Advances in Economics, Business and Management Research, volume 159
Fifth International Conference on Economic and Business Management (FEBM 2020)

How Does a Retailer Improve Profit Under Advance Selling Strategy?

Lan Feng, Puze Yu, Hui Yang*, and Chen Jin

School of Economics and Management, Nanjing University of Science & Technology, Nanjing, Jiangsu 210094, China
**Corresponding author. Email: yanghui@njust.edu.cn*

ABSTRACT
This paper investigates how a retailer in a supply chain improves advance selling profit by offering agency contract instead of wholesale contract. We propose a two-period advance selling model under the wholesale contract as the benchmark model. We assume that consumers are homogeneous in the advance period and heterogeneous in the spot period whose valuations are uniformly distributed. The results show that the advance selling option under the wholesale contract hurts the retailer's profit under some circumstances. We then construct a model where the retailer offers agency contract to the manufacturer. We show that, under the agency contract the retailer's profit can be improved to some extents depending on the range of the marginal cost, the commission rate and the consumer valuation dispersion. Numerical examples are provided to illustrate the main results. Our research can explain why online platform retailers, who apply advance selling strategy, prefer to provide agency contract to manufacturers.
Keywords: *Supply chain, advance selling, wholesale contract, agency contract*

1. INTRODUCTION

Advance selling (AS) is a business strategy which allows retailers to sell products to consumers ahead of the spot period. It has been successfully used in the retailing industry. Consumers can order new products before their release date, such as mobile devices, e-books, video games from retailers such as Amazon and Apple. In the pioneering work, Xie and Shugan [1] reveal that the uncertainty of consumer valuation contributes to the retailer's profit increase under AS strategy. Furthermore, Zhao and Stecke [2] examine the benefits from both consumer valuation uncertainty and demand learning to decide whether a retailer should sell in advance to loss averse consumers or not. Prasad et al. [3] conclude that retailers should sell in advance if consumers' expected valuation exceeds their expected surplus. Zhao and Pang [4] argue that demand uncertainty could benefit a retailer if the pricing mechanism is designed properly in advance selling. Man et al. [5] analyze that the advance selling price will be higher when consumer valuations are highly correlated. All of the studies above-mentioned consider advance selling between a retailer and strategic consumers without considering the upstream manufacturer. Zhao et al. [6] study a retailer's AS option in the supply chain including the retailer and its upstream manufacturer under traditional wholesale contract. They find that the retailer's AS option might hurt its profit. However, they didn't propose a solution to the retailer in disadvantaged situations. This paper focuses on how to improve the retailer's profit by using agency contract instead of wholesale contract in a decentralized supply chain.

Supply chain contracts between the supplier and retailer have been well documented in the literature of Cachon [7]. The wholesale contract and agency contract are the two most popular contracts applied between retailers and manufacturers. When Amazon sold e-books in the market place initially, they set the bestselling books at $9.99. Besides, Apple apply the agency model to allow manufacturers set price themselves. Hao and Fan [8] compared the two contract models and identify that in different market conditions, the retail price of the product is lower in the agency model to help the retailer gain a higher market share. Tan et al. [9] reveals that the agency contract optimally coordinates the whole supply chain while the retailer sells digital goods with zero marginal cost. In our models, we first consider the retailer offers traditional wholesale contract to upstream manufacturer and the retailer has options to choose sell in advance or not. Then we examine whether the agency contract could improve the retailer's profit under AS strategy.

The remainder of the paper is organized as follows. Section 2 proposes a benchmark model under wholesale contract. Section 3 constructs the AS model with a supply chain under agency contract. Numerical examples and managerial implications are placed in Section 4, followed by concluding remarks.

2. BENCHMARK MODEL

2.1. Model Description

We consider a supply chain with a manufacturer (she) and a retailer (he). In the benchmark model, the manufacturer

produces a new product at a constant marginal cost *c* and sells with a wholesale price *w* to the retailer. The retailer sells the product in a two-period selling season. The retailer has the AS option and decides whether to sell in advance. If he sells in advance, the product is sold to consumers in the advance period with price p_1^W and in the spot period with price p_2^W, where the superscript *W* denotes the wholesale contract. For simplicity, the salvage value of unsold inventory at the end of the spot period is normalized to zero. Figure 1 depicts the game sequence under the wholesale contract.

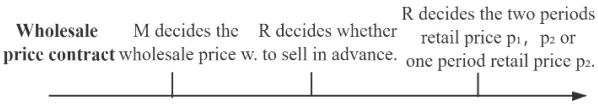


Figure 1 the game sequence under wholesale contract

Consumers can be divided into two groups, informed and uninformed. Informed consumers know the AS option and will decide whether to pre-order the product in the advance period while uninformed consumers do not know the AS option and can only decide whether to purchase at the spot period. Following Xie and Shugan [1], we assume the market size is normalized to 1 and there are 1/2 informed consumers and 1/2 uninformed consumers. Besides, we assume that each consumer has a unit demand.

Consumers form expectations about the valuation *V* of the new product between $[(1-t)/2,(1+t)/2]$, where $0 \le t \le 1$. Here *t* indicates the degree of dispersion of the valuation distribution. A low (high) *t* suggests that consumers have similar(differentiated) valuations of the product. The distribution for consumers' realized valuations in the spot period is the same as the common valuation distribution that consumers believed in the advance period. Consumers decide whether to make purchases based on their expected utility. Their expected utility of buying in advance and delaying the purchase until the next period are $U_A = E(V) - p_1^W$ and $U_W = E(V - p_2^W)^+$, respectively.They choose to pre-order if and only if $U_A \ge U_W$.

As the valuation distributions are the same for all of the informed consumers, the demand in the advance period and spot period can be described as follows, respectively.

$$D_1 = \frac{1}{2} \quad (1)$$

$$D_2 = \frac{1}{2t}\left(\frac{1+t}{2} - p_2^W\right) \quad (2)$$

Let superscript "*NW*" represent the scenario where the retailer doesn't exercise the AS option under the wholesale contract. The manufacturer and the retailer's expected profit with and without AS can be expressed as follows, respectively.

$$\Pi_R^W = (p_1^W - w)D_1 + (p_2^W - w)D_2 \quad (3)$$

$$\Pi_R^{NW} = 2(p_2^{NW} - w)D_2 \quad (4)$$

$$\Pi_M^W = (w - c)(D_1 + D_2) \quad (5)$$

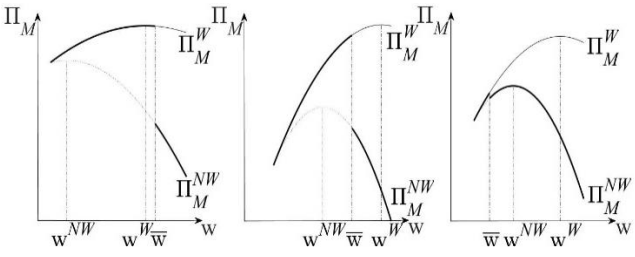
$$\Pi_M^{NW} = 2(w - c)D_2 \quad (6)$$

2.2. Game Equilibrium and Profit Implications

The retailer does not have an incentive to sell the product when the wholesale price is greater than $(1+t)/2$. Therefore, a rational manufacturer should set $w < (1+t)/2$. In order to decide whether or not to sell in advance, the retailer compares the optimal profits Π_R^W with Π_R^{NW}. Note that the optimal spot price p_2^{NW*} is the same as p_2^{W*}. Define $\Delta_R^W = \Pi_R^W - \Pi_R^{NW}$. Lemma 1 shows that if the manufacturer wants to induce the retailer to sell in advance, the wholesale price needs to be lower than the threshold $\bar{w}$.

Lemma 1. *When the manufacturer induces the retailer to sell in advance, she sets the wholesale price at* $w \le \bar{w}$, *where* $\bar{w} = \frac{3-t}{6}$, *i.e,* $\Delta_R^W \ge 0$, *if and only if* $w \le \min\left(\frac{3-t}{6}, \frac{1+t}{2}\right)$.

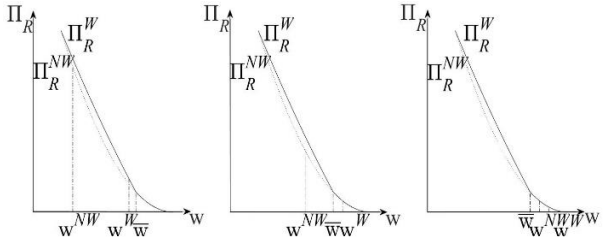
Figure 2 illustrates the manufacturer's profit as a function of the wholesale price. The bold curves represent the manufacturer's piecewise profit. In the first case, $w^{NW} < w^W \le \bar{w}$ (see Figure 2a). The manufacturer maximizes her profit when $w = w^W$ and the retailer sells in advance. In the second case, $w^{NW} \le \bar{w} < w^W$ (see Figure 2b). The manufacturer obtains the optimal profit $\Pi_M^W(\bar{w})$ under the AS strategy. In the third case, $\bar{w} \le w^{NW} < w^W$ (see Figure 2c). The manufacturer obtains the optimal profit $\Pi_M^{NW}(w^{NW})$.



(a)when $c < c^W$ (b) when $c^W < c \le c^{NW}$ (c) when $c > c^{NW}$

Figure 2 The manufacturer's profit function

Figure 3 illustrates the retailer's profit. The solid curve represents the retailer's profit under the AS strategy and the dashed curve shows his spot-selling profit. Figure 3a shows that the wholesale price increases from w^{NW} to w^{W} when the retailer has the option to sell in advance. Similarly, the wholesale price increases from w^{NW} to $\bar{w}$ in Figure 3b. In Figure 3c, however, the wholesale price maintains at w^{NW}.



(a)when $c < c^{W}$ (b) when $c^{W} < c \le c^{NW}$ (c) when $c > c^{NW}$

Figure 3 The retailer's profit function

Using backward induction, we summarize the manufacturer and the retailer's optimal pricing decisions in each period.

Lemma 2. *Define* $c^{W} = \max\{c \ge 0 \mid w^{W}(c) \le \bar{w}\}$ *and* $c^{NW} = \max\{c \ge 0 \mid w^{NW}(c) \le \bar{w}\}$ *.Then* $c^{W} < c^{NW}$ *.The manufacturer and the retailer's optimal pricing decisions are:*

1) If $c \in (0, c^{W}]$, *then* $w^{NW} < w^{W} \le \bar{w}$. *The optimal prices are:* $w^{W*} = \frac{5t+1}{4} + \frac{c}{2}$,

$p_1^{W*} = \frac{-9t^2 + (-12c+70)t - (2c-1)^2}{128t}$, $p_2^{W*} = \frac{3+7t+2c}{8}$;

2) If $c \in (c^{W}, c^{NW}]$, *then* $w^{NW} < \bar{w} < w^{W}$. *The optimal prices are:* $\bar{w} = \frac{3-t}{6}$, $p_1^{\bar{w}} = \frac{1}{2} - \frac{t}{18}$, $p_2^{\bar{w}} = \frac{1}{2} + \frac{t}{6}$;

3) If $c \in (c^{NW}, \frac{1+t}{2})$, *then* $\bar{w} \le w^{NW} < w^{W}$. *The optimal prices are:* $w^{NW*} = \frac{1+t}{4} + \frac{c}{2}$, $p_2^{NW*} = \frac{3+3t+2c}{8}$.

In the cases above, $c^{W} = \frac{3-17t}{6}$ *and* $c^{NW} = \frac{3-5t}{6}$.

When the marginal production cost is low or moderate, that is, in the first two cases in lemma 2, the retailer's profit is hurt by applying AS strategy, as summarized in proposition 1.

Proposition 1. *When* $c \in (0, c^{NW}]$, *the retailer's profit is hurt by applying the AS strategy.*

In a decentralized supply chain, when the retailer exercises the right to pre-sell, the AS benefit is shared in the supply chain between the manufacturer and the retailer. The manufacturer takes all the supply chain benefits when the wholesale price is priced at $\bar{w}$. When the product's marginal production cost is moderate, the wholesale price is set at $\bar{w}$, the retailer won't benefit from the AS option and even get a loss due to a high wholesale price charged by the manufacturer. When the product's marginal production cost is high, the wholesale price is at w^{NW*}. The retailer will obtain an unchanged profit which is equal to the profit while not exercising the AS option.

3. ADVANCE SELLING UNDER AGENCY CONTRACT

3.1. Model Description

How could a retailer improve profit under the AS strategy? In practice, we observed that there were different types of contracts between retailers and manufacturers. Besides the wholesale contract, the agency contract has also been widely used in recent years with the rapid development of online platform retailers such as Amazon and Jing Dong. The agency contract is an agreement that the manufacturer establishes a retail price and the retailer (e.g., Apple or Amazon) takes a percentage cut out of the sales. This contract can sometimes weaken the double marginalization in a supply chain compared with the traditional wholesale model. Thus, we try to examine whether the agency contract could help the retailer to eliminate or weaken the disadvantage under the AS strategy.

Let superscript "*G*" represent the scenario where the retailer sells in advance under the agency contract. In our game model, the event sequence is as follows. Before the advance selling period starts, the manufacturer decides whether to induce the retailer to sell in advance. If so, she sets advance price p_1^G and spot price p_2^G where $p_1^G < p_2^G$ and supplies products to the retailer. In the advance period, informed consumers decide whether to buy or wait. In the spot period, uninformed consumers, as well as the advance period arrivals and decides whether or not to buy in the spot market. The manufacturer retains *s* proportion of his revenue and gives the remaining of the sales revenue to the retailer. The commission rate *s* is exogenously determined before the selling season starts.

Consumers' net utility of buying in advance is $U_A = E(v) - p_1^G$, and their expected utility of waiting till the spot period is $U_W = E(v - p_2^G)^+$. Informed consumers choose to pre-order if and only if $U_A \ge U_W$.

The demands in advance and spot period are both the same as those in the benchmark model. Following the study of Zennyo [10], we disregard the marginal cost of the retailer without loss of generality. Let superscript "*NG*" represent

the scenario where the retailer only spot sells under the agency contract. Thus, the manufacturer and the retailer's expected profits with and without AS can be expressed as follows, respectively.

$$\Pi_M^G = (p_1^G s - c)D_1 + (p_2^G s - c)D_2 \quad (7)$$

$$\Pi_M^{NG} = 2(p_2^{NG} s - c)D_2 \quad (8)$$

$$\Pi_R^G = p_1^G(1-s)D_1 + p_2^G(1-s)D_2 \quad (9)$$

$$\Pi_R^{NG} = 2p_2^{NG}(1-s)D_2 \quad (10)$$

3.2. Game Equilibrium and Profit Implications

The manufacturer determines p_1^G and p_2^G by maximizing the profit function Π_M^G. Meanwhile, p_1^G should motivate informed consumers to make their purchasing decision by comparing the net utility of buying now with the expected utility of delaying the purchase. The following proposition summarizes the manufacturer's optimal price decisions.

Lemma 3. *Given the commission rate s, the manufacturer's optimal prices are*

$$p_1^{G*} = \frac{(-t^2+14t-1)s^2 + 4c(1+t)s - 4c^2}{32s^2 t} \quad \text{and}$$

$$p_2^{G*} = \frac{s + st + 2c}{4s}.$$

If the manufacturer only spot sells, the retailer orders quantities $2D_2$ from the manufacturer. Note that the optimal spot price p_2^{G*} is the same as p_2^{NG*}. When deciding whether to induce the retailer to sell in advance, the manufacturer compares the resulting optimal profits Π_M^G with Π_M^{NG}. Define $\Delta_M^G = \Pi_M^G - \Pi_M^{NG}$.

Lemma 4. The manufacturer's induction strategy is:

1) If $c \in (-\frac{3}{2}st + \frac{1}{2}s, -\frac{1}{6}st + \frac{1}{2}s)$, then $\Delta_M^G \geq 0$. The manufacturer induces the retailer to advance sell by setting the retail prices at p_1^{G*} and p_2^{G*}.

2) If $c \in (0, -\frac{3}{2}st + \frac{1}{2}s) \cup (-\frac{1}{6}st + \frac{1}{2}s, \frac{1+t}{2})$, then $\Delta_M^G < 0$. The manufacturer induces the retailer to spot sell by setting the retail prices at p_2^{NG*}.

Lemma 4 shows that under the agency contract advance selling is profitable for the manufacturer only when the product's marginal production cost is moderate.

We now focus on the interval $c \in (0, c^{NW}]$, where the retailer's profit is hurt by AS under the wholesale contract. By comparing the resulting optimal profits Π_R^G with Π_R^{WF} and Π_R^{NW} on this interval, we have Proposition 2.

Proposition 2.

1)If

$$c \in (\max\left\{0, -\frac{3}{2}st + \frac{1}{2}s, \frac{(1+t-a)s}{2(s^2-3s+3)}\right\}, \min\left\{\frac{3-5t}{6}, -\frac{1}{6}st + \frac{1}{2}s, \frac{(1+t+a)s}{2(s^2-3s+3)}\right\})$$

we have $\Pi_R^{WF} < \Pi_R^{NW} < \Pi_R^G$;

2)If

$$c \in (\max\left\{0, -\frac{3}{2}st + \frac{1}{2}s, c_1\right\}, \min\left\{\frac{3-17t}{6}, -\frac{1}{6}st + \frac{1}{2}s, c_2\right\}) \cap [(0, \frac{(1+t-a)s}{2(s^2-3s+3)}) \cup (\frac{(1+t+a)s}{2(s^2-3s+3)}, \frac{1+t}{2})]$$

we have $\Pi_R^W(w^{W*}) < \Pi_R^G < \Pi_R^{NW}$;

3)If

$$c \in (\max\left\{\frac{3-17t}{6}, -\frac{3}{2}st + \frac{1}{2}s, \frac{(3st+3s-3t+6d-3)s}{18(-1+s)}\right\}, \min\left\{\frac{3-5t}{6}, -\frac{1}{6}st + \frac{1}{2}s, \frac{(3st+3s-3t-6d-3)s}{18(-1+s)}\right\}) \cap [(0, \frac{(1+t-a)s}{2(s^2-3s+3)}) \cup (\frac{(1+t+a)s}{2(s^2-3s+3)}, \frac{1+t}{2})]$$

, we have $\Pi_R^W(\bar{w}) < \Pi_R^G < \Pi_R^{NW}$;

In the cases above,

$$a = \sqrt{(1-s)[(s-1)^2t^2 + (18s^2-52s+50)t + (s-1)^2]}$$

$$b = \sqrt{\frac{(-s^3+71s^2-459s+469)t^2 + (-18s^3+214s^2-342s+146)t}{-(s-13)(-s+1)^2}}$$

$$c_1 = \frac{(9st-3s+4t-2b+4)s}{2(s^2-12s+12)}, \quad c_2 = \frac{(9st-3s+4t+2b+4)s}{2(s^2-12s+12)}$$

$$d = \sqrt{(s-1)[(t^2+14t+1)s + 13t^2/3 - 14t - 1]}.$$

As in Proposition 2, in case 1, the retailer gains more profit from advance selling under agency contract than that from spot selling under wholesale contract. In case 2&3, the manufacturer sets wholesale price at w^{W*} and $\bar{w}$, respectively. Correspondingly, the retailer gains more profit from advance selling under agency contract than that under wholesale contract. However, he gains less profit than that from spot selling under wholesale contract.

Proposition 2 provides the insight that a retailer's profit can be improved under the agency contract when the marginal production cost satisfies the ranges in proposition 2, where the threshold values are related to the degree of dispersion of the true valuation distribution *t* and the commission rate *s*.

4. NUMERICAL EXAMPLES

In this section, we analyze the numerical results to illustrate the influence of contract type. In business practice, we observe that the commission rate *s* is usually high to guarantee the manufacturer's positive earnings. Therefore, we set four different values of *s* to represent

different levels of commission rate, that is $s=\{0.6,0.7,0.8,0.9\}$. We numerically divide the whole parameter space (*t*, *c*) into several regions under different commission rates, as shown in Figure 4.

In each subfigure of Figure 4, the horizontal axis *t* represents the consumers' valuation distribution dispersion and the vertical axis *c* denotes the marginal production cost of the manufacturer. Figure 4 illustrates the retailer's strategic decision on whether to adopt agency contract under certain marginal production cost given the degree of consumers' true valuation distribution dispersion *t*. In Region Ⅰ, the retailer's profit is not improved under the agency contract. In Region Ⅱ, the retailer obtains more AS profit under agency contract than spot selling under wholesale contract, as in case 1 in proposition 2. In this case, the retailer changes the situation of profit hurt thoroughly. In Region Ⅲ and Region Ⅳ, the retailer can realize profit improvement through contract change but still cannot get rid of the profit hurt situation, as in case 2 and case3 in proposition 2.

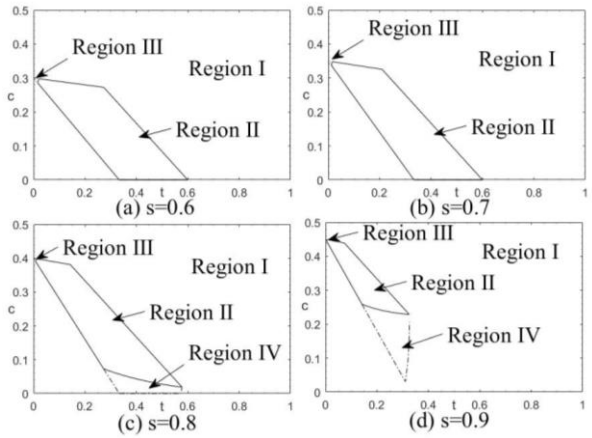


Figure 4 Influence on the retailer's profit

The numerical results provide several management implications. Firstly, as the commission rate *s* charged by the retailer rises, the retailer is more likely to earn greater profit when consumer valuation distribution is concentrated and marginal production cost is high. Secondly, when consumer valuations are differentiated enough, the retailer cannot improve his profit by applying agency contract. Thirdly, in general, the retailer prefers a lower commission rate *s* under agency contract to get a higher proportion of the revenue.

5. CONCLUSIONS

This paper studies the impact of applying agency contract instead of wholesale contract on a retailer's profit in a supply chain. In the benchmark model, we find that the AS strategy hurts the retailer when the marginal production cost is low or moderate. We then extend the benchmark model to the case with agency contract to investigate the impact of supply chain contract on the retailer. The results show that the retailer's profit can be improved to some extents under the agency contract depending on the range of the marginal cost, the commission rate and the consumer valuation dispersion, especially when consumer valuations are concentrated and marginal production cost is relatively moderate. We also show that the retailer prefers a lower commission rate *s* which enables him to get a higher proportion of the revenue in the entire supply chain. The results imply that when the retailer applies the AS strategy, the agency contract is better off than the wholesale contract in certain circumstance.

In this paper, we only consider to change contract type in our game model to help the retailer improve profit and escape from the disadvantaged situation. The downstream consumer payment method will be taken into consideration in further research.

ACKNOWLEDGMENT

The authors gratefully acknowledge financial support from the National Undergraduate Training Program for Innovation and Entrepreneurship (Grant No. 202010288083Z), and National Natural Science Foundation of China (Grant Nos. 71571102 and 71771123).

REFERENCES

[1] J.H. Xie, S. Shugan, Electronic tickets, smart cards, and online prepayments: When and how to advance sell, Market. Sci. 20(3) (2001) 219-243. DOI: https://doi.org/10.1287/mksc.20.3.219.9765

[2] X.Y. Zhao, K.E. Stecke, Pre-orders for new to-be-released products considering consumer loss aversion, Prod. Oper. Manag. 19(2) (2010) 198-215. DOI: https://doi.org/10.1111/j.1937-5956.2009.01092.x

[3] A. Prasad, K.E. Stecke, X.Y. Zhao, Advance selling by a newsvendor retailer, Prod. Oper. Manag. 20(1) (2011) 129–142. DOI: https://doi.org/10.1111/j.1937-5956.2010.01133.x

[4] X.Y. Zhao, Z. Pang, Profiting from demand uncertainty: pricing strategies in advance selling, 2011, Available at SSRN: https://ssrn.com/abstract=1866765

[5] Y. Man, K. Roman, A. Hyun-Soo, Advance selling: effects of interdependent consumer valuations and seller's capacity, Management. Sci. 61(9) (2015) 2100-2117. DOI: https://doi.org/10.1287/mnsc.2014.2047

[6] X.Y. Zhao, Z. Pang, K.E Stecke, When does a retailer's advance selling capability benefit manufacturer, retailer, or both?, Prod. Oper. Manag.

25(6) (2016) 1073-1087. DOI: https://doi.org/10.1111/poms.12535

[7] G. Cachon, Supply chain coordination with contracts. In S. Graves and T.de Kok (Eds.), Handbooks in operations research and management science: Supply chain management. Amsterdam, North-Holland: Kluwer, Amsterdam Netherlands, 2003.

[8] L. Hao, M. Fan, An analysis of pricing models in the electronic book market, MIS. Quart. 38(4) (2014) 1017-1032. DOI: https://dx.doi.org/10.25300/MISQ/2014/38.4.04

[9] Y.R. Tan, J.E. Carrillo, H.K. Cheng, The agency model for digital goods, 2013, Available at SSRN: https://ssrn.com/abstract=2297484

[10] Y. Zennyo, Strategic contracting and hybrid use of agency and wholesale contracts in e-commerce platforms, Eur. J. Oper. Res. 281(1) (2020) 231-239. DOI: https://doi.org/10.1016/j.ejor.2019.08.026