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The Impact of Financial Market and Resale Market on Firm Strategies

Zhiling GUO
Singapore Management University, ZHILINGGUO@smu.edu.sg

Andrew B. WHINSTON
University of Texas at Austin

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Zhiling Guo
Information Systems Department
University of Maryland, Baltimore County
zguo@umbc.edu

Andrew B. Whinston
Department of Information, Risk, and Operations Management
The University of Texas at Austin
abw@uts.cc.utexas.edu

Abstract

The ever-increasing use of information technology (IT) in business transactions greatly expands firms' exposure to different electronic markets. This paper provides a framework to understand how firms can leverage different strategies across external financial markets and an internal resale market to improve overall profitability. We develop a model in which a group of risk-averse retailers sell a homogeneous product to their respective uncertain consumer markets. We study a scenario where an internal resale market can be constructed among the retailers and outside financial markets can be used to improve their ability to manage uncertainty. We identify strategies for retailers operating in these two types of markets. We examine under what conditions which strategy is preferable and what range of economic impacts the two strategies may offer to enhance the retailer's competitive advantages.

1. Introduction

IT reduces coordination costs and transaction risk. Transaction cost economics predicts that significant reductions in transaction costs can enable new organizational and channel structures [11]. The Internet economy is changing the way firms interact with each other. As a result, new business innovations are increasingly relying on electronic marketplace solutions to create a significant organizational change consistent with the emerging business strategies.

Prior research on channel structures focuses on supplier-retailer interactions in a linear supply chain system. Supply chains today are dynamic webs that are coordinated over the Internet. The Internet offers efficient communication and tight connectivity, opening new venues for trade. The new electronic market solutions include new market channels such as auctions and spot market for capacity [6]. By using these channels, firms can dispose of excess inventory or procure needed inventory and build flexible and responsive supply webs. The increasing use of auction and spot markets also provides firms opportunities for risk diversification.

In addition, financial market innovation has offered firms new opportunities for managing risks in their supply chain. In the traditional domains of insurance and financial derivatives, new financial products are emerging to help firms transfer and repackage their risks.

Firms should adopt an integrated approach to manage their business risks. Both the internal operational changes and the external financial market hedge should be aligned with organizational redesign. New institutions can be constructed and new alliance can be formed to facilitate economic activities in e-marketplaces if social benefits can be realized among a group of interested participants in the supply chain. This paper examines and compares the value of an internal resale market in presence of outside financial hedging opportunities.

There is an increasing number of work on the impact of an electronic market on the supply chain performance (e.g., [7], [8], [9], [10]). However, how firms manage their activities across multiple different functional markets present new challenges. In general there is a lack of formal evaluation of the strategic potential of IT usage in organizations. This paper tries to provide some basic insights on the economic impacts of multiple electronic market structures on firm strategies.

Toward this goal, there are two lines of research related to ours. The first is hedging operational profits through trading in the financial markets. The idea is that if there is certain correlation between some financial assets and the firm's uncertain stream of profits, firms can use available financial instruments to hedge their risk exposure (see [3],[4]). Both Gaur and Seshadri (2004) and Caldentey and Haugh (2003) considered a mean-variance newsboy hedge problem when the demand is a function of a financial index and some other noise that is independent of the price process. Under a different framework [2], Anvari (1987) studies the newsboy problem using the capital asset pricing model (CAPM).

The second stream of research is to explore the risk pooling opportunities among peer retailers. In [1], Anupindi et al. (2001) considered a group of retailers'

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inventory and allocation decisions when facing local stochastic demands. They proposed to store partial inventory at a central location. When uncertain demands from retailers are realized, they can easily transfer title of claims to adjust their allocation. In another context [8], Lee and Whang (2002) examined the impact of a secondary market on firm performance. Distinguished from the primary market where the retailers place inventory orders from the manufacturer, the secondary market is opened when uncertainty in demand is better resolved so that retailers can trade among each other their excess inventories associated with independent demand risks.

There is a complementary relationship between financial hedge and operational hedge. Since a retailer's demand is only partially correlated with some tradable financial assets, firm's total risk is not fully hedgable. Aside from the incompleteness in hedge, retailers' ability to hedge through financial markets will result in moral hazard problems – behaving too aggressively in inventory holding will increase the risk for leftover. We propose a resale market as a new institutional design to deal with these two problems in pure financial hedge.

The concepts of either hedging through financial markets [4] or constructing an internal electronic resale market [8] are not new. However, prior research focuses on one type of the market. What is the impact and the interaction of both markets on retailer operating policy and supply chain performance is unexamined. This paper tries to bridge this research gap.

Both the financial market hedge and the resale market risk pooling exchange can provide certain means of insurance mechanisms for retailers' risk reductions. In some sense, these two types of markets can substitute each other in their risk management functions. But having access to both will yield the most economic benefits. In this paper, we investigate the impact of different market mechanisms on risk-averse retailers' hedging and operating policy and the supply chain efficiency. Specifically, we use the traditional newsvendor model as the base case for comparison. We compare three market scenarios: the access to resale market, financial market, and both. We discuss how different informational assumptions on markets give rise to different types of operational and hedging solutions.

Our paper is organized as follows. In section 2, we outline the basic model and examine the firm's inventory policy when operating in either a resale market or a financial market. We present two strategies for firms when they have access to both markets in section 3. In section 4, we provide social welfare analysis and identify conditions under which one specific strategy is preferable than another. We illustrate our basic insights using a numerical example in Section 5. Section 6 concludes our paper.

2. The Model

In this section, we study a model with I risk-averse retailers who order a homogeneous product from the manufacturer at a predetermined wholesale price.

Assumption 1: The retailer has a mean-variance utility function

$$U(W) = E(W) - \lambda Var(W),\ \lambda \in R^+,\ i = 1,...,I$$

where W is the wealth level, and λ reflect the degree of risk aversion. A higher value of λ represents a more risk-averse retailer. For simplicity, we impose symmetry condition on retailers.

Assumption 2: The retailer's demand is *i.i.d.* and $D_i \sim F(\cdot)$, $i = 1,...,I$, where the distribution $F(\cdot)$ with support $[0, +\infty)$, finite mean μ and variance σ^2. Let $f(\cdot)$ denote its density.

We use the traditional newsvendor model as the base case for comparison. In the following, we investigate the impact of different market mechanisms on the risk-averse retailers' hedging and operating policy and the channel efficiency.

2.1. The Decentralized Model

The retailer's optimization problem is to determine the optimal order quantity Q^d to maximize her utility:

$$Q^d \equiv \arg Max\ E\left[r\min\left(Q^d, D_i\right) - sQ^d\right]$$
$$-\lambda Var\left[r\min\left(Q^d, D_i\right) - sQ^d\right]$$

where r is the fixed retail price, s is the predetermined wholesale price charged by the manufacturer. The terms in the first line are the total net expected profit. Those terms in the second line are profit variance.

Solving this optimization problem yields the optimal decentralized order quantity Q^d that satisfies the following equation:

$$r\left[1 - F\left(Q^d\right)\right]\left[1 - 2\lambda r\Gamma\left(Q^d\right)\right] = s \qquad (1)$$

where $\Gamma(Q) = \int_0^Q F(x)dx$ (see Appendix for a complete proof).

For the risk-neutral newsvendor, $\lambda = 0$. Equation (1) reduces to the risk-neutral order quantity, denoted by $Q^n = F^{-1}\left[1 - \frac{s}{r}\right]$. So it is easy to check that the risk-averse retailer's order $Q^d < Q^n$.

Further, from (1) we can see that the distortion from the risk-neutral level is affected by two parameters: the retailer's risk aversion and the demand uncertainty reflected by demand cumulative distribution $F(\cdot)$. Hence, the decentralized order quantity decreases when the retailer becomes more risk averse and when she perceives the demand to be more volatile.

2.2. The Resale Market Model

Now suppose the retailers agree to set up a resale market to trade ex post. The timing is as follows. In the first period, each retailer needs to purchase two types of inventories with different procurement costs: the inflexible inventory Q^r that cannot be resold later at per unit cost *s*, and the relatively flexible inventory q^r that can be resold in the resale market at per unit cost *w*. We impose the condition $s < w < r$ to reflect the fact that the flexible inventory is more expensive. In the second period, the retailer's demand is realized. The retailer can sell off excess inventory and buy additional inventory if needed at an equilibrium market price *p*.

We assume that the exchange in the resale market is restricted to the retailers themselves and there is no other source of supply and demand. Since we consider symmetric retailers, in equilibrium in order for market to be clear it must be the case that for each retailer the expected total flexible quantity has to equal the expected total unmet demand. Therefore, we derive the following equilibrium condition:

$$\int_{Q^r}^{\infty}\left(x-Q^r\right)f\left(x\right)dx=q^r$$

That is,

$$q^r=\int_{Q^r}^{\infty}xf\left(x\right)dx-Q^r\left(1-F\left(Q^r\right)\right) \qquad (2)$$

Note that $Q^r+q^r=\int_{Q^r}^{\infty}xf\left(x\right)dx+Q^rF\left(Q^r\right)$. So $\frac{\partial\left(Q^r+q^r\right)}{\partial Q^r}=F\left(Q^r\right)>0$. Differentiating (2) we have $\frac{\partial q^r}{\partial Q^r}=-\left[1-F\left(Q^r\right)\right]<0$ and $\frac{\partial^2 q^r}{\partial Q^{r2}}=f\left(Q\right)>0$. We have the following result.

Lemma 1: *The retailer's total order quantity* Q^r+q^r *increases in* Q^r*; her flexible inventory* q^r *decreses in* Q^r*. Further,* q^r *is a convex function of* Q^r*.*

The above result is intuitive because from Section 2.1 we know that a retailer would like to choose a relatively high level of inventory when the demand uncertainty is low, and among which, the inflexible inventory level should be higher since it is relatively cheap.

When a retailer chooses a high inflexible inventory level Q^r, the possibility of unmet demand is low. The retailer needs to hold a low level of flexible inventory to satisfy the demand contingency.

We further assume that the resale market equilibrium price is a linear function of the transaction volume. We count the match of one unit inventory between a buyer and a seller as one transaction. So the transaction volume equals to the total amount of sales (or buys, equivalently).

$$p=A-\int_{Q^r+q^r}^{+\infty}\left(x-Q^r-q^r\right)f\left(x\right)dx$$

where A is a positive constant.

Notice that we impose a strong assumption that the resale market will always clear. Note that the demand and supply in the resale market depends on the actual demand realized by every retailer. It is reasonable to assume that a large resale market provides an effective demand pooling mechanism through which one retailer's shortage in inventory can be covered by other's excess inventory so that the total consumer demand can be satisfied ex post. By pooling demand from different symmetric retailers, the resale market has a risk-reduction effect for retailer's operation.

If the resale market is well structured, it should work like an insurance mechanism. By paying for the flexible inventory at the first stage and pooling their flexible inventory together, the retailer in fact is insured that the ex post unmet demand is satisfied at no additional cost. The kinked payoff structure we observed in the decentralized case will be reshaped and to be aligned with the realized demand fluctuation.

Substituting (2) into the pricing function we have

$$p=A-\int_{Q^r}^{Q^r+q^r}F\left(x\right)dx \qquad (3)$$

Given the relationship (2) that must be held in equilibrium, the retailer's first stage problem is simplified as

$$\begin{aligned}&\underset{Q^r}{Max}\ r\mu-\lambda r^2\sigma^2-sQ^r-wq^r+p\int_0^{Q^r}q^rf\left(x\right)dx\\&+p\int_{Q^r}^{+\infty}\left(Q^r+q^r-x\right)f\left(x\right)dx \qquad (4)\\&s.t.\ q^r=\int_{Q^r}^{\infty}xf\left(x\right)dx-Q^r\left(1-F\left(Q^r\right)\right)\end{aligned}$$

Note that since the total consumer demand will be satisfied ex post, the retailer's expected profit variance will be the variance of the demand multiplied by a scalar. The third and fourth terms in the objective function are the cost of inventory for inflexible and flexible orders. The next integral is the retailer's expected profit from selling her flexible inventory, and the last integral is the expected profit from selling excess flexible inventory after satisfying her own demand first. These expectations are calculated in anticipation of the equilibrium resale market price p.

Solving this problem we have

$$F\left(Q^r\right) = 1 - \frac{s}{w} \tag{5}$$

Therefore, $Q^r = F^{-1}\left[1 - \frac{s}{w}\right]$, which is an increasing function of w. This implies that if the cost for ordering flexible inventory is high, the retailers tend to hold more inflexible inventory. In addition, note that the order quantity does not depend on resale market price. This is because in equilibrium, retailers perfectly infer the expected resale market price thus making their flexible inventory order decision accordingly. On expectation, their cost and benefit on the resale market cancel off. The real effect is its risk reduction by the resale market's function of demand pooling.

Recall that $Q^n = F^{-1}\left[1 - \frac{s}{r}\right]$ and $r > w$, we have $Q^r < Q^n$. Compare equation (1) and (5) we have the following relation between order quantities when retailers operate under different markets.

Lemma 2: *The retailer's total order quantity when she has access to a resale market may or may not exceed the decentralized order quantity Q^d. Both Q^r and Q^d are less than the risk neutral order quantity Q^n.*

Lemma 2 tells us that constructing an electronic resale market may or may not increase retailers' order, since the order quantity depends on the cost parameters set by the manufacturer. However, the retailers' utility will increase since operating at the decentralized solution is always feasible. Having access to the resale market will bring additional benefit to reduce risk.

Further we notice that if the manufacturer can impose a high enough price (w close to the retail price r) for the flexible inventory, the retailers' order for the inflexible inventory will be close to the risk neutral solution. This reinforces the role of the resale market. When retailers are risk averse, they tend to order less than the risk neutral solution. But due to the resale market's risk reduction function, the retailers will be willing to order close to their risk neutral solution even by doing so gives them almost no profit margin.

2.3. The Financial Market Model

Now suppose that retailer i find that her demand has a linear correlation with a tradable financial index S_i, i.e., $D_i = a_i + b_i S_i + \varepsilon_i$, a_i and b_i are correlation coefficient, and $\varepsilon_i \sim N\left(0, \sigma_i^2\right)$ is a normally distributed random error with mean 0 and variance σ_i^2. The risk-averse retailer could manage to hedge part of her risk through the financial market where S_i is traded. Note here we allow retailers to choose different index S_i as the hedging instrument as long as that index is publicly traded.

We assume that the financial market is efficient and arbitrage free. Then all the contingent claims such as various types of put, call options can be effectively priced so that the current price should equal to the expected future payoff of those contingent claims. Based on this observation, the financial hedge has the effect to reduce the variance of some uncertain payoff but keep the mean unchanged. An obvious and intuitive hedging strategy is to hedge all the hedgeable risks in the financial market while leave the error term ε_i untouched.

Suppose the order quantity in the commodity market is Q^f. The retailer's profit is $W = r\min\left[Q^f, D_i\right] - sQ^f$. Note that the payoff structure can be approximately replicated using a combination of the financial index and an option. We cannot exactly replicate the payoff because of the idiosyncratic component (the error term) in the demand. So the hedge is incomplete. We assume that the retailer's optimal hedging portfolio consists of short selling α shares of the financial index and purchasing β shares of call option with strike price K_i with maturity in the second period (the same time when demand is realized).

The variance of the profit is

$$\begin{aligned} VarW &= Var\left[r\min\left[Q^f, D_i\right] - \alpha S_i + \beta\left(S_i - K_i\right)^+\right] \\ &= Var\left[\begin{array}{l} ra_i + r\varepsilon_i + rb_i S_i - rb_i\left(S_i - \dfrac{Q^f - a_i}{b_i}\right)^+ \\ -\alpha S_i + \beta\left(S_i - K_i\right)^+ \end{array}\right] \end{aligned}$$

Since ε_i is independent of S_i, by choosing $\alpha = rb_i$, $\beta = rb_i$, and $K_i = \frac{Q^f - a_i}{b_i}$ the minimum variance is achieved by $r^2\sigma_i^2$.

Therefore, the retailer's problem is

$$\underset{Q^f}{Max}\ Er\min\left[Q^f, D_i\right] - sQ^f - rb_i C_i + rb_i\left(S_i - \frac{Q^f - a_i}{b_i}\right)^+$$

$$s.t.\ C_i = \int_{K_i}^{+\infty}\left(x - K_i\right) f_s\left(x\right) dx$$

where C_i is first period price for the option with strike price $\frac{Q^f - a_i}{b_i}$, $f_s\left(x\right)$ is the density function of the financial index S_i. The constraint is based on the efficient market assumption, i.e., the current price for the option should equal the expected payoff of the option in the second period.

Solving this optimization problem we have

$$Q^f = F^{-1}\left(1-\frac{s}{r}\right) = Q^n > Q^d$$

Proposition 1: *With access to the financial market, the retailer's order quantity Q^f will increase to the risk neutral level Q^n.*

The intuition is quite clear. Due to the retailer's risk aversion, she will order less aggressively than the risk neutral case. However, with the access to the finical market, the retailer can use the available financial products to hedge her payoff uncertainty. The reduced uncertainty in payoff will bring up the order quantity to the risk neutral level.

3. Two Strategies Operating in Two Markets

In section 2, we see that the resale market and the financial market have their own merits to deal with the retailer's demand uncertainty respectively. If a retailer can have access to both markets, her optimal control problem would consist of a mean-variance trade-off and the interaction between operational inventory policy and the optimal hedging strategy.

When the financial market and the resale market coexist, there are two possible strategies. Depending on which market (resale or financial) plays the primary role to remove uncertainty, we call the two strategies *R* and *F* respectively.

For the first strategy *R*, the resale market plays a primary role to restructure the retailer's profit uncertainty to match its demand uncertainty. Due to the direct correlation between the demand and the financial index, the financial market hedging strategy is simplified to trade the index only. Continue with the retailer's optimization problem, the expected wealth can be expressed as

$$\begin{aligned} EW &= r\mu - sQ^r - wq^r + p\int_{Q^r}^{+\infty}\left(Q^r + q^r - x\right)f\left(x\right)dx \\ &\quad + p\int_0^{Q^r} q^r f\left(x\right)dx \\ &= r\mu - sQ^r - wq^r \end{aligned}$$

The second equality comes from equation (2) and some simple algebra.

Suppose the hedging portfolio consists of short selling α shares of the financial index. Since in the arbitrage-free market, the first period price for the index equals to the expected value of the index in the second period, the mean effect of hedging is zero. So the retailer's optimal hedging portfolio should minimize the variance of her wealth.

$$\begin{aligned} \underset{\alpha}{Min}\ \ VarW &= Var\left[rD_i - \alpha S_i\right] \\ &= Var\left[r\left(a_i + b_i S_i + \varepsilon_i\right) - \alpha S_i\right] \end{aligned}$$

By choosing $\alpha = rb_i$, the minimum variance is achieved by $r^2\sigma_i^2$.

In the second strategy *F*, the financial market plays an essential role to hedge the major risk in the retailer's profit uncertainty. A hedging strategy includes trading shares of the index and options. If all retailers can find outside financial market to hedge their primary risk in demand, then the resale market is used to deal with the idiosyncratic uncertainty (the independent error terms the retailers cannot hedge through financial markets). Note that the correlated financial index could differ, since each retailer's demand is independently drawn from a common distribution. In addition, the error term variance could also be different. Since the error terms are *i.i.d.*, we denote the aggregate idiosyncratic demand as $d \sim N\left(0, \Sigma^2\right)$, where $\Sigma^2 = \sum_{i=1}^{N} \sigma_i^2$.

Similar analysis can be carried out when we replace the distribution $F(\cdot)$ with $N(\cdot)$ and $f(\cdot)$ with $n(\cdot)$ in equation (2).

$$\sum q^f = \int_{Q^f}^{\infty} xn\left(x\right)dx - Q^f\left(1 - N\left(Q^f\right)\right) \qquad (6)$$

Note that $N(\cdot)$ has zero mean but a large variance since it sums all the idiosyncratic variances, and $F(\cdot)$ has positive mean and smaller variance than $N(\cdot)$, compare (2) and (6) it is trivially held that $q^f < \sum q^f < q^r$ (see appendix for a complete proof).

Proposition 2: *With access to both financial and resale markets, the retailer's order for flexible inventory under strategy F is less than that under strategy R.*

Here the resale market is not used to satisfy the total demand risk but only the idiosyncratic demand risk part. The systematic risk in the demand is dealt with by individual retailers and can be hedged by trading possibly different indices in the financial market.

If neither resale market nor financial market is available, the retailer's payoff exhibits a kink at the order quantity level. Compare the two strategies we find that strategy *R* can reshape the retailer's payoff to align it with the demand uncertainty, thus enabling simple hedging strategy in the financial market (the simple index trading). In contrast, strategy *F* uses both options contract and the index to allow the retailer to hedge her payoff uncertainty and order up to the risk-neutral inflexible inventory level. In either case, the ability to access to both markets will increase the retailer's expected utility.

4. Performance Evaluation

Since the total consumer demand will be satisfied ex post, the retailer's profit will strictly increase if she increases her inflexible inventory level since the inflexible inventory is cheaper than the flexible inventory. On the other hand, increasing the inflexible inventory will possibly lead to leftover stock when the demand is low, causing a loss and reducing the retailer's profit.

Since we assume that the retailers charge a fixed retail price, and the wholesale prices for both inflexible and flexible inventory only matter how the manufacture and the retailers split their profits, we measure the total social welfare loss by the expected leftover stock. The resale market has the effect to maximize the consumer's welfare by satisfying the total demand. The expected leftover stock is measured by $L^r = Q^r + q^r - \mu$ for strategy *R* and $L^f = Q^f + q^f - \mu$ for strategy *F*. From Lemma 1, we have $Q + q$ is an increasing function of Q. Since $Q^f > Q^r$, we know that $L^f > L^r$.

Proposition 3: *With access to both resale and financial markets, the strategy F leads to more social welfare loss than the strategy R.*

This result is not a surprise. If the retailer chooses to hedge her primary demand risk through the financial market, then she is tend to be more careless in ordering her inventory, as she knows that any of her potential future loss in operation will largely be compensated by her financial market gain, and vise versa. This is well known as the classical moral hazard problem [5].

Proposition 3 implies that the conventional wisdom of hedging a firm's operational risk primarily through pure financial market is not socially optimal although from an individual point of view it is desirable. In contrast, relying on a resale market to reconstruct the uncertain payoff will yield less social welfare efficiency loss.

The coexistence of financial market and resale market will enable different combination of operational and financial hedging strategies. To be accurate, we need to compare the total expected utility generated by the two strategies. By calculation, we derive the respective utility as

$$U^R(W) = r\mu - sQ^r - wq^r - \lambda r^2 \sigma_i^2$$

$$U^f(W) = rE\left[\min\left(Q^f, a_i + b_i S_i\right)\right] - sQ^f - wq^f - \lambda r^2 \sigma_i^2$$

Compare these two utilities we have the condition to identify which strategy is preferable.

Proposition 4: *With access to both resale and financial markets, retailers will prefer strategy R to strategy F if the following condition holds:*

$$r\left[\mu - E\left[\min\left(Q^f, a_i + b_i S_i\right)\right]\right] > w\left(q^r - q^f\right) + s\left(Q^r - Q^f\right)$$

We can understand this condition as follows. Note that the left-hand-side μ is the mean consumer market demand, and $E\left[\min\left(Q^f, a_i + b_i S_i\right)\right]$ is the expected satisfied macro demand under strategy *F*. The difference of the two terms is just the expected demand loss in the two primary markets. The left-hand-side represents the total profit loss using strategy *F*. Since $Q^f > Q^r$, $q^r > q^f$, the right-hand-side is the procurement cost savings by using strategy *F*. Adopting which strategy depends on the tradeoff between profit loss versus cost savings.

Note that in this inequality, retailer's risk aversion is not a factor in influencing her strategies. This is primarily because financial market and resale market are substitutable hedging vehicles. Although relying on different hedging strategies, the retailers are able to minimize their profit risks to the same level.

5. A Numerical Example

To see the different impact of market mechanisms on the retailer's operating policy, we present the following numerical example. For simplicity, we assume normal distribution for random variables.

We assume the parameter values are:

$a_i = 0.5,\ b_i = 1$

$S_i \quad N(8,2),\ \sigma_i^2 = 4$

$\lambda = 0.2$

$r = 1,\ s = 0.2,\ w = 0.6$

$A = 0.8$

So $D_i \quad N(8.5, 6)$.

The risk-neutral retailer's order quantity is $Q^n = 10.562$.

The decentralized risk-averse retailer's order quantity is $Q^d = 9.057$.

Strategy *R*:

1) With primary access to pure resale market: $Q^r = 9.555,\ q^r = 0.539$. The total inventory level is $Q^r + q^r = 10.094$. The resale market price is $p = 0.42$.

2) With additional access to the financial market and

using simple hedge, the retailer's inventory policy doesn't change, but the retailer's expected utility is increased by $\lambda r^2 b_i^2 \sigma^2 = 0.4$. $U(W) = 5.866$.

Strategy *F*:

1) With access to financial market and using macro hedge: $Q^f = 10.562$. The inflexible quantity is restored to the risk-neutral level.

2) With additional access to the resale market, $q^f = 0.273$. The total inventory level is $Q^f + q^f = 10.835$. The resale market price is $p = 0.5775$. The retailer's expected utility is $U(W) = 5.778$.

Note that in this example we have the following order quantity relation:

$$Q^f + q^f > Q^n > Q^r + q^r > Q^d$$

This illustrates that retailers will order more when they largely rely on external financial hedging opportunities.

Moreover, strategy *F* generates more social welfare loss than strategy *R*. Strategy *R* yields higher utility for retailers than strategy *F*. Check back with the condition specified in Proposition 4, the inequality is satisfied. It does confirm that the retailer should prefer strategy *R*.

6. Conclusions

The growing use of IT in organizations enables new business models and support new business processes that lower firm costs and improve coordination. This paper provides a framework to characterize the economic impact and the strategic potential of electronic markets on organizations. We quantitatively measured the efficiency generated by new market coordination structures among economic activities. We then compare two simple strategies that can be easily implemented by firms to control risk and improve profitability. We further examined under what conditions which strategy is preferable. Our analysis provides insights on the strategic potential of managing interaction with different electronic markets to improve firms' responsiveness to uncertain market conditions.

One limitation of this paper is our strong assumptions on market clearance in the resale market where the realized unmet consumer demand is satisfied by reallocating flexible inventory from retailers. Although in electronic marketplace market clearing is easily achievable, it is hard to quantify what the smallest number of retailers should be and what level of flexible inventory holding are necessary in order to guarantee the resale market will clear ex post. One interesting question is whether there is possibility of consolidation or merger among retailers if the resale market can generate significant value or lead to less social welfare loss, as suggested by proposition 4.

In this paper, we assume the manufacturer's wholesale price and the retailer's retail price are exogenously given. In a more complete market structure, we relax this assumption to allow strategic interaction between the two echelon supply chain players and examine the pricing decisions under a game theoretical modeling framework. In an extension of this paper, we further allow the retailer to have certain market power to choose profitable retail price by assuming a linear demand function in the consumer market. Future work could further explore the most desirable market structure and the optimal hedging strategy in both financial market and the resale market.

An extension to our current model could be an idea of setting up a mutual fund among retailers. Instead of asking the retailers to find their respective best hedging instruments in the financial market, a mutual fund manager could serve as an intermediary to manage the retailers' risks. Since the retailers' uncertain demands are independently identically distributed, the mutual fund manager could extract a macro risk factor to hedge at an aggregate level. The cancellation of idiosyncratic risks among retailers could save the transaction cost. In addition, economy of scales in activities such as balancing portfolio or managing the mutual fund account can be realized. This could be a future research direction.

Appendix

Proof of Equation (1):

Calculate the retailer's utility as:

$$W = r\min\left(Q^d, D_i\right) - sQ^d$$

$$\begin{aligned} EW &= r\int_0^{Q^d} xf(x)\,dx + r\int_{Q^d}^{+\infty} Q^d f(x)\,dx - sQ^d \\ &= (r-s)Q^d - r\int_0^{Q^d} F(x)\,dx \end{aligned}$$

$$\begin{aligned} VarW &= Var\left[r\min\left(Q^d, D_i\right)\right] \\ &= r^2 E\left[\min\left(Q^d, D_i\right)\right]^2 - r^2\left[E\min\left(Q^d, D_i\right)\right]^2 \end{aligned}$$

$$\begin{aligned} \underset{Q^d}{Max}\ U(W) &= (r-s)Q^d - r\int_0^{Q^d} F(x)\,dx \\ &\quad -\lambda r^2 \begin{bmatrix} \int_0^{Q^d} x^2 f(x)\,dx + Q^{d\,2}\left(1-F\left(Q^d\right)\right) \\ -\left[\int_0^{Q^d} xf(x)\,dx + Q^d\left(1-F\left(Q^d\right)\right)\right]^2 \end{bmatrix} \end{aligned}$$

FOC w.r.t Q^d we have

$$r\left[1-F\left(Q^d\right)\right]\left[1-2\lambda r\Gamma\left(Q^d\right)\right] = s$$

where $\Gamma(Q) = \int_0^{Q^d} F(x)\,dx$.

Q.E.D.

Proof of Lemma 2:

By equation (1),

$$1-F\left(Q^d\right)<\left[1-F\left(Q^d\right)\right]\left[1-2\lambda r\Gamma\left(Q^d\right)\right]=\frac{s}{r}$$

Proof of Proposition 1:

The retailer's optimization problem is:

$$\underset{Q^f}{Max}\ r\min\left[Q^f,D_i\right]-sQ^f-rb_iC_i+rb_i\left(S_i-\frac{Q^f-a_i}{b_i}\right)^+$$

$$s.t.\ C_i=\int_{K_i}^{+\infty}\left(x-K_i\right)f_s\left(x\right)dx$$

From options pricing theory we know that, for given, a_i, b_i, $\frac{\partial C_i}{\partial Q^f}<0$. FOC w.r.t. Q^f we have

$$r\left(1-F_s\left(Q^f\right)\right)-s-rb_i\frac{\partial C_i}{\partial Q^f}-r\left[1-F_s\left(\frac{Q^f-a_i}{b_i}\right)\right]=0 \quad (6)$$

where $F_s\left(\cdot\right)$ is the distribution for the financial index.

By efficient market assumption, the current price for the option should equal the expected payoff of the option at time T:

$$C_i=\int_{K_i}^{+\infty}\left(x-K_i\right)f_s\left(x\right)dx$$

$$\frac{\partial C_i}{\partial Q^f}=-\frac{1}{b_i}\left[1-F_s\left(\frac{Q^f-a_i}{b_i}\right)\right] \quad (7)$$

Substituting (7) into (6) and simplifying the expression we have

$$Q^f=F^{-1}\left(1-\frac{s}{r}\right)$$

Q.E.D.

Proof of Proposition 2:

By equation (2),

$$q^r=\int_{Q^r}^{\infty}xf\left(x\right)dx-Q^r\left(1-F\left(Q^r\right)\right)$$
$$=E\max\left[Q^r,D_i\right]-Q^r$$
$$=E\max\left[0,D_i-Q^r\right]$$

Similarly, by equation (6),

$$\sum q^f=E\max\left[Q^f,d\right]-Q^f=E\max\left[0,d-Q^f\right]$$

We've normalize the integration. Since $Q^r<Q^f$, the aggregation area for D_i-Q^r is greater than that for $d-Q^f$. Therefore, $q^r>\sum q^f>q^f$.

Q.E.D.

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