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Does Format of Pricing Contract Matter?

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Abstract

The use of linear wholesale price contract has long been recognized as a threat to achieving channel efficiency. Many formats of nonlinear pricing contract have been proposed to achieve vertical channel coordination. Examples include two-part tariff and quantity discount. A two-part tariff charges the downstream party a fixed fee for participation and a uniform unit price. A quantity discount contract does not include a fixed fee and charges a lower unit price for each additional unit. Extant economic theories predict these contracts, when chosen optimally, to be revenue and division equivalent in that they all restore full channel efficiency and give the same surplus to the upstream party assuming constant relative bargaining power. We conduct a laboratory experiment to test the empirical equivalence of the two pricing formats.

Surprisingly, both pricing formats fail to coordinate the channel even in a well-controlled market environment with subjects motivated by significant monetary incentives. The observed channel efficiencies were significantly lower than 100%. In fact, they are statistically no better than that of the linear wholesale price contract. Revenue equivalence fails because the quantity discount scheme achieves a higher channel efficiency than the two-part tariff. Also, division equivalence does not hold because the quantity discount scheme accords a higher surplus to the upstream party than the two-part tariff.

To account for the observed empirical regularities, we allow the downstream party to have a reference-dependent utility in which the upfront fixed fee is framed as loss and the subsequent contribution margin as gain. The proposed model nests the standard economic model as a special case with a loss aversion coefficient of 1.0. The estimated loss aversion coefficient is 1.6, thereby rejecting the standard model. We rule out other plausible explanations such as parties having fairness concerns and non-linear risk attitudes.

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1 Introduction

A classical problem in vertical control is the so-called “Double-Marginalization” (DM) problem (Spengler, 1950). The market setting is one in which an upstream party sells a product to a downstream party that in turn serves a group of customers. Both parties must decide independently the prices at which these transactions occur in order to maximize their own profits. If the upstream party is restricted to employ a linear price at which the product is transferred, then it can be shown that the total profit of the two parties is less than that of an integrated channel in which both parties coordinate their prices to maximize their total profit. This inefficiency occurs because the upstream party fails to account for the externality of its pricing decision on the downstream party’s profit. Consequently, the downstream party over-prices relative to the efficient level that would occur in the integrated channel. The phenomenon is persistent even if the demand is nonlinear and the marginal cost of production is not constant.

Many theoretical solutions have been proposed to address this problem (Tirole, 1988). They all involve the upstream party using a more sophisticated pricing format to induce the downstream party to charge the efficient price in order to restore full channel efficiency.² A straightforward way to accomplish this is to have the upstream party control the price at which the downstream party can charge. This price fixing scheme is frequently called resale-price maintenance, which can be legally problematic in the US. Equivalently, the upstream party can impose a minimum resale quantity on the downstream party. If this minimum is set to the efficient quantity in the integrated channel, the downstream party will charge the efficient price and full efficiency is restored. Both schemes however involve direct interference with the downstream party’s pricing decision.

There are two other ways to eliminate DM problem without direct control of the downstream party’s pricing decision. First, the upstream party can use a two-part tariff pricing structure: charge a fixed fee for participation (F) and a uniform price (w) per unit sold. The total revenue to the upstream party is then $F + w \cdot q$ where q is the total quantity sold. Second, a quantity discount scheme can be designed such that the total

²Iyer and Villas-Boas (2003) show that with product non-specifiability, demand uncertainty, unobservability of retailer behavior, costless ex-post negotiation, and late product delivery (after demand realization), the equilibrium contract is a uniform wholesale price contract.

revenue to the upstream party is identical to that given in the two-part tariff structure if the downstream party is charged a unit price given by $\frac{F+wq}{q}$ for a sales quantity q .³ Note that the quantity discount scheme presented here is identical to the two-part tariff structure because the former is simply a reframing of the latter in terms of average cost instead of total cost. If w is set to the marginal cost of the upstream party (i.e., there is only one margin in the channel instead of two margins), then the downstream party would want to set the price at the efficient level. The upstream party can then divide the surplus between the two parties by appropriately setting the fixed fee F taking into account the reservation utility for participation of the downstream party.

The channel coordinating pricing contracts make three sharp predictions. First, they predict that the more complex price contracts restore full channel efficiency. As discussed before, this is accomplished by inducing the downstream party to charge the efficient price. Second, a weaker form of full channel efficiency prediction is to require these contracts to generate the same channel profits for both parties. Third, they predict that the division of the surplus is identical in all pricing formats as long as the downstream party's reservation utility is kept constant across pricing formats. We call the first the *Full Efficiency Property*, the second the *Revenue Equivalence Property* and the third *Division Equivalence Property*. Whether these properties hold is an open empirical question. If they do, the upstream party should be indifferent to any of the pricing formats. If they do not, it will be interesting to know which format is more efficient, and which one benefits the upstream party the most. In this paper, we provide the first experimental test to the Full Efficiency, Revenue Equivalence and Division Equivalence properties.

We run an economic experiment with three treatment conditions: 1) linear price (LP), 2) two-part tariff (TPT), and 3) quantity discount scheme (QD) as discussed above. Each treatment condition has about 24 subjects acting as either upstream or downstream party playing the above channel game with linear demand and constant marginal cost. Subjects are motivated by monetary incentives to make optimal decisions. The key results are:

³Other quantity discount schemes are possible. For example, we can have a two-block tariff where a linear price is charged up to a threshold quantity and then a different linear price is used for any excess above this threshold. Another commonly used scheme is the all units discount contract. Under this scheme, different common unit prices are used for all units depending on the quantity bought.

1. TPT and QD do not restore full channel efficiency. In fact, their channel efficiency are statistically no better than LP.
2. TPT and QD are not revenue equivalent. QD generates a statistically higher surplus than TPT.
3. TPT and QD are not division equivalent. QD gives a higher fraction of channel surplus to the upstream party than TPT.

All these experimental results run counter to the standard theoretical predictions. To account for these results, we propose a behavioral model in which the downstream party has a reference-dependent utility and the upstream party strategically takes this into account in designing the pricing formats. We estimate the behavioral model on the experimental data and show that \$1 of fixed fee payment outflow (an initial loss) needs to be compensated by \$1.6 of contribution margin inflow (a subsequent gain) to make the downstream party indifferent. In addition, the reservation utility of the downstream party is estimated to be 8%-14% of the integrated channel surplus.

The rest of the paper is organized as follows. Section 2 outlines the standard economic theory about channel coordinating pricing contracts and formulates the corresponding hypotheses. Section 3 describes the experimental design and Section 4 reports the main results. Section 5 develops an extended model and estimate it on the experimental data. Section 6 rules out a set of competing explanations for the observed results. Section 7 concludes the paper and suggests future research directions.

2 Channel Coordination and Pricing Formats

In this section we review the standard economic theory on vertical control. We describe two pricing formats and explain how they help to achieve channel coordination. We then derive the empirical implications and develop hypotheses based on the standard theory.

We consider a simple one-manufacturer-one-retailer channel. The manufacturer, an upstream monopolist, produces a product at a constant marginal cost c . The manufacturer makes a take-it-or-leave-it offer, specifying a uniform wholesale price w , to a

retailer, who is a monopolist in the downstream market. The retailer sells the product to end consumers at a retail price p . The retailer incurs no additional selling costs. Demand is assumed to be linear, taking the form of $q = d - p$, where d is the choke-off demand and is assumed to be greater than c . This is a one-shot game in which there is no inventory and the quantity sold to consumers is equal to the volume purchased from the manufacturer.

If the channel is integrated, a retail price p should be chosen to maximize the total channel profit given by $\pi(p) = (p - c) \cdot q = (p - c) \cdot (d - p)$. It follows that the channel profit maximizing retail price equals $\frac{d+c}{2}$, yielding an efficient sales quantity of $\frac{d-c}{2}$ and a channel profit of $\frac{(d-c)^2}{4}$. The manufacturer and the retailer can then negotiate a transfer price w to divide the total channel profit.

If the channel is not integrated, the manufacturer and the retailer independently choose their respective prices (w and p) to maximize their own profits. In this set up, the manufacturer moves first by offering a wholesale price w . Consequently, the retailer faces a profit of $\pi_R(p) = (p - w)(d - p)$ and responds by choosing a profit maximizing retail price $\frac{d+w}{2}$. Rationally expecting the retailer's reaction, the manufacturer chooses a w to maximize a profit of $\pi_M(w) = (w - c) \cdot (d - \frac{d+w}{2})$. The profit maximizing wholesale price equals to $\frac{d+c}{2} > c$, inducing a retail price of $\frac{3d+c}{4}$, which exceeds the efficient price level of $\frac{d+c}{2}$. Consequently, the manufacturer ends up with a profit of $\frac{(d-c)^2}{8}$ and the retailer earns $\frac{(d-c)^2}{16}$. The total profit realized in this channel thus shrinks to $\frac{3(d-c)^2}{16}$, representing only 75% of the integrated channel profit. The inefficiency stems from the double price distortion which occurs when the two firms stack their price-cost margins, thus the term “*double marginalization*”.

The manufacturer can impose some vertical restraints to solve the double-marginalization problem. For instance, the “resale-price maintenance” provision in a retail contract can directly stipulate the efficient retail price. Alternatively, a “*quantity forcing*” contract specifies the minimum sales quota that the retailer must achieve. If this quota is set to the integrated channel sales quantity, the retailer is forced to choose the efficient price level. Both contracts involve the manufacturer directly interfering with the retailer's pricing decision.

A less “intrusive” solution to the double-marginalization problem is to use a more

complex pricing contract like the *two-part tariff*. Here, the manufacturer asks for a franchise fee F and charges a fixed marginal wholesale price w . If a retailer buys a quantity q , it incurs a total cost of $wq + F$. The retailer thus faces a profit of $\pi_R(p) = (p - w)(d - p) - F$. It follows that the best-responding retail price equals $\frac{d+w}{2}$, with the corresponding retailer profit being $\frac{(d-w)^2}{4} - F$. The manufacturer can set the franchise fee up to $\frac{(d-w)^2}{4}$ depending on the reservation utility of the retailer.⁴ If the retailer has zero reservation utility, the manufacturer's optimization problem becomes $\max_{0 \leq w \leq d} \pi_M = (w - c)(d - \frac{d+w}{2}) + \frac{(d-w)^2}{4}$. In equilibrium, $w = c$, inducing a retail price of $\frac{d+c}{2}$, which is at the efficient level. The resulting channel profit is $\frac{(d-c)^2}{4}$, which is the same as that of an integrated channel. If the retailer's reservation utility is not zero, the manufacturer will have to lower the franchise fee to accommodate the retailer's positive reservation utility. The central result however remains the same: $w = c$ is essential to achieving full channel efficiency. The basic idea is to eliminate one of the two margins. Here, the manufacturer sets its price margin to zero and uses the franchise fee to gain its share of the surplus. As a result, the retailer faces the same margin of $p - c$ as an integrated channel does. The price distortion is therefore removed, and channel efficiency restored.

Instead of a two-part tariff, a *quantity discount* contract can also be used to solve the double marginalization problem. One possible quantity discount scheme specifies an average unit wholesale price of $\frac{F}{q} + w$, where F and w are some nonnegative constants, and q is the total amount bought by the retailer. The more the retailer buys, the lower its average cost. It can be seen that this price contract is equivalent to two-part tariff: for both contracts the total cost to the retailer is $F + wq$ for a given q . Hence this quantity discount scheme can be viewed as the average-cost version of a two-part tariff. Consequently, the same reasoning as in the two-part tariff applies here: If $w = c$, the retailer would want to charge the retail price at the efficient level. The manufacturer can then divide the surplus between the two parties by appropriately setting F taking into account the retailer's reservation utility for participation.

These pricing formats lead to three sharp theoretical predictions about the channel outcome. First, it is predicted that channel efficiency will be restored if the manufacturer is allowed to use these more complex (than linear price) pricing formats. That is, they

⁴In the experiments, the retailer can choose not to participate in the channel. Based on their participation decision, we empirically estimate the reservation utility of the retailer in Section 5.

all achieve 100% of the integrated channel efficiency. Second, a weakened form of the first prediction is that the two price formats are revenue equivalent in that they lead to the same channel profit. Third, it is predicted that the division of the surplus is identical in two formats as long as the retailer's reservation utility is the same. We call the first the *Full Efficiency Property*, the second the *Revenue Equivalence Property* and the third *Division Equivalence Property*. Whether these properties hold is still an open empirical question.

In this paper, we directly test the above predictions in a controlled lab environment. We focus our attention on two-part tariff and its quantity-discount variation because the two are immediate mathematical equivalence. We thus include three treatment conditions in our experiment: 1) Linear price (LP) contract, 2) two-part tariff (TPT), and 3) quantity discount (QD). The LP condition serves as the benchmark: It helps to verify whether the double-marginalization problem indeed exists, and to what extent TPT and QD alleviate the problem.

The above theoretical predictions are recast in the following hypotheses:

Hypothesis 1 *Full Efficiency Property: The channel is efficient under TPT and QD. Formally, $\pi_M(TPT) + \pi_R(TPT) = \pi_M(QD) + \pi_R(QD) = \frac{(d-c)^2}{4}$.*

Hypothesis 2 *Revenue Equivalence Property: TPT and QD are revenue equivalent: $\pi_M(TPT) + \pi_R(TPT) = \pi_M(QD) + \pi_R(QD) = K$, $0 < K \leq \frac{(d-c)^2}{4}$.*

Hypothesis 3 *Division Equivalence Property: TPT and QD are division equivalent: $\frac{\pi_M(TPT)}{\pi_M(QD) + \pi_R(TPT)} = \frac{\pi_M(QD)}{\pi_M(QD) + \pi_R(QD)} = \alpha$, $0 \leq \alpha \leq 1$.*

We can illustrate the above three hypotheses pictorially by Figure 1. The figure plots the manufacturer's profit as a function of the retailer's profit. In the figure, we have $d = 10$, $c = 2$, so that the maximum channel surplus is 16. The full efficiency property requires that all profit pairs of TPT and QD fall on line A, which is given by $\pi_M + \pi_R = 16$. The revenue equivalence property implies that all profit pairs of the contract forms fall on any line parallel to A given by $\pi_M + \pi_R = K$, $0 < K \leq 16$ (Line

B is one such example where $K = 14$). Framing the hypotheses this way allows one to see that the revenue equivalence property is implied by the full efficiency property. Also, both properties require that the surplus transfer between the manufacturer and the retailer must be efficient (every dollar given up by one party must be gained by another party and there is no loss) for both properties to hold since they both predict the slope to be -1.0 . The division equivalence property requires that all profit pairs of both contract forms fall on a line that passes through the origin. Line C is an example with slope $= 1.0$. Note that the standard economic theory predicts that all three properties hold and hence it implies that all profit pairs for either contract form fall on the same point E. We shall later test the three hypotheses by running regressions of manufacturer profits over retailer profits and checking a set of restrictions on the coefficients.

3 Experimental Design

3.1 Decision Task

As discussed before, we want to give the standard theory the best shot by testing it in the simplest possible market environment. If a theory fails in the laboratory environment, which isolates the simplest features and limits naturally-occurring complications, then the failure raises doubts about how well the theory will apply in a more complex setting. The laboratory market environment involves a manufacturer and retailer pair facing a linear end consumer demand given by $q = 10 - p$. The marginal cost c is set to 2. The task of the subjects is to act either as a manufacturer or a retailer and to choose either wholesale price contract or retail price to maximize their profits (which are converted to monetary payoffs).

TABLE 1 shows the theoretical predictions under the LP, TPT, and QD treatment conditions. LP predicts a wholesale price of 6, a retail price of 8, and a total channel profit of 12. TPT and QD, on the other hand, make the same predictions of a wholesale price of 2, a retail price of 6, and a total channel profit of 16. Note that Full Efficiency Property is achieved under TPT and QD. Revenue Equivalence and Division Properties hold since TPT and QD generate the same profit for both parties.

3.2 Experimental Procedure

A total of six experimental sessions were run, two for each treatment condition. Seventy-five undergraduate students at a western university participated in the experiment.⁵ Most experimental session had 12 subjects and each session always consisted of 11 decision rounds. Each subject played the game 11 times.⁶ This design allowed a subject to play against each other subject anonymously and at most once. Each session lasted for one and a half hours. Subjects earned an average payment of \$14. Before the experiment began, subjects were given a quiz to make sure that they understood the decision task. A copy of the instruction for the TPT treatment condition is given in Appendix B.

We simplified the decision task as much as possible. For example, a table was given to depict the linear demand under different integer price points. The anonymous matching of subjects was intended to avoid any communication between subjects. Since each subject was matched with a different partner in each round, we controlled for collusion, reciprocity, and reputation building behaviors. Therefore, each round could be framed as a one-shot game with a new partner.

In each round, subjects were randomly assigned to be either RED (manufacturer) or BLUE (retailer). Under the LP condition, the RED player moved first and chose a RED PRICE w (an integer between 0 and 10) at which she sold her product to the BLUE player. The administrator passed the information on w to the corresponding BLUE player. The BLUE player made her decisions in two stages. First, she must decide whether or not to accept the pricing contract given by the manufacturer. If the BLUE player chose to participate, she chose a BLUE PRICE p (an integer between 0 and 10)

⁵It is common to use undergraduates to test theories of industrial organization (see Holt, 1995). The results could in principle be replicated with managers. Several previous studies comparing professionals and students find little difference between the two groups (see Plott, 1987, and Ball and Cech 1996). Alternatively, one could use student subjects with different levels of experience with the task to assess whether experts behave differently from novices (e.g., Jung, Kagel, and Levin 1994). Note that the downstream party can also be a end customer (e.g., a customer who has to choose between alternative cell phone plans). So the results reported here are relevant for business-to-customer markets as well.

⁶In one session only 11 subjects showed up. In order to ensure unrepeated matching, we had each subject play the game 10 times with one subject sitting still in each round. In another session 16 subjects participated, and each subject played 11 times only.

at which she sold the product to a group of consumers behaving according to the linear demand function. If the BLUE player quitted, then the round ended and both players earned 0 point. Otherwise the quantity q sold was determined according to a simple table where $q = 10 - p$. For each unit sold, the RED player earned $(w - 2)$ points and the BLUE player earned $(p - w)$ points. Each player's total point earnings for that round were calculated as the unit point earnings multiplied by q . At the end of the session, point earnings for all rounds were summed up and redeemed for cash payment at the rate of \$0.20 per point.

The procedures were similar in the TPT condition, except that the RED player had to choose both a RED PRICE w and a lump-sum FIXED FEE F she would ask from BLUE. Again the BLUE player made her decisions in two stages. If the BLUE player rejected the offer and chose not to participate, then both players earned 0 for that round. If she chose to participate, she paid a fixed fee and chose a retail price. In this case, the RED player earned $(w - 2) \times q + F$, and the BLUE player earned $(p - w) \times q - F$, where quantity sold q was determined in the same manner as before.

In QD condition, RED moved first and determined a price scheme to offer BLUE. Specifically, the relationship between the average unit price (denoted by RED PRICE) and the units sold by BLUE was represented by the formula $w + \frac{F}{q}$, where w corresponds to the wholesale price and F corresponds to the franchise fee. The RED player's decision then reduced to choosing the value for the coefficients w and F , where w is required to be an integer between 0 and 10, and F is an integer greater than or equal to 0. Then similar to the other conditions, both players earned 0 if the BLUE player decided not to participate. Otherwise, BLUE needed to decide on a BLUE PRICE p (an integer between 0 and 10). BLUE's point earnings equaled to $(p - (w + \frac{F}{q})) \times q$, and RED's point earnings was $(w + \frac{F}{q} - 2) \times q$.

4 Results

TABLE 2 and TABLE 3 show the subject decisions, the total surplus, and the division of surplus. The t-statistics for testing the various hypotheses are reported in TABLE

4a and TABLE 4b.⁷ As shown in TABLE 2, the wholesale price is higher than the marginal cost of 2 in both TPT and QD conditions, contrary to the prediction of the standard economic theory. The fixed franchise fee is also lower than 16 in both cases. A high fraction of retailers (29% (TPT) and 17% (QD)) refuse to participate when confronted with nonlinear pricing contracts. In the TPT and QD conditions, the retail price is significantly higher than the optimal price of 6. The surplus for each condition was lower than that predicted by the standard theory and the division of surplus varies across nonlinear pricing contract conditions. We shall discuss these results in detail by answering the following questions.

4.1 Does Double-Marginalization Problem Exist?

In order to test whether double marginalization exists, we can examine both the wholesale and the retail prices under the LP condition. With $d = 10$ and $c = 2$, the wholesale price $w = 6$ and the retail price $p = 8$ if double marginalization occurs. If the channel is integrated, the predictions become $w = 2$ and $p = 6$ respectively. The average wholesale price is 5.47, which is statistically different from both 6 and 2 (see the top panel of TABLE 4a). The average retail price is 7.75, which is different from both the double-marginalization level of 8 and the efficient level of 6. Note that the wholesale and retail prices are closer to the double-marginalization levels than the efficient levels. The average channel efficiency is 72.95% overall, which is not statistically different from the double marginalization prediction (see top panel of TABLE 4b), but significantly lower than the integrated efficiency of 100%. Overall, we conclude that double-marginalization problem does exist under the LP condition, as expected.

4.2 Does Full Efficiency Property Hold?

The unconditional channel efficiency for TPT and QD are 66.71% and 77.04% respectively. Statistically, they are no more efficient than the LP condition. The channel

⁷We assume observations to be independent across time. In Section 5 we show that this assumption is not rejected.

efficiency for TPT and QD are statistically less than 100% (see second panel of TABLE 4b). Conditional on retailer participation, both TPT and QD achieve a channel efficiency exceeding 90% (93.68% (TPT) and 93.29% (QD)). Note that these conditional channel efficiencies are significantly higher than the channel efficiency in the LP condition. Thus, TPT and QD do help alleviate the double-marginalization problem conditional on retailer participation. However, full efficiency is not achieved even conditional on participation.

As discussed above, a stronger test for the full efficiency property is to check whether the profit pairs of both contract forms (conditional on participation) fall on the same line A as given in Figure 1. We investigate this by regressing the retailer's profit against the manufacturer's profit and testing whether the joint restriction that both the intercepts are 16 and the slopes are 1 is rejected. Note that this test is stronger than the t-test given in Table 4b because it also requires the surplus transfer between the manufacturer and the retailer to be efficient (i.e., the slope = -1.0). The χ^2 statistic is 196.86 ($p = 0.0000$, $dof = 4$).

In sum, we conclude that Hypothesis 1 is rejected.

4.3 Does Revenue Equivalence Property Hold?

QD achieves a statistically higher level of channel efficiency than TPT (77.04% versus 66.71%. See the third panel of TABLE 4b for t-statistics). Results from the wholesale price and franchise fee explain why. QD has a lower wholesale price of 3.20 (versus 4.05 under TPT), a higher franchise fee of 7.45 (versus 4.61), and a lower quitting rate of 17.42% (versus 28.79%). Since a lower wholesale price reduces the price distortion, it helps alleviate the double-marginalization problem. Combined with a better participation rate, this leads to a higher degree of channel efficiency.

Again, we provide a stronger test of the revenue equivalence property by checking whether $\pi_M + \pi_R = K$ for both contract forms. This is done by regressing the retailer's profit against the manufacturer's profit with the joint restriction that the slopes are -1.0 and the intercepts are identical but freely estimated. The χ^2 statistic is 47.62 ($p=0.0000$, $dof=3$).

Overall, we conclude that hypothesis 2 is rejected and that TPT and QD are not revenue equivalent. QD is superior to TPT in surplus generation.

4.4 Does Division Equivalence Property Hold?

To test the division equivalence property, we compute the ratio of manufacturer profit over actual total channel profit, which measures the share of the entire pie captured by the manufacturer. When the retailer refuses to participate in the trade and hence both parties receive zero profit, we assign the value of .5 to this measure. For the entire sample, the manufacturer obtains an average share of 64.79% under QD, which is higher than the share of 61.57% under TPT (see the bottom panel of TABLE 4b). Conditional on retailer participation, both contracts lead to higher manufacturer share, being 67.91% under QD and 66.25% under TPT. The difference in the shares across the two contracts is not insignificant however.

Again, we investigate the division equivalence property by checking whether $\pi_M = \frac{\alpha}{1-\alpha}\pi_R$ (see Hypothesis 3) for both contract forms. We regress the retailer's profit against the manufacturer's profit with the joint restriction that the slopes are identical but freely estimated and the intercepts are 0. The χ^2 statistic is 4093.55 (p=0.0000, dof=3). This result suggests that the division equivalence property is violated under the stronger test.

In sum, we can reject hypothesis 3.

5 An Extended Model

Our experiment data run counter to the predictions given by standard economic theory. The most puzzling empirical regularities are that the wholesale price is significantly higher than the marginal cost c in the TPT and QD conditions, and that TPT has a higher wholesale price than QD does. In this section, we attempt to account for these empirical regularities by allowing the retailer to have a reference-dependent utility function. Below, we develop a model of two-part tariff incorporating reference dependence and loss aversion, next we estimate the model on the experiment data.

5.1 Equilibrium with Loss Aversion

If the retailer uses the status quo as a reference point when it evaluates a two-part tariff contract (TPT), the lump-sum fixed fee (F) represents an upfront loss regardless of the sales quantity. In contrast, the subsequent contribution margin $((p - w) \cdot q)$ is perceived as a gain. If the retailer is loss averse, it may weigh the upfront loss more heavily than the subsequent gain (Kahneman and Tversky, 1979). Put differently, the retailer creates two separate mental accounts for the cash flow and these accounts do not integrate dollar for dollar (Thaler, 1985). This gain-loss dichotomy doesn't apply to the manufacturer because the wholesale margin and the franchise fee are both gains.

If the same two-part tariff is presented as a quantity discount contract (QD), then the reference-dependent effect disappears. In QD, no upfront fixed fee is required. The retailer pays an average cost for any quantity bought. Consequently, the retailer only sees the contribution margin component (i.e., there is no loss aversion in the QD condition).

We have the same model setup as before. The only difference is that we now allow the retailer's utility to be reference dependent. We solve for the equilibrium using backwards induction. After observing the wholesale price and franchise fee offered by the manufacturer, the retailer determines the best-response retail price if it is willing to accept the offer. A retail price p leads to the retailer profit of $\pi_R = (p - w)(d - p) - F$. If retailer is loss averse, she will maximize the reference-dependent utility given by⁸:

$$\max_{0 \leq p \leq d} U_R = (p - w)(d - p) - \lambda F \quad (5.1)$$

where $\lambda \geq 1$ stands for the loss aversion coefficient, which is typically defined as the ratio between the marginal disutility of losses (in absolute value) and the marginal utility of gains. Let $V \geq 0$ represent the reservation utility of the retailer, then the participation constraint of the retailer is $\max_{0 \leq p \leq d} U_R \geq V$.

If U_R is above V , the retailer accepts the offer, otherwise she rejects it. Conditional on

⁸We assume the value function to be kinked at the reference point while linear over the gain/loss domain. We use the linear specification because it is mathematically tractable and amenable to econometric estimation.

accepting, the best-response retail price is $p = \frac{d+w}{2}$, which is the same as in the standard model since the franchise fee, whether weighted by λ or not, does not enter the retailer's first-order condition. The maximized retailer utility is $U_R = \frac{(d-w)^2}{4} - \lambda F$.

On the manufacturer side, since both wholesale income and franchise fee contribute positively to his well-being, they are weighted equally. Hence the manufacturer's utility maximization is equivalent to the profit maximization:

$$\begin{aligned} \max_{0 \leq w \leq d, F \geq 0} \pi_M &= (w - c)\left(d - \frac{d + w}{2}\right) + F \\ \text{s.t.} \quad &\frac{(d - w)^2}{4} - \lambda F \geq V \quad (IR) \end{aligned} \quad (5.2)$$

We focus on the non-degenerate equilibrium by assuming V to be small enough such that the manufacturer is always willing to stay in the business (i.e. assume the equilibrium manufacturer profit is nonnegative). The loss aversion coefficient λ affects the franchise fee through the IR constraint and therefore feeds into the first-order incentive structure of the manufacturer. The equilibrium depends on λ , as described in proposition 1. The proof is presented in the Appendix.

Proposition 1 *The equilibrium channel decisions and outcomes are shown below as a function of retailer's loss aversion coefficient:*

$$\begin{aligned} w^* &= \frac{(\lambda-1)d + \lambda c}{2\lambda-1} & F^* &= \frac{(d-c)^2 \lambda}{4(2\lambda-1)^2} - \frac{V}{\lambda} \\ p^* &= \frac{(3\lambda-2)d + \lambda c}{2(2\lambda-1)} & q^* &= \frac{\lambda(d-c)}{2(2\lambda-1)} \\ \pi_M^* &= \frac{(d-c)^2 \lambda}{4(2\lambda-1)} - \frac{V}{\lambda} & \pi_R^* &= \frac{(d-c)^2 \lambda (\lambda-1)}{4(2\lambda-1)^2} + \frac{V}{\lambda} \\ \pi_M^* / \pi_R^* &= \frac{(d-c)^2 \lambda^2 (2\lambda-1) - 4V(2\lambda-1)^2}{(d-c)^2 \lambda^2 (\lambda-1) + 4V(2\lambda-1)^2} & \text{Channel Efficiency} &= \frac{\lambda(3\lambda-2)}{(2\lambda-1)^2} \end{aligned} \quad (5.3)$$

Figure 2 plots the equilibrium predictions, where we set $d = 10$, $c = 2$, and $V = 2$. The two dotted lines in each graph correspond to the the predictions of the integrated channel and the double marginalization ("DM"). Note several interesting patterns. First, the curves in all graphs cross the "integrated" line at $\lambda = 1$. That is, when gains and

losses are symmetric, two-part tariff is fully efficient in solving the double-marginalization problem: the equilibrium wholesale price, retail price, quantity and total profit are all at the integrated level. The channel is efficiently coordinated, with the channel profit being $\frac{(d-c)^2}{4}$. Note that when $\lambda = 1$, the extended model reduces to the standard economic models.

When $\lambda > 1$, wholesale price is above the marginal cost and is concave and increasing in λ . The fixed franchise fee, on the other hand, is decreasing and convex in λ . Retail price and sales are above and below the optimal respectively. As λ increases, the franchise fee becomes less effective as a channel coordination instrument and the manufacturer puts less weight on it. That is, he shifts his source of income towards the sales margin and hence sets a higher wholesale price. The channel efficiency decreases with the degree of loss aversion. Interestingly, loss aversion hurts the manufacturer, since both channel profit and the manufacturer's share in it decreases with λ .

When $\lambda \rightarrow \infty$, all curves converge to the DM level: Franchise fee is no longer feasible, and two-part tariff degenerates into a single instrument (linear price) contract.

5.2 Estimation

5.2.1 The TPT Model and QD Model

We estimate the proposed model on the experiment data using maximum likelihood method. We use subject decisions (manufacturer's choices of F and w and retailer's choice of whether to participate) to develop the likelihood function in order to estimate the loss aversion coefficient λ and the retailer reservation utility V .⁹

⁹There are two reasons why retail price is not included in the estimation: First, the retailer is best-responding in price, hence the retail price can be viewed as a derived variable from the wholesale price (note that the best-response retail price is a function of w given by $p = \frac{10+w}{2}$). For both the TPT and the QD conditions, t-test fails to reject the null hypothesis that the actual retail prices are equal to the best-response retail prices (with p-values being .295 and .109 respectively). Hence, retail price adds little new information to the estimation. Second, a separate estimation run including the actual retail price led to roughly the same parameter estimates and slightly worse fit. Consequently, we did not include actual retail price in the estimation.

Individual observations of w_{it} and F_{it} are assumed to follow the joint normal distribution:

$$\begin{pmatrix} w_{it} \\ F_{it} \end{pmatrix} \sim N \left\{ \begin{pmatrix} w^* \\ F^* \end{pmatrix}, \begin{pmatrix} \sigma_w^2 & \rho_{wF}\sigma_w\sigma_F \\ \rho_{wF}\sigma_w\sigma_F & \sigma_F^2 \end{pmatrix} \right\} \quad (5.4)$$

where $i = 1, \dots, I$, and $t = 1, \dots, T$. I stands for the number of manufacturer-retailer pairs in each round and T is the total number of rounds. w^* and F^* are the equilibrium values as prescribed in Proposition 1. The random errors of manufacturer decisions are distributed normally with mean 0 and variance σ_w^2 and σ_F^2 respectively. These errors are assumed to be identically and independently distributed.¹⁰ Since the same manufacturer chooses the wholesale price and franchise fee simultaneously, they may be correlated. Let ρ_{wF} denote the correlation coefficient.

The retailer's participation decision is incorporated into the likelihood function using a binary-response latent utility model. Let the retailer's utility follow the normal distribution:

$$U_{Rit} \sim N(U_{Rit}^*, \sigma_U^2) \quad (5.5)$$

where $U_{Rit}^* = \frac{(10-w_{it})^2}{4} - \lambda F_{it}$ is the utility that the retailer can best enjoy by choosing the best responding price¹¹. The retailer is willing to participate in the trade ($quit = 0$) if and only if the latent utility is greater than V .¹² Therefore the probability for $quit_{it} = 1$

¹⁰In a separate estimation, we allowed w and F to follow an AR1 process. The resulting likelihood value is only slightly improved. The carryover coefficients for w and F are not significantly different from 0 at a .05 level. Consequently, we assume the errors to be independent across time as well as across individuals.

¹¹Alternatively, for the cases where the retailer does participate, actual retailer profit can be used instead of the best responding retailer profit. Two approaches generate approximately the same estimates.

¹²We have also explored the case where retailer's reservation utility V evolves over time. We assume a certain retailer's current reservation utility to be a weighted sum of its last period reservation utility and last period actual utility. By this means, we allow the reservation utility to be heterogeneous across retailers. We found that the weight put on the last period actual utility is not significantly different from 0. Also, there is neither significant improvement in model fit nor change in parameter estimates. We thus conclude that retailer's reservation utility is reasonably constant and homogeneous in our data.

is equal to $\Phi\left(\frac{V+\lambda F_{it}-(10-w_{it})^2/4}{\sigma_U}\right)$, where Φ stands for the c.d.f. of the standard normal.

Assume the retailer's random utility errors to be independent of the manufacturer's randomness in the choice of w and F , then the joint likelihood function is:

$$\begin{aligned}
LL(\lambda, V, \sigma_w, \sigma_F, \sigma_U, \rho_{wF}) &= \sum_{i=1}^I \sum_{t=1}^T \left\{ -\log(2\pi) - \frac{1}{2} \log |\Sigma| - \frac{1}{2} \begin{pmatrix} w_{it} - w^* \\ F_{it} - F^* \end{pmatrix}' \Sigma^{-1} \begin{pmatrix} w_{it} - w^* \\ F_{it} - F^* \end{pmatrix} \right. \\
&\quad \left. + quit_{it} \log\left(\Phi\left(\frac{V + \lambda F_{it} - (10 - w_{it})^2/4}{\sigma_U}\right)\right) \right. \\
&\quad \left. + (1 - quit_{it}) \log\left(1 - \Phi\left(\frac{V + \lambda F_{it} - (10 - w_{it})^2/4}{\sigma_U}\right)\right) \right\} \quad (5.6)
\end{aligned}$$

$$\text{where } \Sigma = \begin{pmatrix} \sigma_w^2 & \rho_{wF} \sigma_w \sigma_F \\ \rho_{wF} \sigma_w \sigma_F & \sigma_F^2 \end{pmatrix}$$

The set of parameters are estimated with the Maximum Likelihood method. Note that although our proposed model applies directly to TPT, we can also estimate it using data from QD. We expect the loss aversion coefficient λ estimated from QD to be smaller however.

5.2.2 The LP Model

The LP model is estimated using the similar strategy. The set of relevant parameters reduces to V , σ_w and σ_U . The corresponding likelihood function is:

$$\begin{aligned}
LL(V, \sigma_U) &= \sum_{i=1}^I \sum_{t=1}^T \left\{ -\frac{1}{2} \log(2\pi) - \log \sigma_w - \frac{(w_{it} - w^*)^2}{2\sigma_w^2} + quit_{it} \log\left(\Phi\left(\frac{V - (10 - w_{it})^2/4}{\sigma_U}\right)\right) \right. \\
&\quad \left. + (1 - quit_{it}) \log\left(1 - \Phi\left(\frac{V - (10 - w_{it})^2/4}{\sigma_U}\right)\right) \right\} \quad (5.7)
\end{aligned}$$

where $w^* = \frac{d+c}{2}$.

5.3 Results

TABLE 5 presents the estimation results. A series of nested models are also estimated and tested. The χ^2 values for the Wald test and associated p-values are reported at the bottom of each column.

The most striking finding is that the loss aversion coefficient is significantly larger than 1 in both TPT and QD. All nested models with the $\lambda = 1$ restriction are strongly rejected. Interestingly, the estimated λ is 1.57 under TPT, and is 1.22 under QD. These estimates imply that the pain in \$1 increase in the franchise fee imposed on the retailer can only be compensated by a \$1.57 or \$1.22 increase in her contribution margin. These two estimates are significantly different ($\chi^2(1)=17.59$, $p=.000$). Hence, loss aversion is significantly weakened in the QD condition.

Our estimate of the loss aversion coefficient λ (1.57 under TPT) is comparable to the typical finding in the literature. Bateman et al. (2004) report a loss-aversion for goods of 1.3 after controlling for loss-aversion of money. Hardie et al. (1993) find in a longitudinal study of brand choice that the effect of price increases is 1.66 times that of price cuts. Benartzi and Thaler (1995) show that a coefficient of about 2 can help resolve the equity premium puzzle. Tversky and Kahneman (1991) find 2 to be the approximate ratio of the slopes of the value function in loss and gain domains in riskless choice settings. Kahneman, Knetsch and Thaler (1990) report 2.29 as the mean ratio of selling prices to buying prices in endowment effect experiments. Also, Chua and Camerer (2004) estimate a slope coefficient of 2.63 in savings contexts. Overall, these studies show a loss-aversion coefficient ranging from 1.3 to 2.6 with an average of about 2.0.

Another finding is that retailer's reservation utility is positive in all three conditions, being 2.20 under LP, 1.28 under TPT, and 1.51 under QD. This represents about 8%-14% of the total pie of 16. Omitting retailer reservation utility leads to an over-estimation for the loss aversion coefficient. Specifically, when the $V = 0$ restriction is imposed, the estimated λ becomes 1.75 in TPT and 1.35 in QD.

There is a negative correlation between the random error term associated with w and that associated with F . The correlation coefficient is -.78 under TPT and -.91 under QD. This suggests that a low wholesale price is accompanied by a high franchise fee and the manufacturer shoots for a earning target in setting the parameters in the two-part tariff. Put differently, the manufacturer treats the two contract instruments as substitutes.

TABLE 6 provides the fitted values of w , F , p and the rate of quitting based on the behavioral model. As shown, the fitted values are close to the actual data, providing direct support to the model.

In sum, the standard economic model does not fit the experiment data well. We show that the retailers are loss-averse and have a positive reservation utility. Consequently, the two-part tariff cannot fully solve the double-marginalization problem. Accounting for the retailer’s loss aversion, the manufacturer offers a lower franchise fee and charges a higher wholesale price. The degree of loss aversion can be substantially reduced by reframing the two-part tariff contract as a quantity discount scheme. Hence quantity discount is a more efficient mechanism in solving the double-marginalization problem.

6 Competing Explanations

There are several potential competing explanations for the observed empirical regularities. We examine and rule out three of them in this section.¹³

6.1 Fairness Concerns

Recently, research in behavioral economics has shown that people may not be completely self-interested and may care about the well-being of others (e.g., Rabin, 1993; Fehr and Schmidt, 1999). If the retailer cares about the manufacturer, she may cut the retail price relative to the self-interested level to benefit the manufacturer. The manufacturer therefore might not have to lower wholesale price w to marginal cost c in a two-part tariff in order to induce the efficient retail price. If this is true, fairness concerns might have

¹³We also rule out an additional explanation which is based on the complexity of a pricing contract. If subjects are boundedly rational and dislike more complex contracts, then they may be more likely to quit when faced with a more nonlinear contract. We measure nonlinearity by the ratio of the fixed fee (F) and the marginal wholesale price (w) (which is proportional to the ratio of average and marginal costs). If this is true, we would expect a smaller quitting rate for LP and a larger quit rate for TPT and QD. Indeed, we observed a smaller quit rate for LP (6%). However, the same explanation also predicts that there should be no difference in the quitting rate between TPT and QD, which is contrary to the data (29% and 17% are statistically different). In addition, the complexity explanation implies that quitting rate and $\frac{F}{w}$ should be positively correlated within each treatment condition. This is not supported by the data: The correlation between quitting and $\frac{F}{w}$ is -0.21 for TPT and 0.53 for QD. Hence the results are mixed and we conclude that complexity does not explain the observed empirical regularities.

explained why in our data wholesale price is higher than marginal cost of production. However, in the model below we show that this argument does not hold.

Consider a model in which the the manufacturer's and the retailer's utilities are weighted sums of the manufacturer and the retailer profits.¹⁴ Specifically, we have:

$$U_M = \theta \cdot \pi_M + (1 - \theta) \cdot \pi_R$$

$$U_R = \rho \cdot \pi_R + (1 - \rho) \cdot \pi_M$$

where $0 \leq \theta \leq 1$ and $0 \leq \rho \leq 1$ are the degree of other-regarding behavior for manufacturer and retailer respectively. In this setup, we show that it is optimal for the manufacturer to set the wholesale price to the marginal cost (See Appendix A). The basic idea is that the manufacturer prefers to achieve the maximum possible surplus even with fairness concerns by charging c . The fairness concerns affect only the division of surplus but not the total surplus.

6.2 Non-Linear Risk Attitude

The retailer faces no risk because everything is known with certainty when she makes the participation and pricing decisions. Some uncertainty however exists for the manufacturer. When making his pricing decisions, the manufacturer may not know the retailer's reservation utility for certain. Thus one may wonder whether the manufacturer's risk attitude will lead to the observed departure of wholesale price from the marginal cost of production. Here, we relax the risk neutrality assumption.

Let $U_R(\pi_R)$ be the retailer's utility as a function of her profit. Let ϕ denote the probability that the retailer rejects a two-part tariff contract (w, F) :

$$\phi = \text{prob} \left(U_R \left[\left(\frac{d+w}{2} - w \right) \left(d - \frac{d+w}{2} \right) - F \right] \leq V \right)$$

¹⁴There are other specifications to incorporate fairness. A general specification of fairness may incorporate three plausible behavioral assumptions: 1. people care about their own payoffs, 2. people dislike to be behind (i.e., envy) and 3. people dislike being ahead (i.e., guilt). We leave this for future research.

where V is uncertain from the manufacturer's perspective.

Let $U_M(\pi_M)$ be the manufacturer's utility as a function of his profit. Then, the manufacturer's expected utility of offering a contract (w, F) is as follows:

$$EU_M = \phi \cdot U_M(0) + (1 - \phi) \cdot U_M((w - c)(d - \frac{d + w}{2}) + F)$$

Under this setup, we show that the equilibrium wholesale price still equals the marginal cost (See Appendix A). The basic idea is that if the manufacturer is risk-averse and cares about retailer participation, he can increase the participation probability by lowering the franchise fee without changing the wholesale price. So, relaxing risk neutrality does not help to explain the empirical regularity that the wholesale price is higher than the marginal cost.

6.3 Irrational Retailers

Another competing explanation is that the retailer population consists of a mixture of "irrational" and "rational" players (c.f., Camerer, Ho, and Chong, 2004). The irrational retailers choose randomly between prices from wholesale price and the maximum price (that yields zero demand) giving an average retail price of $\frac{w+d}{2}$. The rational retailers choose rationally as before. In this setup, the irrational retailers choose the same average price as the rational retailers. Consequently, the risk-neutral manufacturer will choose the optimal two-part tariff contracts as before.

7 Conclusions and Discussions

This paper is the first experimental test of channel coordinating pricing contracts. We investigate the two-part tariff and quantity discount pricing formats. Standard economic theories predict the two contracts are equivalent: 1) both fully restore channel efficiency, 2) they lead to the same level of channel efficiency, and 3) they divide the total surplus between the parties in the same way.

All three properties did not hold in our experimental data. Both two-part tariff (TPT) and quantity-discount (QD) scheme fail to solve the double-marginalization problem. Interestingly, QD significantly outperforms TPT in terms of revenue generation, thereby violating the revenue equivalence property. Also, TPT and QD are not division equivalent: The manufacturer obtains a higher share of channel profit under QD than under TPT.

We propose a reference-dependent utility model to account for the main empirical regularities. If the reference point is fixed at the status quo level, then the franchise fee in a two-part tariff contract may be framed as loss, and the subsequent contribution margin as gain. The resulting equilibrium is thus a function of the degree of loss aversion: The more loss averse the retailer is, the higher the wholesale price and retail price, the lower the franchise fee, the less efficient the channel is, and the smaller share the manufacturer captures in the channel profit. On the other hand, the quantity-discount scheme is not subject to loss aversion because there is no fixed fee and the cost to the retailer is framed in per unit term and is naturally incorporated as part of the contribution margin.

The proposed model is estimated using the Maximum Likelihood method. The standard economic models assuming gain-loss symmetry are strongly rejected. Indeed, the loss aversion coefficient is found to be 1.6 in the TPT treatment. Put differently, \$1 in the fixed fee payment is equivalent to \$1.6 in unit cost payment. This is similar to the loss-aversion coefficient of about 2 documented in previous studies.

Several directions for future research are possible. First, other pricing formats, such as blocked tariffs and all-unit quantity discount schemes, can be investigated. Second, our proposed model can be extended by incorporating some dynamics. For example, the reference point may evolve over time, and the loss aversion coefficient itself may change as time goes on. One way to do this is to allow a dynamic reference point and reservation utility that depend on past payoffs of the subjects. Third, our model cannot explain why the loss coefficient parameter is 1.22 rather than 1 in the QD condition. It will be interesting to explore this “anomaly” in the future.

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8 Appendix A: Proof of Propositions

8.1 Proof of Proposition 1

The manufacturer chooses a franchise fee such that the retailer's IR constraint is just binding, hence $F = \frac{(d-w)^2}{4\lambda} - \frac{V}{\lambda}$ and $\pi_M = \frac{(w-c)(d-w)}{2} + \frac{(d-w)^2}{4\lambda} - \frac{V}{\lambda}$. It follows immediately that

$$FOC : \frac{\partial \pi_M}{\partial w} = \frac{1}{2} \left((d-w) \left(1 - \frac{1}{\lambda} \right) - (w-c) \right)$$

with

$$\frac{\partial \pi_M}{\partial w} \Big|_{w=0} = \frac{1}{2} \left(d \frac{\lambda-1}{\lambda} + c \right) > 0 \quad (\text{given } \lambda \geq 1)$$

and

$$\frac{\partial \pi_M}{\partial w} \Big|_{w=d} = -\frac{1}{2} (d-c) < 0$$

At the same time, the curvature of the manufacturer profit function is determined by:

$$SOC : \frac{\partial^2 \pi_M}{\partial w^2} = -\frac{1}{2} \left(2 - \frac{1}{\lambda} \right) < 0 \quad (\text{given } \lambda \geq 1)$$

meaning that the curve is uniformly concave. Hence the optimal w can be solved by equating the FOC to 0:

$$w^* = \frac{(\lambda-1)d + \lambda c}{2\lambda - 1}$$

The equilibrium values of F , p , q and profits are then derived from w^* .

8.2 Proof of Equilibrium Two-part Tariff Contract with Fairness Concerns

We first show that $w = c$ induces the retail price that maximizes channel profit. Assume a general demand function $D(p)$. Given a two-part tariff contract, $\pi_M = (w - c)D(p) + F$, and $\pi_R = (p - w)D(p) - F$. The retailer's optimization problem is

$$\max_p U_R = \rho \cdot \pi_R + (1 - \rho) \cdot \pi_M$$

By chain rule, the FOC has:

$$\frac{dU_R}{dp} = \rho \times \frac{d\pi_R}{dp} + (1 - \rho) \times \frac{d\pi_M}{dp}$$

However, at $w = c$, $\pi_M = F$, and hence $\frac{d\pi_M}{dp} = 0$. Therefore,

$$\frac{dU_R}{dp} = \rho \times \frac{d\pi_R}{dp}$$

where $\rho \geq 0$ by assumption. Also, $\pi_R = (p - c)D(p) - F$ at $w = c$, so that $\frac{d\pi_R}{dp}$ is exactly the FOC of retail price for the channel. Consequently, the utility maximizing retailer ends up maximizing the channel profit given $w = c$.

Next, we show that the manufacturer always prefers a larger channel profit. Suppose not, and that in equilibrium $\pi_T < \pi_T^E$, where π_T^E denotes the integrated channel profit. Given that manufacturer utility is the weighed sum of π_M and π_R , at least one profit is associated with positive weight. Then increase this profit by $\pi_T^E - \pi_T > 0$, and the manufacturer is strictly better off.

Combining the above two arguments, in equilibrium $w^* = c$.

8.3 Proof of Equilibrium Two-part Tariff Contract with Non-linear Risk Attitudes

The manufacturer's optimization problem is

$$\max_{(w,F)} EU_M = \phi \cdot U_M(0) + (1 - \phi) \cdot U_M((w - c)(d - \frac{d+w}{2}) + F)$$

Since $\frac{\partial U_M(0)}{\partial w} = 0$ and $\frac{\partial U_M(0)}{\partial F} = 0$, the first-order conditions are simplified as:

$$\frac{\partial EU_M}{\partial w} = [U_M(0) - U_M(\frac{(w-c)(d-w)}{2} + F)]\phi'_w + (1 - \phi)U'_M(\frac{d+c}{2} - w) = 0$$

and

$$\frac{\partial EU_M}{\partial F} = [U_M(0) - U_M(\frac{(w-c)(d-w)}{2} + F)]\phi'_F + (1 - \phi)U'_M = 0$$

Combining the two first-order conditions we get

$$\frac{\phi'_w}{\phi'_F} = \frac{d+c}{2} - w \quad (*)$$

Now we analyze the quitting probability ϕ . Assume V to follow a distribution with c.d.f $G(\cdot)$ and corresponding p.d.f $g(\cdot)$. Hence ϕ becomes

$$\phi = G(U_R[\frac{(d-w)^2}{4} - F])$$

It follows that

$$\phi'_w = g(U_R[\frac{(d-w)^2}{4} - F]) U'_R \frac{w-d}{2}$$

and that

$$\phi'_F = g(U_R[\frac{(d-w)^2}{4} - F]) U'_R (-1)$$

Dividing the two equations we get

$$\frac{\phi'_w}{\phi'_F} = \frac{d-w}{2} \quad (**)$$

Combining equations (*) and (**), we get the result that in equilibrium $w^* = c$.

Appendix B: Sample Instructions (TPT)

Thank you for participating in this decision-making experiment. The instructions are simple; if you follow them carefully and make good decisions, you could earn a considerable amount of money which will be paid to you in cash before you leave today.

As you entered this room, you were randomly assigned a number, which would be your ID number throughout this experiment. The experiment will consist of 11 decision rounds. In each round, you will be **randomly and anonymously matched with a different partner**. You are not going to be matched with anyone twice. In each round, you can either be a RED or a BLUE player, which is determined randomly and will be announced at the beginning of that round. *Please record your role (either RED or BLUE) in the “Your role (RED/BLUE)” column of Table 2.*

The decisions needed to be made by you, the players, are outlined as follows. The RED player is to choose a price at which to sell products to the BLUE player, and to decide on a lump sum fixed fee asked from BLUE. BLUE in turn must decide whether she accepts this offer, and if she does, at what price she wants to sell these products to a group of customers. All these decisions will affect the payoffs of both players.

Experimental Procedures

The following procedural steps will be repeated in each of the decision rounds you participate in.

Step 1: (RED makes decisions while BLUE sits still)

RED moves first and chooses a RED PRICE (an integer) between 0 and 10. Also, RED need to decide on a lump sum FIXED FEE he would ask from BLUE. For each unit sold to BLUE, the cost to RED is 2, hence RED will make a point earning of (RED PRICE – 2) per unit sold. The total number of units sold (QUANTITY) depends on the decision of BLUE, which is described in step 2.

Each RED player, please write down your chosen price in the “RED PRICE” column of Table 2, and your choice of FIXED FEE in the “FIXED FEE” column. The administrator will walk up to you, record the RED PRICE and the FIXED FEE, and then show them to your anonymous BLUE partner.

Step 2: (BLUE makes decisions while RED sits still)

After knowing from the administrator the RED PRICE and FIXED FEE charged by her anonymous RED partner, each BLUE player can choose to quit that round by not buying anything from RED. In that case, this round ends and both RED and BLUE get 0. If BLUE chooses to still buy from RED, she then need to decide on a BLUE PRICE (an integer) between 0 and 10 to sell the products to the customers. Depending on the chosen BLUE PRICE, the

QUANTITY of the products sold varies as given in Table 1. For example, if the BLUE PRICE is 5, the QUANTITY sold is 5. Similarly, if the BLUE PRICE is 9, the QUANTITY sold is 1.

Each BLUE player, please put YES in the “Quit?” column of Table 2 in you choose not to buy from RED, and put NO otherwise. If you put NO, write down your price decision in the “BLUE PRICE” column. The administrator will walk up to you, record your decision on whether to quit and the BLUE PRICE, and then show them back to your RED partner.

Point Earnings

Up till now each player will have known RED PRICE, FIXED FEE, BLUE’s decision on whether to quit, and BLUE PRICE if BLUE chooses not to quit for the current round. Based on these decisions, each player will be able to calculate the QUANTITY sold and his/her point earnings of this round.

If BLUE chooses to quit, then QUANTITY will be 0. Also, the point earnings for both RED and BLUE are 0. If BLUE chooses not to quit, then:

BLUE’s point earning is equal to $(\text{BLUE PRICE} - \text{RED PRICE}) \times \text{QUANTITY} - \text{FIXED FEE}$. That is, the difference between the price she charges customers and the price she buys the product from RED times the quantity sold, and reduced by the fixed fee paid to RED.

RED’s point earning is equal to $(\text{RED PRICE} - 2) \times \text{QUANTITY} + \text{FIXED FEE}$. That is, the difference between the price RED charges and the unit cost of the product times the quantity sold, and finally plus the fixed fee collected from BLUE.

Each player, please record the QUANTITY sold and your point earnings of this round in the corresponding columns of Table 2.

You will repeat the above task for each decision round, only with reassignment of your role (RED/BLUE) and with a different partner each time.

Final Dollar Payoffs

We will sum up your point earnings in all rounds to determine your dollar payoff. Your dollar payoff is your total point earnings times \$0.2. That is, each point you earn is worth 20 cents. We will pay you in cash immediately after the experiment.

Exercise

To make sure you understand the procedures correctly, let's do a small exercise before we actually begin the experiment. Please fill in the blanks below and compare your solutions with the right answer to be announced later.

If in a certain round RED PRICE is 3, BLUE PRICE is 5, the FIXED FEE asked from RED is 4, and if BLUE chooses not to quit, then QUANTITY is _____. It follows that BLUE earns _____ points, and that RED earns _____ points.

If in another round RED PRICE is 4, BLUE PRICE is 9, the FIXED FEE asked from RED is 2, and if BLUE chooses not to quit, then QUANTITY is _____. It follows that BLUE earns _____ points, and that RED earns _____ points.

If in another round RED PRICE is 5, and RED asks a FIXED FEE of 5, and if BLUE decides to reject this offer and quit, then BLUE earns _____ points, and RED earns _____ points.

TABLE 1

BLUE PRICE	QUANTITY
0	10
1	9
2	8
3	7
4	6
5	5
6	4
7	3
8	2
9	1
10	0

TABLE 2

Your name _____ Your ID in this experiment _____

Round	Your role (RED/BLUE)	RED PRICE	FIXED FEE	Quit?	BLUE PRICE	QUANTITY	Point Earnings
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
Total point earnings							
Your cash payment =total point earnings × \$0.20							\$

Note:

Unless BLUE quits that round (where both RED and BLUE get 0),

BLUE point earnings = (BLUE PRICE – RED PRICE) × QUANTITY – FIXED FEE

RED point earnings = (RED PRICE – 2) × QUANTITY + FIXED FEE if you are RED

TABLE 1: PREDICTIONS OF STANDARD ECONOMIC THEORY

Variables	Treatment Conditions		
	LP	TPT	QD
w	6	2	2
F	---	16-V	16-V
p	8	6	6
manufacturer profit	8	16-V	16-V
retailer profit	4	V	V
channel profit	12	16	16
channel efficiency (%)	75	100	100

Note 1: The parameter values are chosen such that $q=10-p$, and that $c=2$.

Note 2: V denotes retailer's reservation utility.

TABLE 2: SUBJECT DECISIONS

Variables	Treatment Conditions		
	LP N=143	TPT N=132	QD N=132
w	5.47 (.95)	4.05 (1.29)	3.20 (1.43)
F	---- ----	4.61 (2.04)	7.45 (5.10)
quit (%)	6.29 (24.37)	28.79 (45.45)	17.42 (38.08)
p (conditional on participation)	7.75 (.69)	6.82 (.59)	6.83 (.62)

Note: Values in parentheses represent standard deviations.

TABLE 3: REVENUE AND DIVISION EQUIVALENCE

Variables	Treatment Conditions		
	LP	TPT	QD
<i>Entire sample</i>	N=143	N=132	N=132
M profit / channel profit (%)	57.40 (11.69)	61.57 (11.22)	64.79 (11.41)
channel profit	11.67 (3.71)	10.67 (6.86)	12.33 (5.77)
channel efficiency (%)	72.95 (23.22)	66.71 (42.87)	77.04 (36.09)
<i>Conditional on participation</i>	N=134	N=94	N=109
M profit / channel profit (%)	57.90 (11.91)	66.25 (10.02)	67.91 (10.08)
channel profit	12.46 (2.21)	14.99 (.94)	14.93 (1.12)
channel efficiency (%)	77.85 (13.83)	93.68 (5.90)	93.29 (7.00)

Note 1: Values in parentheses represent standard deviations.

Note 2: In cases where the retailer quits, M profit / channel profit is regarded as 0.5.

TABLE 4a: TESTS OF SUBJECT DECISIONS AGAINST STANDARD PREDICTIONS

Condition	Variables	Mean	Test Value	t-statistic	p-value
LP	w	5.47	2	43.75	.000
			6	-6.70	.000
	quit (%)	6.29	0	3.09	.002
	p (conditional on participation)	7.75	6	29.53	.000
			8	-4.15	.000
TPT	w	4.05	2	18.23	.000
			6	-17.42	.000
	F	4.61	16	-64.03	.000
	quit (%)	28.79	0	7.28	.000
	p (conditional on participation)	6.82	6	13.56	.000
		8	-19.54	.000	
QD	w	3.20	2	9.60	.000
			6	-22.48	.000
	F	7.45	16	-19.25	.000
	quit (%)	17.42	0	5.26	.000
	p (conditional on participation)	6.83	6	14.14	.000
		8	-19.74	.000	

TABLE 4b: TESTS OF DOUBLE MARGINALIZATION, FULL EFFICIENCY, REVENUE EQUIVALENCE, AND DIVISION EQUIVALENCE

LP and Double Marginalization

	Null	t-statistic	p-value
<i>Entire sample</i>	Efficiency(LP)=75%	-1.06	.292
	Efficiency(LP)=100%	-13.93	.000
<i>Conditional on participation</i>	Efficiency(LP)=75%	2.38	.019
	Efficiency(LP)=100%	-18.54	.000

Full Efficiency Hypothesis

	Null	t-statistic	p-value
<i>Entire sample</i>	Efficiency(TPT)=75%	-2.21	.028
	Efficiency(TPT)=100%	-8.92	.000
	Efficiency(TPT)=Efficiency(LP)	-1.48	.140
	Efficiency(QD)=75%	.648	.518
	Efficiency(QD)=100%	-7.31	.000
	Efficiency(QD)=Efficiency(LP)	1.11	.269
<i>Conditional on participation</i>	Efficiency(TPT)=75%	30.68	.000
	Efficiency(TPT)=100%	-10.37	.000
	Efficiency(TPT)=Efficiency(LP)	11.81	.000
	Efficiency(QD)=75%	27.29	.000
	Efficiency(QD)=100%	-10.01	.000
	Efficiency(QD)=Efficiency(LP)	11.28	.000

Revenue Equivalence Hypothesis

	Null	t-statistic	p-value
<i>Entire sample</i>	Efficiency(TPT)=Efficiency(QD)	-2.12	.035
	w(TPT)=w(QD)	5.06	.000
	F(TPT)=F(QD)	-5.94	.000
	quit%(TPT)=quit%(QD)	2.20	.029
<i>Conditional on participation</i>	Efficiency(TPT)=Efficiency(QD)	.43	.665
	w(TPT)=w(QD)	1.23	.221
	F(TPT)=F(QD)	-2.84	.005

Division Equivalence Hypothesis

	Null	t-statistic	p-value
<i>Entire sample</i>	M's profit share(TPT)=M's profit share(QD)	-2.31	.022
<i>Conditional on participation</i>	M's profit share(TPT)=M's profit share(QD)	-1.17	.243

TABLE 5: MODEL ESTIMATION RESULTS

Parameters		LP (N=143)		TPT (N=132)				QD (N=132)			
		Full Model	$V=0$	Full Model	$\lambda=1$	$V=0$	$\lambda=1$ $V=0$	Full Model	$\lambda=1$	$V=0$	$\lambda=1$ $V=0$
Retailer	λ	--	--	1.57	--	1.75	--	1.22	--	1.35	--
		--	--	(.08)	--	(.04)	--	(.03)	--	(.03)	--
	V	2.20	--	1.28	8.86	--	--	1.51	3.44	--	--
		(.28)	--	(.55)	(.18)	--	--	(.27)	(.26)	--	--
	σ_U	.84	2.38	2.48	100*	2.61	6.52	.56	1.67	.77	4.04
		(.21)	(.45)	(.25)	(0)	(.32)	(.87)	(.14)	(.40)	(.27)	(.79)
Manufacturer	σ_w	1.08	1.08	1.29	2.41	1.33	2.42	1.43	1.86	1.49	1.86
		(.06)	(.06)	(.08)	(.27)	(.08)	(.61)	(.11)	(.27)	(.12)	(.28)
	σ_F	--	--	2.04	3.25	2.04	11.57	5.14	7.21	5.08	9.95
		--	--	(.14)	(.48)	(.14)	(3.87)	(.35)	(1.11)	(.31)	(1.97)
	ρ_{wF}	--	--	-.78	-.92	-.77	-.91	-.91	-.95	-.87	-.91
		--	--	(.04)	(.02)	(.04)	(.05)	(.02)	(.02)	(.02)	(.03)
	LL	-229.93	-235.33	-510.84	-614.26	-516.36	-769.61	-539.54	-621.45	-558.81	-693.83
	B.I.C.	237.37	240.30	525.49	626.46	528.57	779.37	554.18	633.65	571.01	703.59
	Wald Chi-square	--	62.16	--	56.12	5.51	746.15	--	43.67	31.51	258.97
	P-value	--	.000	--	.000	.019	.000	--	.000	.000	.000

Values in parentheses represent standard errors.
 All estimates are statistically significant at $p = 0.05$
 * Standard deviation was capped at 100.

TABLE 6: DATA VERSUS BEST FITTED VALUES OF THE REFERENCE-DEPENDENCE MODEL

Variables	Treatment Conditions			
	TPT		QD	
	Data	Best Fitted Values	Data	Best Fitted Values
w	4.05	4.13	3.20	3.22
F	4.61	4.65	7.45	8.17
quit (%)	28.79	34.85	17.42	18.94
p (conditional on participation)	6.82	7.06	6.83	6.61

FIGURE 1: FULL EFFICIENCY, REVENUE EQUIVALENCE,
AND DIVISION EQUIVALENCE HYPOTHESES

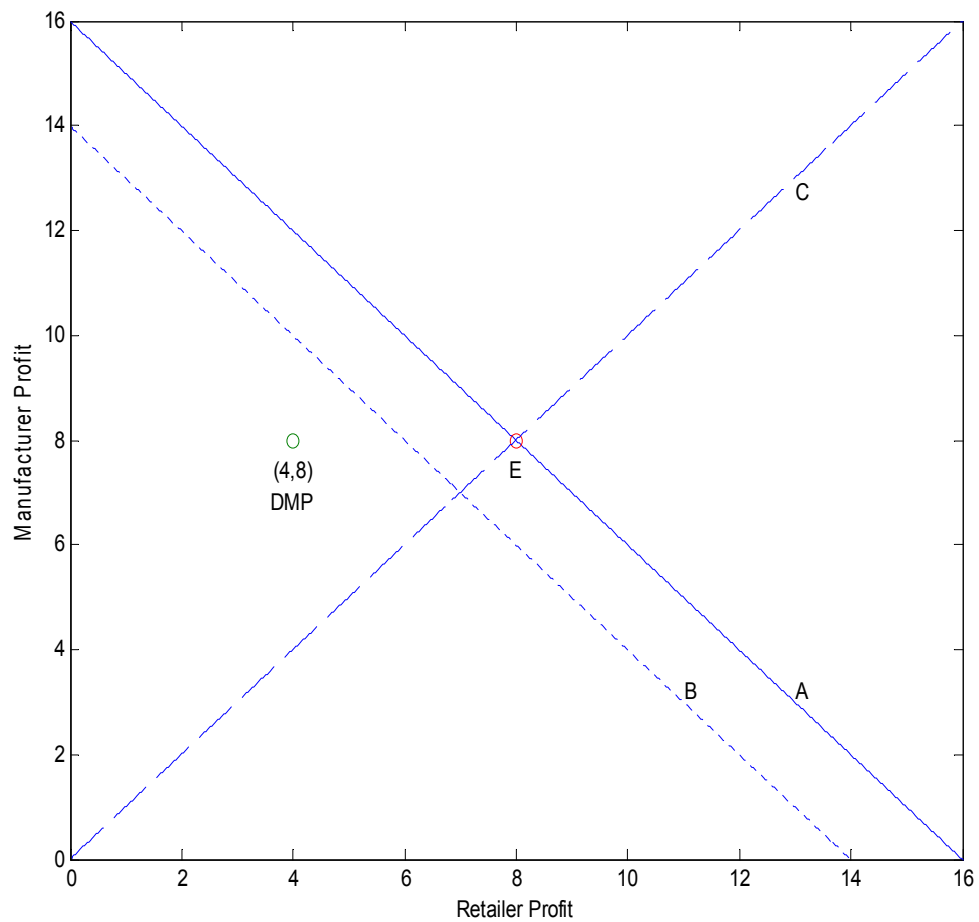


FIGURE 2: PREDICTIONS OF THE REFERENCE DEPENDENT MODEL

