consumer type who is indifferent between adopting the software and doing without under the retail channel is $P_r + C_m$. The marginal consumer type who is indifferent between adopting the software and doing without under the SaaS channel is given by $\frac{P_s}{\theta}$. The marginal consumer type who is indifferent between adopting the software under the SaaS channel and the retail channel is given by $\frac{P_r + C_m - P_s}{1-\theta}$.

We first consider the case where $P_r + C_m > \frac{P_s}{\theta}$. After some algebra, $P_r + C_m > \frac{P_s}{\theta}$ becomes $\frac{P_r + C_m - P_s}{1-\theta} > P_r + C_m$. Thus, in this case, consumers whose valuation in $\left[\frac{P_s}{\theta}, \frac{P_r + C_m - P_s}{1-\theta}\right]$ will adopt the software through the SaaS channel. Consumers whose valuation in $\left[\frac{P_r + C_m - P_s}{1-\theta}, 1\right]$ will adopt the software through the retail channel, and those whose valuation in $\left[0, \frac{P_s}{\theta}\right]$ will not adopt the software.

If $P_r + C_m < \frac{P_s}{\theta}$, the condition amounts to $\frac{P_r + C_m - P_s}{1-\theta} < P_r + C_m$. In this case, consumers whose valuation in $[P_r + C_m, 1]$ will adopt the software through the retail channel, while consumers whose valuation in $[0, P_r + C_m]$ will not adopt the software and no consumers will adopt the software through the SaaS channel.

Therefore, the profit function of the VAR has two forms as follows depending on whether $P_r + C_m > \frac{P_s}{\theta}$.

$$\pi_{var} = \begin{cases} (P_r - w)\left[1 - \frac{P_r + C_m - P_s}{1-\theta}\right] \text{ if } P_r + C_m > \frac{P_s}{\theta}, \\ (P_r - w)(1 - P_r - C_m) \text{ otherwise.} \end{cases} \tag{11}$$

Further analysis of the VAR's profit function leads to Lemma 3.

Lemma 3 (Short-Run Problem, Not Vertically Integrated): *There are three cases for the VAR's optimal retail price decision.*

Case 1: $\frac{1+C_m+P_s+w-\theta}{2} > \frac{P_s}{\theta}$ *and* $\frac{1+C_m+w}{2} > \frac{P_s}{\theta}$

In this case, there are demands from both the retail channel and the SaaS channel and $P_r^* = \frac{1-C_m+P_s+w-\theta}{2}$.

Case 2: $\frac{1+C_m+P_s+w-\theta}{2} < \frac{P_s}{\theta}$ *and* $\frac{1+C_m+w}{2} \leq \frac{P_s}{\theta}$

In this case, there is only demand from the retail channel and $P_r^* = \frac{1-C_m+w}{2}$.

Case 3: $\frac{1+C_m+P_s+w-\theta}{2} < \frac{P_s}{\theta}$ *and* $\frac{1+C_m+w}{2} > \frac{P_s}{\theta}$

In this case, there is only demand from the retail channel and $P_r^* = \frac{P_s}{\theta} - C_m$.

Then, we solve the stage-one problem in each of the three cases specified in the above lemma and compare results from the three cases to find the optimal pricing decisions and profit for the software firm under the dual channel. This leads to the following lemma.

Lemma 4 (Firm's Optimal Pricings and Profit under Dual Channel, Short-Run Problem, Not Vertically Integrated): *When* $\theta \le 1 - C_m$, $P_s^* = \frac{\theta}{2}$, $w^* = \frac{1-C_m}{2}$ *and*

$\pi_{dual}^* = \frac{(1-C_m)^2 + 2C_m\theta - \theta^2}{8(1-\theta)}$. *When* $\theta > 1 - C_m$, *indicating that* $\frac{P_r + C_m - P_s}{1-\theta} \ge 1$, *there is only demand through SaaS channel, and the dual channel reduces to an SaaS channel.*

When the software firm adopts the retail channel, the software firm decides the wholesale price w in the first stage and the VAR decides the retail price P_r in the second stage. The VAR's profit function is given by $\pi_{r(\text{var})} = (P_r - w)(1 - P_r - C_m)$. The optimal retail price is derived as $P_r^* = \frac{1 - C_m + w}{2}$. The software firm's profit function is given by $\pi_{r(m)} = w(1 - P_r - C_m)$. Plugging in $P_r^* = \frac{1 - C_m + w}{2}$, we obtain that $\pi_{r(m)} = w\left(\frac{1 - C_m - w}{2}\right)$. Thus, $w^* = \frac{1-C_m}{2}$, $\pi_{r(m)}{}^* = \frac{(1-C_m)^2}{8}$. When the software firm adopts the SaaS channel, the results remain the same as in Section 3.1.1. Thus, $P_s^* = \frac{\theta}{2}$, $\pi_{SaaS}{}^* = \frac{\theta}{4}$. Comparing the optimal profits under the three channel strategies, we obtain the following proposition:

Proposition 2 (Firm's Optimal Distribution Strategy, Short-Run Problem, Not Vertically Integrated): *The best channel strategy for the firm is to adopt the dual channel when* $\theta \le 1 - C_m$ *and the SaaS channel when* $\theta > 1 - C_m$.

We next compare social welfare under each channel strategy. Social welfare under the retail channel strategy is shown as

$$SW_r = \pi_{r(m)} + \pi_{r(var)} + \int_{P_r + C_m}^{1} (v - P_r - C_m)dv = \frac{7(1-C_m)^2}{32}, \tag{15}$$

where $\pi_{r(m)}$ indicates the profit of the software firm and $\pi_{r(var)}$ indicates the profit of the VAR in the retail channel strategy. Social welfare under the SaaS channel equals

$$SW_{S_{aa}S} = \pi_{S_{aa}S} + \int_{P_s/\theta}^{1} (\theta v - P_s) dv = \frac{3\theta}{8}. \tag{16}$$

Social welfare under the dual channel is

$$\begin{aligned} SW_{dual} &= \pi_{dual} + \pi_{var} + \int_{P_s/\theta}^{\frac{P_r + C_m - P_s}{1-\theta}} (\theta v - P_s) dv + \int_{\frac{P_r + C_m - P_s}{1-\theta}}^{1} (v - P_r - C_m) dv \\ &= \frac{7 C_m{}^2}{32(1-\theta)} + \frac{7 - 14 C_m + 5\theta}{32} \end{aligned} \tag{17}$$

where π_{var} indicates the profit of the VAR in the dual channel. The following lemma presents the optimal social welfare result of the short-run problem in the presence of a VAR.

Lemma 5 (Optimal Social Welfare, Short-Run Problem, Not Vertically Integrated): *The dual channel strategy leads to the highest social welfare when* $\theta \le 1 - C_m$, *while the SaaS channel strategy leads to the highest social welfare when* $\theta > 1 - C_m$.

Summarizing the foregoing lemmas and propositions of the short-run problem leads to several unique findings not available in prior literature. First, prior literature analyzing the optimal distribution strategy of physical goods requires that the wholesale price under the indirect channel cannot surpass the retail price under the direct channel; otherwise, the reseller can purchase the product from the direct channel at a cheaper price and resells it (e.g., Cattani et al. (2006); Chiang et al. (2003)). This assumption is no longer needed for enterprise software since it is technically infeasible for the VAR to purchase an SaaS product and resell it as an On-Premises product. More interestingly, the optimal wholesale price $w^* = \frac{1 - C_m}{2}$ is actually *higher* than the optimal SaaS price $P_s^* = \frac{\theta}{2}$ under the dual channel. The condition for this unique phenomenon to occur is identical to that for the dual channel to exist.

Another unique finding of our study is that retail-only channel strategy is never an optimal distribution strategy for the enterprise software firm. Prior literature on the optimal channel strategy for physical goods indicates that retail-only strategy can be an optimal one depending on the interplay of marginal production and distribution costs of the various channels. Unlike physical goods, enterprise software's distinct features of negligible marginal production and distribution costs are the major driver of our unique result of retail-only channel strategy being never an optimal distribution strategy. We find that in the presence of a high unit cost relative to the customization cost ($\theta \leq 1 - C_m$), the dual channel strategy generates the highest profit for the firm and the highest social welfare for society as a whole; otherwise, the SaaS channel strategy is optimal in terms of both firm profit and social welfare. This result holds for both cases, whether the firm is vertically integrated or not.

3.2 The Long-Run Model

In the long-run model, the quality of the enterprise software becomes a decision variable for the software firm. To simultaneously explore the software firm's optimal channel strategies and the optimal software quality under each channel, we let consumer's valuation of the software be uniformly distributed in $[0, 1+x]$, if the quality of software is set at x. To achieve the quality lever of x, the software vendor incurs the cost of αx^2. The unit of x in our model is the software functionality measured in function points. Houston and Keats (1998) have shown that the cost of achieving software quality follows a convex function with a positive second order derivative. The same cost pattern is also observed in other more general settings involving quality improvement (Magalhaes, 2015). We use the quadratic functional form to describe the cost of quality in our model, as it is the most commonly used in information systems (e.g., Choudhary 2007), marketing (e.g., Netessine and Taylor 2007), and operations management literature (e.g., Xiong and Chen 2013). The quadratic form of cost of quality also reflects the decreasing rate of return on investment in quality.

3.2.1 A vertically integrated firm

We first investigate the case where the software firm is vertically integrated with the VAR. The profit under the retail channel is

$$\pi_r = P_r(1 + x - P_r - C_m) - \alpha x^2. \tag{18}$$

The software firm's optimal price and quality equal $P_r^* = \frac{2(1-C_m)\alpha}{4\alpha - 1}$ and $x_r^* = \frac{1-C_m}{4\alpha - 1}$ respectively. The optimal profit the software firm achieves is $\pi_r^* = \frac{(1-C_m)^2\alpha}{4\alpha - 1}$.

Under the SaaS channel, the profit function is

$$\pi_{SaaS} = P_s(1 + x - \frac{P_s}{\theta}) - \alpha x^2. \tag{19}$$

The optimal price and quality equal $P_s^* = \frac{2\alpha\theta}{4\alpha - \theta}$ and $x_s^* = \frac{\theta}{4\alpha - \theta}$. The optimal profit achieved under the SaaS channel equals $\pi_{SaaS}^* = \frac{\alpha\theta}{4\alpha - \theta}$.[4]

When the software firm adopts the dual channel, there are two cases to consider. When $P_r + C_m < \frac{P_s}{\theta}$ corresponding to the condition of $v_1 > v_2$ in Figure 3, no consumer will choose the

[4] We require $4\alpha - 1 > 0$ and $4\alpha - \theta > 0$ to ensure non-negative optimal prices, software quality, and profits.

SaaS channel, leading to the same market equilibrium as under the retail channel strategy. When $P_r + C_m \geq \frac{P_s}{\theta}$, there will be customers participating in both channels, and the profit function for the software firm equals

$$\pi_{dual} = P_r \cdot \left[1 + x - \frac{P_r + C_m - P_s}{1-\theta}\right] + P_s \cdot \left[\frac{\theta(P_r + C_m) - P_s}{\theta(1-\theta)}\right] - \alpha x^2 . \tag{20}$$

The software firm's decision problem is given by

$$\max_{P_r, P_s, x} \pi_{dual} = P_r \cdot \left[1 + x - \frac{P_r + C_m - P_s}{1-\theta}\right] + P_s \cdot \left[\frac{\theta(P_r + C_m) - P_s}{\theta(1-\theta)}\right] - \alpha x^2 \tag{21}$$

Subject to:

$$\frac{P_s}{\theta} \leq P_r + C_m$$

$$\frac{P_r + C_m - P_s}{1-\theta} \leq 1 + x$$

Solving the above optimization problem, we obtained Lemma 9.

Lemma 6 (Long-Run Problem, Vertically Integrated): *When* $\theta \leq \frac{4\alpha(1-C_m)}{4\alpha - C_m}$, *there is demand through both channels and* $P^*_{r,dual} = \frac{2\alpha(1-C_m)}{4\alpha - 1}$, $P^*_{s,dual} = \frac{\theta(4\alpha - C_m)}{2(4\alpha - 1)}$, $x^*_{dual} = \frac{1-C_m}{4\alpha - 1}$, *and* $\pi^*_{dual} = \frac{4\alpha\left[(1-C_m)^2 + (2C_m - 1)\theta\right] - \theta C_m{}^2}{4(1-\theta)(4\alpha - 1)}$. *When* $\theta > \frac{4\alpha(1-C_m)}{4\alpha - C_m}$ *there is only demand through the SaaS channel and* $P_r^* = \frac{\theta C_m - 2\alpha(2C_m + \theta - 2)}{4\alpha - \theta}$, $P_s^* = \frac{2\alpha\theta}{4\alpha - \theta}$, $x_s^* = \frac{\theta}{4\alpha - \theta}$, *and*

$\pi^*_{SaaS} = \frac{\alpha\theta}{4\alpha - \theta}$.

We now compare the optimal profit and level of quality achieved under each channel strategy in the long-run model and obtain Proposition 3:

Proposition 3 (Firm's Optimal Distribution Strategy, Long-Run Problem, Vertically Integrated): *The software firm achieves the highest profit by adopting the dual channel strategy when* $\theta \le \frac{4\alpha(1-C_m)}{4\alpha - C_m}$*, and the SaaS channel strategy otherwise. The software has the same level of quality under the dual channel and retail channel strategies. Furthermore, the quality level of the software is the highest under the SaaS channel when* $\theta > \frac{4\alpha(1-C_m)}{4\alpha - C_m}$*, while it is the highest under the dual channel (or retail channel) when* $\theta \le \frac{4\alpha(1-C_m)}{4\alpha - C_m}$.

We then analyze the social welfare under each channel. The social welfare under the retail channel strategy is given by

$$SW_r = \pi_r + \int_{P_r+C_m}^{1+x} (V - P_r - C_m)dv = \frac{(1-C_m)^2(6\alpha-1)\alpha}{(4\alpha-1)^2}. \tag{22}$$

The social welfare under the SaaS channel strategy is

$$SW_{S_{aa}S} = \pi_{S_{aa}S} + \int_{P_s/\theta}^{1+x} (\theta v - P_s)dv = \frac{\alpha\theta(6\alpha-\theta)}{(4\alpha-\theta)^2}. \tag{23}$$

The social welfare under the dual channel equals

$$\begin{aligned} SW_{dual} &= \pi_{dual} + \int_{P_s/\theta}^{\frac{P_r+C_m-P_s}{1-\theta}} (\theta v - P_s)dv + \int_{\frac{P_r+C_m-P_s}{1-\theta}}^{1+x} (v - P_r - C_m)dv \\ &= \frac{48\alpha^2(1-2C_m) - 3C_m{}^2 + 8\alpha(2C_m{}^2 + 2C_m - 1)}{8(4\alpha-1)^2} + \frac{3C_m{}^2}{8(1-\theta)} \end{aligned}. \tag{24}$$

It can be shown that $SW_{dual} - SW_r = \frac{3\theta C_m^{\ 2}}{8(1-\theta)} \geq 0$. Thus, the dual channel dominates the retail channel in terms of social welfare. The comparison between the social welfare under the dual channel and the SaaS channel is analytically complicated. We thus resort to computational analysis to gain further insights. Figure 4 shows how the comparison between social welfare under each channel strategy changes as θ varies. Recall that θ is the discount factor capturing the unfit cost under the SaaS channel, and a higher θ corresponds to a lower unfit cost. Figure 4 (with parameter values of $C_m = 0.2$, $\alpha = 1.5$) shows that when θ is lower than a threshold value (approximately 0.8 in Figure 4), the dual channel leads to the highest social welfare. When θ is greater than 0.8, the dual channel reduces to an SaaS channel and the two lines overlap as a result.

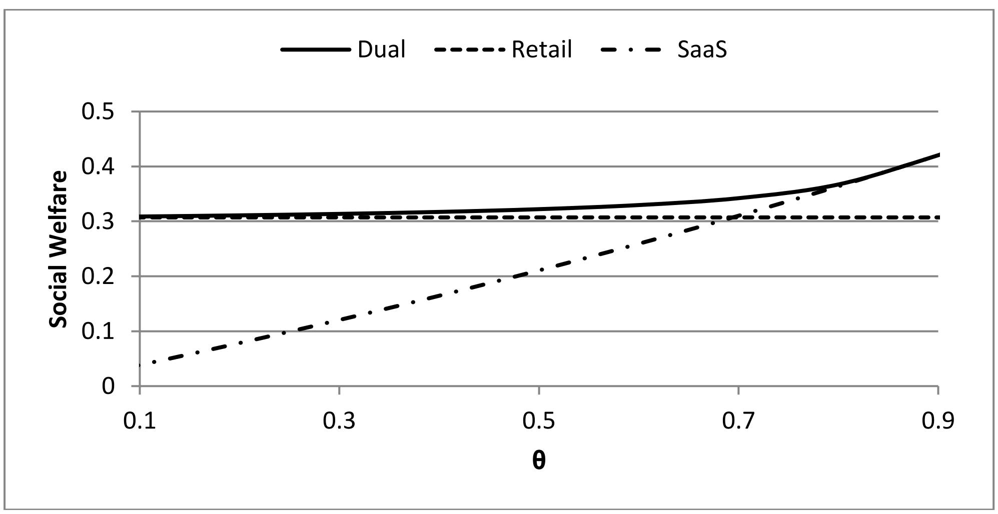

Figure 4. Comparison of social welfare with vertical integration in the long-run model

3.2.2 With the existence of a value-added retailer (VAR)

In this section, we investigate the software firm's optimal price, software quality level and profit under each channel when there exists a value-added retailer to resell its product to the market.

We first investigate the case when the firm adopts the dual channel strategy. Similar to the previous analysis, this is a two-stage Stackelberg game where the software firm decides the software quality level x, the wholesale price in the retail channel w, and the SaaS price P_s in stage one, and the VAR decides the retail price P_r in stage two. As usual, solving a two-stage Stackelberg game requires solving the stage-two problem first and then the stage-one problem.

In stage two, the VAR needs to maximize $\pi_{var} = (P_r - w)Q_r$. Similar to the analysis in Sec. 3.1.2, there are two possible forms of the profit function depending on whether $P_r + C_m > \frac{P_s}{\theta}$.

$$\pi_{var} = \begin{cases} (P_r - w)\left[1 + x - \frac{P_r + C_m - P_s}{1-\theta}\right] \text{ if } P_r + C_m > \frac{P_s}{\theta} \\ (P_r - w)(1 + x - P_r - C_m) \text{ otherwise} \end{cases}.$$

The software firm needs to consider three cases described in the following lemma to optimize its profit.

Lemma 7 (Long-Run Problem, Not Vertically Integrated): *There are three cases for the software firm to consider:*

Case 1: $\frac{1 + C_m + P_s + w + x - (1+x)\theta}{2} > \frac{P_s}{\theta}$ *and* $\frac{1 + C_m + w + x}{2} > \frac{P_s}{\theta}$

In this case, there exist demands from both channels and $P_r^* = \frac{1 - C_m + P_s + w + x - (1+x)\theta}{2}$.

Case 2: $\frac{1 + C_m + P_s + w + x - (1+x)\theta}{2} < \frac{P_s}{\theta}$ *and* $\frac{1 + C_m + w + x}{2} \le \frac{P_s}{\theta}$

In this case, there is only demand from the retail channel and $P_r^* = \frac{1 - C_m + w + x}{2}$.

Case 3: $\frac{1 + C_m + P_s + w + x - (1+x)\theta}{2} < \frac{P_s}{\theta}$ *and* $\frac{1 + C_m + w + x}{2} > \frac{P_s}{\theta}$

In this case, there is only demand from the retail channel and $P_r^* = \frac{P_s}{\theta} - C_m$.

Next, we solve the stage-one problem in each case of Lemma 7 and compare results from each case to derive the optimal pricings and profit for the software firm described as follows:

Lemma 8 (Firm's Optimal Pricings and Profit under Dual Channel, Long-Run Problem, Not Vertically Integrated): *When* $\theta \le \frac{4\alpha(1-C_m)}{4\alpha - C_m}$, $P_s^* = \frac{(C_m - 8\alpha)\theta}{2(1-8\alpha+\theta)}$, $w^* = \frac{C_m\theta + 8\alpha(1-C_m)}{16\alpha - 2(1+\theta)}$, $x^* = \frac{1+\theta - C_m}{8\alpha - 1 - \theta}$, *and* $\pi_{dual}^* = \frac{4(1-C_m)^2\alpha - C_m(C_m - 8\alpha)\theta - 4\alpha\theta^2}{4(8\alpha-1-\theta)(1-\theta)}$. *When* $\theta > \frac{4\alpha(1-C_m)}{4\alpha - C_m}$, *the constraint* $\frac{P_r + C_m - P_s}{1-\theta} < 1 + x$ *is violated and thus there is only demand through the SaaS channel. The dual channel reduces to an SaaS channel.*

As in the short-run problem, we find from Lemma 8 that the wholesale price of the enterprise software to the VAR is higher than the SaaS price under the dual channel in the long-run problem, and the condition for this intriguing situation to occur is the same as that for the dual channel to exit.

When the software firm adopts the retail channel strategy, it decides the wholesale price w and x in the first stage and the VAR decides the retail price P_r in the second stage. The VAR's optimal retail price can be shown to be $P_r^* = \frac{1 - C_m + w + x}{2}$. The software firm's profit function is given by $\pi_{r(m)} = w(1 + x - P_r^* - C_m) - \alpha x^2$. First order conditions lead to $w^* = \frac{4\alpha(1-C_m)}{8\alpha - 1}$, $x^* = \frac{1-C_m}{8\alpha-1}$, and $\pi_{r(m)}^* = \frac{\alpha(1-C_m)^2}{8\alpha - 1}$.

When the software firm adopts the SaaS channel strategy, the results remain the same as in Sec. 3.2.1. Thus, $P_s^* = \frac{2\alpha\theta}{4\alpha-\theta}$, $x_s^* = \frac{\theta}{4\alpha-\theta}$, and $\pi_{SaaS}^* = \frac{\alpha\theta}{4\alpha-\theta}$. We then compare the optimal profit and level of quality under each channel strategy and obtain Proposition 4.

Proposition 4 (Firm's Optimal Distribution Strategy, Long-Run Problem, Not Vertically Integrated): *The best channel strategy is the dual channel to achieve the highest profitability when* $\theta \le \frac{4\alpha(1-C_m)}{4\alpha-C_m}$ *and the SaaS channel is the best strategy when* $\theta > \frac{4\alpha(1-C_m)}{4\alpha-C_m}$. *The software has the highest quality under the dual channel when* $\theta \le \frac{4\alpha(1-C_m)}{4\alpha-C_m}$. *The highest software quality is attained under the SaaS channel strategy otherwise.*

In the proof of Proposition 3, we find that under both the retail channel and dual channel, $P_r^* = \frac{2\alpha(1-C_m)}{4\alpha-1}$ and $x^* = \frac{1-C_m}{4\alpha-1}$. This outcome shows that introducing the SaaS channel in the dual channel strategy does not impact the software vendor's decision on optimal retail price and optimal software quality because of the vertical integration. However, this is not the case in Proposition 4, as the optimal wholesale price changes from $\frac{4\alpha(1-C_m)}{8\alpha-1}$ to $\frac{C_m\theta+8\alpha(1-C_m)}{16\alpha-2(1+\theta)}$, the optimal retail price changes from $\frac{6\alpha(1-C_m)}{8\alpha-1}$ to $\frac{C_m\theta+2\alpha(3-3C_m-\theta)}{8\alpha-1-\theta}$, and the optimal software quality changes from $\frac{1-C_m}{8\alpha-1}$ to $\frac{1+\theta-C_m}{8\alpha-1-\theta}$. Notice that the optimal wholesale price and software quality are both increased, while no conclusion can be drawn regarding whether the optimal retail price is increased or decreased. The software vendor cannot commit to the same price under the retail channel and the dual channel due to the existence of the VAR.

We next compare the social welfare under each channel strategy. The social welfare under the retail channel equals

$$\begin{aligned} SW_r &= \pi_{r(m)} + \pi_{r(var)} + \int_{P_r+C_m}^{1+x} (v - P_r - C_m)dv \\ &= \frac{\alpha(1-C_m)^2(14\alpha-1)}{(8\alpha-1)^2} \end{aligned}. \quad (28)$$

Social welfare under the SaaS channel equals

$$\begin{aligned} SW_{S_{aa}S} &= \pi_{S_{aa}S} + \int_{P_s/\theta}^{1+x} (\theta v - P_s)dv \\ &= \frac{\alpha\theta}{4\alpha-\theta} + \frac{\theta(8\alpha-C_m)^2(8\alpha-2\theta-1)^2}{8(8\alpha-1)^2(8\alpha-1-\theta)^2} \end{aligned}. \quad (29)$$

Social welfare under the dual channel is

$$\begin{aligned} SW_{dual} &= \pi_{dual} + \pi_m + \int_{P_s/\theta}^{\frac{P_r+C_m-P_s}{1-\theta}} (\theta v - P_s)dv + \int_{\frac{P_r+C_m-P_s}{1-\theta}}^{1+x} (v - P_r - C_m)dv \\ &= \frac{C_m{}^2\theta(3+4\theta)+16\alpha^2(7(-1+C_m)^2+2(-1+7C_m)\theta-5\theta^2) - 8\alpha(1+\theta-\theta^2(1+\theta)+C_m(-1+\theta)(2+3\theta)+C_m{}^2(1+6\theta))}{8(1-\theta)(8\alpha-1-\theta)^2} \end{aligned}. \quad (30)$$

We resort to the numerical analysis to compare the social welfare under the three channel strategies, as analytical comparisons are not feasible due to the complexity of expressions. Figure 5 (with the same parameter values as those in Figure 4) illustrates how the social welfare under different channel strategies changes with respect to θ, the discount factor which captures the unfit cost under the SaaS channel. It shows that the social welfare is the highest under the dual channel for all ranges of θ.

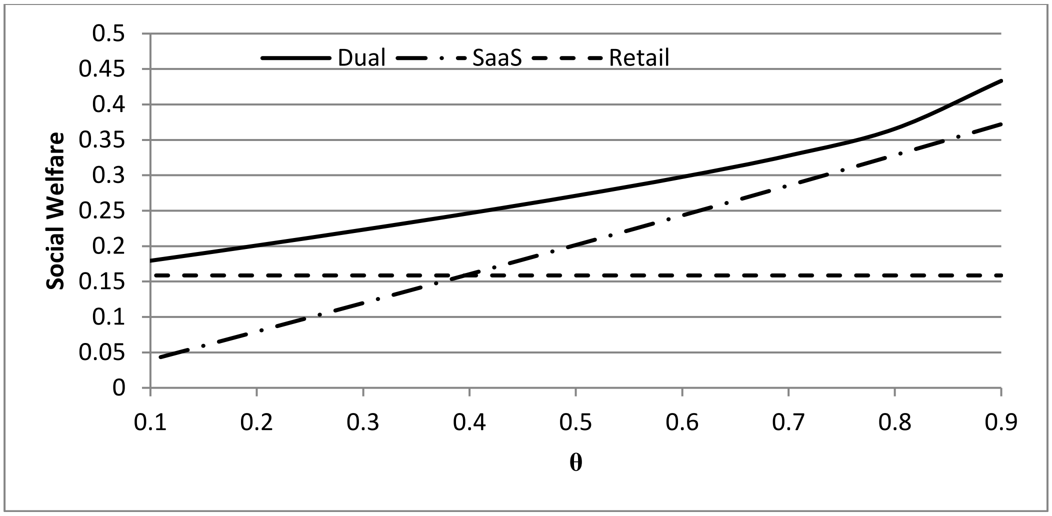

Figure 5. Comparison of social welfare with the existence of VAR in the long-run model

The key findings from the short-run problem (where the software quality is fixed) remain robust for the long-run problem where the software quality becomes part of the enterprise software firm's strategic decisions. That is, the retail channel only is never an optimal distribution strategy. In the presence of high unfit cost relative to the customization cost, the dual channel strategy exists and generates the highest profit for the firm and the highest software quality is achieved. When the unfit cost is low relative to the customization cost, the SaaS channel strategy becomes the best strategy for the firm in terms of profit and software quality. Analytical results for comparing social welfare under retail, SaaS, and dual channels are not available due to the complexity of the expressions. However, numerical results indicate that they are in line with those of the short-run problem.

4. Conclusion

While there exists abundant literature analyzing the distribution channel strategy of physical goods, there is a lack of research on the optimal distribution channel strategy for enterprise software as a digital good. Enterprise software exhibits several distinct features different from the physical goods, most notably the negligible marginal production and distribution costs. Moreover, different distribution channel strategies of enterprise software are associated with different licensing practices. In particular, the retail channel strategy comes with the On-Premises licensing model, while the direct Internet channel strategy is associated with the SaaS licensing model. As a result, customization cost and the unfit cost are incurred under the On-Premises and SaaS licensing models, respectively. This research analyzes the optimal distribution strategies of enterprise software by taking into account the aforementioned distinct features of enterprise software for both the short-run model, in which the software quality is fixed, and the long-run model, in which the software quality becomes part of the strategic decisions.

Our results indicate that in the presence of high unfit cost relative to the customization cost, the dual channel strategy exists and generates the highest profit for the firm and the highest social welfare. When the unfit cost is low relative to the customization cost, the SaaS channel strategy becomes the best strategy for both the firm in term of profitability and for society in terms of social welfare. This key finding is robust in that it holds for both the short-run problem and the long-run problem. When the optimal channel strategy is the dual channel, the optimal profit and social welfare of the enterprise software firm will be lower when there exists a VAR, and this applies to both the short-run and long-run models.[5] When the optimal channel strategy is the pure SaaS channel, the VAR does not come into play and has no influence on the optimal profit or social welfare.

[5] This finding can be easily derived from synthesizing the four propositions.

A key finding of our research is that the retail-only channel strategy is never an optimal strategy, while it can be an optimal strategy in prior literature analyzing the channel strategy decision involving physical goods, since different channels have different marginal distribution costs for physical goods. A major driver of our result is that the marginal distribution cost of digital goods (enterprise software) is negligible. Other distinct features of the enterprise software also contribute to our key finding that the retail-only channel strategy is never optimal. For example, when the dual channel exists in the short-run problem with vertical integration, the condition for the dual channel to generate a higher optimal profit than the retail-only channel is for the customization cost to be positive. When the dual channel strategy degenerates to a pure SaaS strategy, the condition for this degeneration to occur is also the condition for the pure SaaS strategy to generate a higher optimal profit than the retail-only strategy. Since it is practically impossible to avoid the customization cost when corporations implement the enterprise software, the presence of customization cost makes the retail-only channel strategy never optimal.

Prior literature analyzing optimal distribution strategy of physical goods often requires that the wholesale price be lower than the direct channel price; otherwise, the retailer will purchase from the direct channel. However, in the context of enterprise software, it is technologically infeasible for the VAR to purchase an SaaS product and resell it as an offline product. Therefore, this typical constraint, that the wholesale price be lower than the direct channel price, is no longer needed in the enterprise software supply chain, another distinct feature of enterprise software making it significantly different from the physical goods. An intriguing finding of our research is that a wholesale price *higher* than the direct channel price can occur in the equilibrium of the enterprise software supply chain in both the short-run and long-run problems.

There are several directions to extend this research. First, this paper can be extended to the situation of duopoly, where two software firms may adopt different channel strategies. The software firm's optimal channel choice might be influenced by the competition. Second, future research can analyze the impact of network effects on the software firm's optimal channel strategies. Finally, the price of SaaS is being charged per time period, while the price of the retail channel is mostly charged only once. The SaaS price, P_s, in our model corresponds to the aggregated subscription fee customers are charged for the entire time of usage. We made this simplification for several reasons. First, empirical evidence indicates that once customers subscribe to the SaaS service, it is difficult for them to quit due to the existence of significantly high switching costs (The Economist (2015)). Therefore, it is reasonable to use a single price to model the total costs to customers within multi-periods. Second, a multi-period modeling approach of SaaS is usually adopted to examine the upgrade issue and the interaction between upgrade and pricing (e.g., Jia et al. (2018)), while the focus of our study is on the optimal distribution strategy and investment on the quality of enterprise software. It would be of interest to extend our study to a multi-period setting.

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Table 1. List of Notations

v	Consumer's valuation of the software, uniformly distributed in $[0,1]$
θ	The valuation discount factor under the SaaS channel
p_r	Retail price under the retail channel
p_s	Price under the SaaS channel
w	Wholesale price under the retail channel
C_m	Customization cost under the On-Premises model
α	The cost coefficient of software quality
x	The software quality