An Experimental Study of Quantity Discount Contracts: Counterfactual Cognition in Multi-Block Tariffs

Noah Lim
Marketing Department
The Wharton School
University of Pennsylvania

September 19, 2004

[ PLEASE DO NOT CIRCULATE WITHOUT PERMISSION ]

---

I thank Colin Camerer, Hai Che, Josh Eliashberg, Teck Ho, Steve Hoch, Ganesh Iyer, Barbara Kahn, Botond Koszegi, Miguel Villas-Boas, Keith Weigelt and Juanjuan Zhang for helpful comments. I am grateful to Mario Capizzani and Taizan Chan for their assistance during the experiments. This research is partially supported by HP Labs. Direct correspondence to tslim@wharton.upenn.edu, Marketing Department, The Wharton School, University of Pennsylvania, Philadelphia, PA 19104-6340.
An Experimental Study of Quantity Discount Contracts: Counterfactual Cognition in Multi-Block Tariffs

Abstract

Theoretical research in economics and marketing has shown that quantity discount schemes such as the two-block tariff and three-block tariff can be used to solve the so-called ‘double-marginalization problem’ in independent channels. In addition, this research predicts that the number of blocks in the multi-block tariff does not matter so that both the two-block and the three-block tariffs are equally effective in restoring full channel efficiency. Put differently, both contracts are revenue-equivalent; that is, they yield the same total channel profits as if the channel members were vertically integrated. Moreover, they are division-equivalent; that is, channel profits are divided the same way between channel members across both contracts. However, the revenue-equivalent and division-equivalent properties of these multi-block tariffs have not been empirically tested.

This paper contributes to the understanding of business-to-business contract design by testing the revenue and division equivalence properties of the two-block and three-block tariffs using controlled laboratory experiments. The experimental results indicate that both contracts are neither revenue nor division equivalent. Not only is full channel efficiency not achieved in both contracts, channel efficiency is also lower in the two-block tariff. Moreover, the upstream firm in the channel receives a greater share of total profits in the three-block tariff. In sum, the number of blocks in multi-block tariffs matters both in generating and dividing the total channel profits. This finding runs counter to the prediction of the standard theories.

To account for the key empirical regularities in the data, we develop a behavioral model which assumes that the downstream firm in the channel cares both about actual and counterfactual profits. These counterfactual profits are generated by the differences between the marginal wholesale prices in adjacent blocks of the multi-block tariff. We also assume that the upstream firm rationally anticipates this and revise its contract offer accordingly. The equilibrium predictions are consistent with the experimental data and show that the two-block and three-block tariffs are neither revenue nor division equivalent. We estimate the downstream firm’s weight on the counterfactual profits using maximum likelihood methods. The results indicate that every counterfactual dollar is approximately equivalent to 30 actual cents.
1 Introduction

We investigate a business-to-business setting where an upstream firm must sell a product to a group of customers through a downstream firm. If the two channel members act independently and the upstream firm is only allowed to use a simple linear pricing contract, it has been shown that the total channel profits generated in such a de-centralized channel is lower than that of an integrated channel where the channel members act cooperatively to maximize the total channel profits. This loss in efficiency is termed the ‘double-marginalization’ problem and presents a compelling argument for vertical integration.

Standard theories in economics and marketing suggest that if the upstream firm is allowed to use more complex pricing contracts, then the double-marginalization can be solved even if the channel members act independently. These channel-coordinating (i.e. efficiency restoring) contracts include quantity discount schemes such as the two-block and three-block tariffs. Interestingly, these theories also predict that the number of blocks (or breakpoints) in a multi-block tariff has no effect on the contracts’ efficacy at restoring channel efficiency. That is, the two-block and three-block tariffs are equally effective in achieving channel coordination and there is no ex ante reason to prefer one contract to another. This in turn implies that both contracts are revenue-equivalent; that is, they yield the same total channel profits as if the channel members were vertically integrated. Moreover, they are division-equivalent; that is, channel profits are divided the same way between channel members across both contracts. However, due to the paucity of data, these important properties of the two contracts have not been empirically tested.

This paper contributes to the understanding of channel contract design in three ways:

1. We provide the first empirical test of the revenue and division equivalence properties of the two-block and three-block tariffs using standard experimental economics methodology where undergraduate subjects are induced to have values over outcomes and are motivated by significant monetary incentives. These contracts are chosen because they are widely adopted in practice and also because they involve the same mathematical logic in achieving channel coordination. Our experimental results indicate that both contracts are neither revenue nor division equivalent.
In particular, channel efficiency is lower in the two-block tariff compared to the three-block tariff. Moreover, the upstream firm receives a greater share of the channel profits in three-block tariff. We replicate these results with MBA students and experienced managers working in groups and motivated by larger monetary stakes. Hence, the results are robust to factors such as experience, stake size, and group decision-making. Together, these experimental results strongly suggest that the number of blocks in the multi-block tariff matters both in terms of channel profit generation and channel profit division. This finding runs counter to standard theories in economics and marketing.

2. We develop a behavioral model that generalizes the standard economic model to account for the above empirical regularities. These regularities can be nicely captured in a model in which the downstream firm cares not only about actual but also counterfactual profits. The counterfactual profits are the additional profits the downstream firm would have earned if the lower marginal price paid in the next adjacent block were applied to the current block of units. We solve the strategic game by assuming that the upstream firm rationally anticipates the fact that the downstream firm cares about these counterfactual profits. The equilibrium results show that the two-block and three-block tariffs are neither revenue nor division equivalent. Furthermore, we consider three alternatives (e.g., channel members have fairness concerns) to our proposed model and show that the equilibrium predictions of these models are incongruent with the experimental results.

3. We estimate the behavioral model using the decisions of both channel members. We obtain a maximum likelihood estimate of the weight of a counterfactual dollar in the utility function of the downstream firm. In our estimation, the upstream firm’s decisions follow a joint normal density centered on the equilibrium predictions of the behavioral model, while the downstream firm’s decision follows an extreme value distribution that results in a multinomial logit choice rule. The estimation results show that the standard economic model is strongly rejected by the data: that is, the downstream firm does care about counterfactual profits. Each counterfactual dollar is estimated to be equivalent to 30 actual cents.
The paper proceeds as follows: Section 2 reviews the double-marginalization problem and the literature on channel coordination. From this, we formulate two testable hypotheses about the two-block and three-block tariffs. The experimental design and results are reported in Section 3. In Section 4, we derive a behavioral model of counterfactual cognition analytically and describe the econometric model used to estimate the parameters. Section 5 discusses and rules out three alternative explanations for the experimental results. The final section concludes.

2 Double-Marginalization Problem

Consider a simple channel that consists of an upstream firm and a downstream firm. We shall call the firms in this bilateral monopoly the manufacturer and retailer respectively. The manufacturer produces a product at a constant marginal cost $c$ and sells the product to the retailer, who sells it to a group of customers by charging a retail price $p$. The final demand is given by the linear function $q = a - p$, where $a$ represents the choke-off price. There are no other costs incurred by the firms. We assume that the manufacturer is a Stackelberg leader who offers a pricing contract to the retailer on a take-it-or-leave-it basis. The retailer has a reservation utility $V \geq 0$ and accepts the contract as long as she attains this level of utility. For notational purposes, the type of contract associated with the variables is indicated in parentheses in the subscript. When the type of contract is not specified, the variable applies to the all contracts discussed.

In this channel, if the firms act independently and the manufacturer offers a linear price contract (LP) which specifies a per unit wholesale price of $w_{(LP)}$, the retailer will choose a best-response retail price of $p_{(LP)} = \frac{a + w_{(LP)}}{2}$, since its profits are given by $\pi_R(p_{(LP)}) = (p_{(LP)} - w_{(LP)})(a - p_{(LP)})$. The manufacturer anticipates this and makes her wholesale price decision by maximizing $\pi_M(w_{(LP)}) = (w_{(LP)} - c)(a - \frac{a + w_{(LP)}}{2})$, which yields $w^*_{(LP)} = \frac{a + c}{2}$. This results in an equilibrium retail price of $p^*_{(LP)} = \frac{3a + c}{4}$, with a corresponding purchase quantity of $q^*_{(LP)} = \frac{a - c}{4}$. The manufacturer and the retailer earn equilibrium profits of $\pi^*_M(LP) = \frac{(a - c)^2}{8}$ and $\pi^*_R(LP) = \frac{(a - c)^2}{16}$ respectively. Total channel profits $\pi^*_T(LP)$ in this linear price regime are $\frac{3(a - c)^2}{16}$. The manufacturer’s share of profits,
defined by $m^*(LP) = \frac{\pi^M(LP)}{\pi^T(LP)}$, is $\frac{2}{3}$.

However, if the firms are vertically integrated, it can be shown that the total channel profits are larger. The integrated firm can simply choose a retail price that maximizes $\pi_T(p) = (p - c)(a - p)$, which yields $p^* = \frac{a+c}{2} < p^*(LP)$. This lower retail price results in a larger purchase quantity, producing channel profits of $\frac{(a-c)^2}{4}$. In comparison, the independent channel with a linear price contract yields only 75% of the surplus realized by the integrated firm\(^2\). This failure to achieve the efficient level of channel profits in the independent channel is also known as the double-marginalization problem (Spengler (1950)). The double-marginalization problem is also shown on Point A in Figure 1; this point shows that channel profits fall below the efficient frontier.

The double-marginalization problem thus provides a compelling argument for vertical integration. However, integration is not the only solution that can restore channel efficiency. It has been shown that if the channel members can adopt more complex pricing contracts, the efficient level of profits can be achieved even if the firms act independently. These complex pricing contracts can restore efficiency or coordinate the channel because they possess sufficient instruments to generate the efficient level of total profits and divide the surplus between the firms simultaneously. Examples of these contracts include the two-part tariff (Moorthy (1987)) and quantity discount schemes such as the two-block and three-block tariffs (Jeuland and Shugan (1983), Dolan (1987), Weng (1995), Kolay et al (forthcoming))\(^3\).

\(^1\)The 2:1 ratio of manufacturer to retailer profits results from the assumption of a linear demand schedule (Tirole (1988)).

\(^2\)It can be shown that the efficient level of channel profits cannot be achieved with a linear wholesale price contract even when channel members make decisions simultaneously or if the retailer commits to setting a margin first (Choi (1991)).

\(^3\)There has been extensive research done on channel coordination in the marketing. Other papers include Coughlan and Wernerfelt (1989), Gerstner and Hess (1995), Ingene and Parry (1995), Iyer (1998), Iyer and Villas-Boas (2003). Anderson and Coughlan (2002) provides an excellent review of the marketing literature on channel coordination. The channel coordination problem has also been widely researched in the field of operations management. These ‘newsvendor’ models in the operations literature typically assume that demand is stochastic and independent of the retail price, and that operating costs vary with order quantities. Cachon (2003) provides an extensive review. In this paper, we assume that demand is price sensitive and do not consider operating costs.
More importantly, this theoretical stream of research has shown that all these contracts are equally effective in achieving channel coordination. In other words, these contracts are revenue-equivalent: that is, the contracts yield the same total channel profits as if the channel members were vertically integrated. Moreover, they are division-equivalent; that is, channel profits are divided the same way between channel members across all contracts\(^4\). The revenue and division equivalence properties of channel-coordinating contracts are fundamentally important because they imply that there are no \textit{ex ante} bases for managers to prefer one contract to another. Since there is a multiplicity of contracts that generate the maximum possible profits and guarantee the same level profits for both channel members, managers can enjoy the advantage of simply adopting the contract that involves the least decision and implementation costs\(^5\).

However, these two types of equivalence have not been empirically tested in the field. The reasons are apparent: in order to construct an unbiased test of these predictions, the researcher would have to control for potentially unobserved factors such as the channel structure, the informational setting and the nature of the interaction (for example, the sequence of moves) between channel members, to name a few. Furthermore, field data that are relatively free of these problems are difficult to obtain. This suggests that the use of controlled laboratory experiments, in which subjects are induced to have values over outcomes and motivated by monetary incentives, may be an appropriate tool for testing the validity of these properties\(^6\).

Ho and Zhang (2004) conducted experimental tests of the revenue and division equiv-

\(^{4}\)Strictly speaking, from the manufacturer’s point of view, the two-block tariff weakly dominates the three-block tariff.

\(^{5}\)We can also extend the revenue and division equivalence properties to consumer markets by thinking of the retailer as a customer whose usage of the product increase with a decline in price. These two properties suggest that both firms and customers should be indifferent to the structure of pricing contracts.

\(^{6}\)This point is also taken up in Anderson and Coughlan (2002) which write ‘Channels research needs to enlarge the currently very small place given to laboratory experiments. This may be particularly productive when seeking to test analytic models...Such models are difficult to test in the field environment, but in a laboratory context, the relevant factors can be isolated and tested.’ An example of the application of laboratory methods to channels research is Srivastava et al (2000), which investigated the comparative static predictions of the sequential equilibrium solution concept by varying the levels of delay costs in a multi-period bargaining setting.
rence hypotheses by comparing two different formats of the two-part tariff: the ‘franchise-fee’ format where the manufacturer charges a franchise fee \( F_{(2P)} \) and a marginal wholesale price \( w_{(2P)} \), and an equivalent and a slightly reframed ‘average-price’ contract where she charges an average price of \( w_{(2P)} + \frac{F_{(2P)}}{q_{(2P)}} \). Results from their experiments showed that manufacturers chose higher values of \( w_{(2P)} \) and lower values of \( F_{(2P)} \) in the franchise-fee format. Also, more contract offers were rejected by the retailers compared to the average-price format. Interestingly, conditional on retailers accepting the contract, both the revenue and division hypotheses cannot be rejected. If the entire sample is considered however, both channel efficiency and the manufacturer’s share of channel profits are significantly lower in the franchise-fee format. The authors proposed an elegant explanation for these results: they hypothesized that retailers are loss-averse with respect to paying the franchise fee \( F_{(2P)} \) and estimated the corresponding loss-aversion coefficient to be 1.57. Since the franchise fee was not explicitly levied in the average-price format, the loss aversion effect is attenuated.

This paper extends the literature on channel contract design by experimentally testing the revenue and division equivalence hypotheses on two channel-coordinating contracts: the two-block tariff and the three-block tariff. These contracts are chosen not only because such multi-block tariffs are widely adopted in practice, but also because of the similar mathematical logic used to induce channel coordination in both contracts. In addition, we can use them to study the importance of the number of blocks (or breakpoints) in quantity discount contracts. In the following paragraphs, we shall describe the structure of the two-block and three-block tariffs and the instruments used to achieve channel coordination. The structures of both contracts are also graphically shown in Figure 2.

In the two-block tariff (2B), the manufacturer charges an initial marginal price of \( w_{1(2B)} \) up to ‘breakpoint’ number of \( x_{1(2B)} \) units, followed by a lower marginal price of \( w_{2(2B)} \) on units beyond \( x_{1(2B)} \). Mathematically, the contract can be represented by

\[
T\left(q_{(2B)}\right) = \begin{cases} 
  w_{1(2B)}q_{(2B)} & \text{if } 0 < q_{(2B)} \leq x_{1(2B)} \\
  w_{1(2B)}x_{1(2B)} + w_{2(2B)}(q_{(2B)} - x_{1(2B)}) & \text{if } q_{(2B)} > x_{1(2B)}
\end{cases}
\]

(2.1)

where \( w_{1(2B)} > w_{2(2B)} \). To achieve channel efficiency, the manufacturer simply sets
The other instruments of the contract, \( w_{1(2B)} \) and \( x_{1(2B)} \), can then be used to divide the channel profits. In the optimal contract, the manufacturer earns a profit of \( \pi_{M(2B)}^* = (w_{1(2B)}^* - c) x_{1(2B)}^* \). Note that the values of \( w_{1(2B)}^* \) and \( x_{1(2B)}^* \) are not uniquely determined and the manufacturer can trade-off the values of these two instruments. However, it can be shown that \( \frac{a-c}{4} \) is the unique value of \( x_{1(2B)}^* \) that allows the manufacturer to appropriate all possible levels of channel profits. Depending on the reservation utility of the retailer, the manufacturer can then choose a \( w_{1(2B)}^* \in (c, a] \) to determine her profits.

The three-block tariff (3B) is closely related to the two-block tariff both in terms of the contract structure and the instruments used to achieve channel coordination. It has the form

\[
T(q_{3B}) = \begin{cases} 
  w_{0(3B)} q_{3B} & \text{if } 0 < q_{3B} \leq x_{0(3B)} \\
  w_{0(3B)} x_{0(3B)} + w_{1(3B)} (q_{3B} - x_{0(3B)}) & \text{if } x_{0(3B)} < q_{3B} \leq x_{1(3B)} \\
  w_{0(3B)} x_{0(3B)} + w_{1(3B)} (x_{1(3B)} - x_{0(3B)}) + w_{2(3B)} (q_{3B} - x_{1(3B)}) & \text{if } q_{3B} > x_{1(3B)} 
\end{cases}
\]

where \( w_{0(3B)} > w_{1(3B)} > w_{2(3B)} \). As in the two-block tariff, efficiency can be achieved if the manufacturer chooses \( w_{0(3B)}^* = c \). Similarly, the manufacturer can set \( x_{1(3B)}^* = \frac{a-c}{4} \) in order to capture all possible levels of channel profits. She can then choose an average price of \( \frac{w_{0(3B)} x_{0(3B)}^* + w_{1(3B)} (x_{1(3B)} - x_{0(3B)}^*)}{x_{1(3B)}^*} \in (c, a] \) to determine the division of the channel profits. The optimal values \( w_{0(3B)}^*, w_{1(3B)}^*, x_{0(3B)}^*, x_{1(3B)}^* \) are also not uniquely determined; for example, the manufacturer can compensate an increase in \( w_{0(3B)} \) with a corresponding decrease in \( x_{0(3B)} \).

From the above discussion, the equivalence of the two-block and three-block tariffs can be readily observed: to achieve channel efficiency, the manufacturer chooses \( w_{2(2B)}^* = w_{2(3B)}^* = c \). To generate the same level of profits for herself, she chooses \( x_{1(2B)}^* = x_{1(3B)}^* = \frac{a-c}{4} \) and \( w_{1(2B)}^* = \frac{w_{0(3B)} x_{0(3B)}^* + w_{1(3B)} (x_{1(3B)} - x_{0(3B)}^*)}{x_{1(3B)}^*} \). This is also summarized in Table 1. We now state the revenue and division equivalence hypotheses formally:
**Hypothesis 1A:** Revenue Equivalence (Strong). The two-block tariff and three-block tariff are equally effective in achieving the efficient level of channel profits. Thus, the strong version of revenue equivalence predicts that both contracts achieve channel profits of \((a-c)^2\).

**Hypothesis 1B:** Revenue Equivalence (Weak). Total channel profits are identical across the two-block tariff and three-block tariff. In addition, they are greater than the channel profits with the linear price contract.

**Hypothesis 2:** Division Equivalence. The manufacturer’s share of channel profits is identical across the two-block tariff and three-block tariff.

Figures 3 and 4 show the revenue and division equivalence hypotheses diagrammatically. In Figure 3, the strong version of revenue equivalence shows both the two-block tariff (2B) and the three-block tariff (3B) lying along the efficient frontier. The weak version of revenue equivalence is similarly shown by a parallel line where total channel profits are below \((a-c)^2\). Figure 4 describes the division equivalence property. In the diagram, each line drawn from the origin represents a possible division of channel profits. Division equivalence states that both contracts will lie along the same line drawn, which implies that the manufacturer’s share of channel profits will be equal across both contracts.

### 3 Experimental Tests

#### 3.1 Design and Procedure

The treatment variable in our experiments was the form of the pricing contract. There were a total of three treatments: the two-block tariff, three-block tariff, plus a ‘benchmark’ treatment involving the linear price contract. The latter serves as a useful check of whether the double-marginalization problem indeed exists. We conducted two experimental sessions for each treatment, making a total of six experimental sessions. Each session lasted for ninety minutes. Subjects were recruited from an undergraduate mar-
keting course at a major western university. Each subject was allowed to participate in only one session and received course credit for arriving on time. During the experiment, subjects earned experimental points according to their payoffs, which were converted into cash at the end of each session. The conversion rate was set at 20 cents per 100 points. Average earnings were 12 dollars, with minimum and maximum earnings of 4 and 20 dollars respectively.

Each experimental session consisted of eleven subjects and eleven decision rounds. In each round, there were five manufacturer-retailer pairs. Each subject participated in a total ten rounds and sat out in one round. In every round, subjects were either assigned a role of RED (Manufacturer) or BLUE (Retailer). In order to ensure that subjects understand the incentives facing each channel member, we designed the experiment so that subjects assumed the roles of RED and BLUE five times each, with the sequence randomly determined. To control for potential collusive or reputation-building behavior, each subject was matched with another subject only once in the session. This translated effectively into ten independent one-shot games played by each subject.

Once the subjects entered the room, they were seated apart and the instructions were read aloud by the experimenter. To save time and reduce decision errors, subjects were also provided an Excel spreadsheet to help calculate their payoffs. This spreadsheet also functioned as a decision aid as it allowed subjects to simulate different decisions for both RED and BLUE and obtain the payoffs for both players. To ensure that subjects were familiar with the use of the spreadsheet, they were made to go through some exercises before the experimenter started the first decision round.

As the experiment involved complex pricing contracts, we kept the instructions and the decision tasks as simple as possible. In each treatment, subjects were told that RED produces a product at a unit cost of 20 points and sells the product to the BLUE player, who in turn sells it to a group of customers. The customers’ demand is given by \(\text{QUANTITY}=100-\text{PRICE}\). Each decision round began with RED offering a pricing contract to BLUE. In the two-block tariff treatment, RED offered a contract that consisted of prices \(X\) and \(Y\) and a breakpoint \(\text{BREAK}\) (corresponding to \(w_{1(2B)}\), \(w_{2(2B)}\) and \(x_{1(2B)}\) respectively). In the three-block tariff treatment, the values of \(w_{0(3B)}\) and \(x_{0(3B)}\) were exogenously set to 100 and 8 respectively. By eliminating two additional decision choices
and ruling out some equilibria \textit{a priori}, we controlled for the level of decision complexity \textit{vis-à-vis} the two-block tariff treatment. Moreover, the value of $w_{0(3B)} = 100$ was chosen so that RED could potentially capture the entire channel surplus, while $x_{0(3B)} = 8$ pinned the minimum share of profits earned by the manufacturer down to 40\% of the maximum possible pie. Hence, RED also determined an offer that also involved prices $X$ and $Y$, and a breakpoint $BREAK$ ($w_{1(3B)}$, $w_{2(3B)}$ and $x_{1(3B)}$ respectively). In both treatments, RED was told to choose integers values of 0 to 100 for $X$, $Y$ and $BREAK$, with the condition that $X$ must be greater than $Y$\footnote{Subjects were told that $X$ must be less than 100 in the three-block tariff.}. The decision task was simpler in the linear price treatment: RED determined only a single wholesale price $X$ corresponding to $w_{(LP)}$.

After the RED players have made their decisions, the experimenter collected the decisions and revealed them privately to their BLUE counterparts. The BLUE player then chose the \textit{PRICE} that determined the final \textit{QUANTITY} sold by RED ($p$ and $q$ respectively) if she accepted the contract offer. This \textit{QUANTITY} sold in turn determined the payoffs $\pi_M$ and $\pi_R$. Alternatively, BLUE could reject the offer, which resulted in zero point earnings for both players. For example, if RED chose $X = 70$, $Y = 30$, and $BREAK = 20$ in the two-block tariff treatment and BLUE responded with a price of $p_{(2B)} = 65$, the RED player earned $\pi_{M(2B)} = X \times BREAK + Y \times (QUANTITY - BREAK) - 20 \times QUANTITY = 1150$ points, while the BLUE earned $\pi_{R(2B)} = PRICE \times QUANTITY - X \times BREAK - Y \times (QUANTITY - BREAK) = 425$ points. The detailed instructions for the two-block tariff treatment are given in Appendix II.

We also conducted two sessions of another experiment that may conform more closely to decision-making by firms in the ‘real world’. In this experiment, we raised the level of experience, doubled the stake size, gave subjects more time to understand the instructions, and allowed subjects make decisions in groups. First, in order to better simulate decision-making by experienced managers, we recruited subjects who are MBA students at the same university. These MBA students are ten years older on average and have more decision-making experience in the business world compared to our undergraduate subjects. Moreover, half of these subjects were experienced managers enrolled in the
part-time MBA program. We also doubled the stake size by increasing the conversion rate from 20 cents to 40 cents per 100 experimental points. To ensure that subjects had sufficient time to understand the complexities of the contracts, the instructions were given out one week before the sessions. Furthermore, the subjects were randomly assigned into groups of about 4 members each. There were a total of 12 groups in each session. Each group participated in a total of three decision rounds, making decisions for the two-block tariff treatment. The main objectives of this experiment are to check if the results of our experiment involving undergraduate subjects are robust and to collect data that is more representative of ‘real-world’ decision-making.

The theoretical predictions for each of the contracts given our design parameters are shown in Table 2. In the linear price treatment, economic theory predicts that the manufacturer will choose a wholesale price of \( w_{(LP)} = 60 \), while the retailer will respond with a retail price of \( p_{(LP)} = 80 \). For the two-block tariff and three-block tariff treatments, the manufacturer is predicted to choose \( w_{(2B)} = w_{(3B)} = 20 \) to induce the retailer to choose an efficient purchase quantity of 40 units. The revenue equivalence hypothesis predicts total channel profits in both contracts to be 1600 at 100% channel efficiency, while the division equivalence hypothesis predicts that the manufacturers’ share of channel profits \( m \) will be equal across both contracts.

3.2 Results

3.2.1 Are Experienced Managers More Rational?

First, we examine if the experimental results are robust to factors such as experience, stake size and group decision-making. We do this by comparing the decisions and outcomes of the experiment involving undergraduates with those involving the MBA students. In particular, we compare the mean values of \( w_1, w_2, x_1 \) decided by the manufacturer, the retail price \( p \), the channel efficiency \((\frac{\pi_T}{1000})\) and the manufacturer’s share of profits \( m \) \((\frac{\pi_M}{\pi_T})\). The results are reported in Table 3. First, it can be observed that the decisions and outcomes in the two experiments are strikingly close: except for \( w_{(2B)} \), none of the other variables is significantly different. We note that while the values of \( w_{(2B)} \) in both experiments are higher than the predicted value of 20, it is even more so in the
experiment involving the MBA students. Overall, these suggest that experience, stake size and group decision-making have little or no effect on the results; if these factors have any effect, they appear to lead to decisions that are further away from, rather than closer to the theoretical predictions. In our subsequent analysis, we pool the data of these two experiments together.

3.2.2 Empirical Regularities

The mean values of the subjects’ decisions and outcomes are reported in Table 4\(^8\). In the linear price treatment, we observe that \(w_{(LP)}\) and \(p_{(LP)}\) are at 60.3 and 82.3 respectively. Channel efficiency is at 66.6\%, which is lower than the predicted level of 75\%. The manufacturer’s share of channel profits, at 64.2\%, is also slightly lower than the predicted value of 66.7\%. In the two-block tariff and three-block tariff treatments, both \(w_{2(2B)}\) and \(w_{2(3B)}\) are at 33.9 and 29.9 respectively, which are higher than the predicted value of 20. The same pattern of results is true for the retail prices: both \(p_{(2B)}\) and \(p_{(3B)}\), at 74.0 and 66.2 respectively, are higher than the theoretical optimum of 60. Conditional on contract acceptance, channel efficiency in the three-block tariff is 95.1\%, which is close to full efficiency. However, efficiency is only 80.8\% in the two-block tariff. The manufacturer’s receives 72.7\% of the channel profits in the three-block tariff, which is higher than the corresponding value of 65.3\% in the two-block tariff. Tables 5 to 7 report the formal statistical tests for the double-marginalization problem, the revenue equivalence and the division equivalence hypotheses respectively.

3.2.3 Double-Marginalization Problem

Table 5 shows that the manufacturer’s offer of \(w_{(LP)}\) in the linear price contract is exactly at the predicted value of 60 (\(p\text{-value}=0.894\)). Next, although the retailer’s price of 82.3 is significantly different from the theoretical prediction of 80, it is much closer to the\(^8\)There is no evidence of learning in the data. To check for learning effects, we test for differences in the data for rounds 1 to 6 with the data for rounds 7 to 11. For example, in the three-block tariff, the average value of \(w_{2(3B)}\) was 29.80 for the first six rounds, while it was 29.95 in the later rounds (\(p\text{-value}=0.951\)). We obtain the same pattern of results for \(w_{2(2B)}\) (\(p\text{-value}=0.150\)).
predicted value than to the efficient price of 60. Conditional on contract acceptance, the efficiency level of 66.6\% is significantly lower than the predicted level of 75\% (p-value=0.000). Moreover, the manufacturer’s share of channel profits is at 64.2\%, which is significantly lower than the predicted value of 66.67\% (p-value=0.005). Overall, the results indicate that the double-marginalization problem is more severe than predicted, thus underlining the potential efficacy of nonlinear pricing contracts.

3.2.4 Revenue Equivalence Hypothesis

We begin by examining the validity of the revenue equivalence hypothesis by looking at the subjects’ decisions for the two-block and the three-block tariffs. The hypotheses tests reported in Table 6 show that the values of \( w_{2(2B)} \) and \( w_{2(3B)} \) are significantly higher than the predicted value of 20 (both p-values = 0.000). Moreover, \( w_{2(3B)} \) is lower than \( w_{2(2B)} \) (p-value=0.005). Next, the retail prices in both treatments are significantly higher than the theoretical optimum of 60 (both p-values 0.000). Furthermore, \( p_{(2B)} \) is higher than \( p_{(3B)} \) (p-value=0.000). These results suggest that revenue equivalence does not hold for the two contracts.

We proceed to examine the revenue equivalence hypothesis more formally by considering the channel efficiency for both the two-block and three-block tariffs treatments. The results show clearly that channel efficiency is lower than the theoretical prediction of 100\%. Conditional on retailers accepting the contract, efficiency levels are at 80.8\% and 95.1\% for the two-block tariff and three-block tariff respectively. Hence, the strong version of revenue equivalence (Hypothesis 1A), which states that full channel efficiency is achieved in both contracts, can be rejected. However, we note that channel efficiency in the three-block tariff is close to full efficiency.

The weak form of revenue equivalence (Hypothesis 1B) states that channel efficiency is equal in the two-block and three-block tariffs. Conditional on acceptance, we observe from Table 6 that channel efficiency in the three-block tariff is higher relative to the two-block tariff (p-value=0.000). Hence, the weak form of revenue equivalence can also be rejected. Finally, despite the fact that both the strong and weak versions of revenue equivalence are rejected, conditional on contract acceptance, channel efficiency in both
the two-block and three-block tariffs are higher compared to the linear price contract (both p-values 0.000). This allows us to conclude that adopting multi-block tariffs can indeed alleviate the double-marginalization problem.

3.2.5 Division Equivalence Hypothesis

The statistical tests of the division-equivalence hypothesis are reported in Table 7. The \( t \)-tests show that the manufacturer’s share of channel profits \( m \) is higher in the three-block tariff (72.7\%) compared to the two-block tariff (65.3\%), with a p-value of 0.000. This is true even when rejected contract offers are included in the analysis. Hence, the division-equivalence hypothesis can be rejected. Note also that the manufacturer’s share of profits in the two-block tariff and the linear price regime are equal. Overall, the three-block tariff gives the manufacturer the highest share of channel profits.

4 A Behavioral Model

The experimental results presented in the preceding section show that both the revenue and division equivalence hypotheses do not hold for the two-block and three-block tariffs. In this section, we develop a behavioral model that accounts for the major empirical regularities in the experimental data for these two contracts. These major regularities are:

1) Both contracts are not fully efficient. In particular, both \( w_{2(2B)} \) and \( w_{2(3B)} \) are higher than the marginal cost. 2) The contracts are not revenue-equivalent: the three-block tariff is more efficient than the two-block tariff. Specifically, we have \( w_{2(2B)} > w_{2(3B)} \), \( p_{(2B)} > p_{(3B)} \) and \( \pi_{T(2B)} < \pi_{T(3B)} \). 3) The contracts are not division-equivalent: the manufacturer enjoys a higher share of the channel profits in the three-block tariff.

4.1 Counterfactual Cognition

Research in psychology has shown that decision-makers engage in counterfactual thinking (Kahneman and Miller (1986), Roese (1994), Medvec et al (1995), Roese (1997), Medvec
and Savitsky (1997)). Counterfactual thoughts are mental alternatives to a factual outcome and are typically described as thoughts of ‘what if’ and ‘what might have been’. A classic illustration of counterfactual thinking can be found in Medvec et al (1995). In their paper, they observed that the silver medalists at the Olympics appeared less happy than the bronze medalists, despite the fact that winning a silver medal represents a greater achievement by objective standards. This surprising finding can be attributed to the different types of counterfactual thoughts generated by the medalists. For the silver medalists, they were less happy because they were thinking of the counterfactual scenario of winning the gold medal, which they had just missed. In this case, they are said to be engaging in upward counterfactual thinking, as the counterfactual scenario is preferred. For the bronze medalists however, they appeared happier because they were focusing on the downward counterfactual of coming in fourth and missing a medal.

The research on counterfactual thinking has focused on three aspects of this type of mental activity: activation, which deals with the antecedents to the generation of counterfactual thoughts; content, which examines the nature and type of the counterfactuals generated; and consequences, which studies the psychological effects of counterfactual thinking. In terms of activation, it has been found that the chief determinants of counterfactual thoughts are affect (Sanna and Turley (1996)) and closeness to achieving the counterfactual outcome (Kahneman and Tversky (1982)). Next, it has been found that counterfactuals are often extant norms, expected outcomes, or category anchors (Kahneman and Miller (1986), Medvec and Savitsky (1997)). Moreover, it has been found that upward counterfactuals are generated more frequently than downward counterfactuals (Roese and Olson (1997)). Finally, counterfactual thinking can produce either negative or positive consequences when the factual outcome is made more extreme by contrasting it with the counterfactual.

In multi-block tariffs, the structure of the contract mandates that the retailer pay different marginal prices for different units of the same product. These differences in marginal prices can result in a variety of counterfactual thoughts generated by the retailer. For example, the retailer may engage in upward counterfactual thinking and wish that the lower marginal price which she paid for some units of the product can be applied to units for which she paid a higher marginal price. This type of cognition is synonymous with the typical thoughts of ‘If you can afford to charge me the lower price for some units,
why can’t you charge me that price for all units?’ or more simply ‘You could have given me a better deal!’ In this case, the retailer experiences disutility because she would have earned additional profits if the lower marginal price were actually applied. Conversely, the retailer may engage in downward counterfactual cognition: for example, she may be relieved that the higher marginal price in a previous block was not applied to the current block. Here, she experiences positive utility due to the additional profits she earns as a result of not paying that higher marginal price.

In this paper, we generalize the standard economic model by positing that the retailer cares about counterfactual profits in addition to actual profits. Our model makes three assumptions about the nature of counterfactual cognition undertaken by the retailer. First, we assume that the retailer engages in upward counterfactual cognition. This is not only because upward counterfactuals are generated more frequently, but also because research has shown that economic agents are likely to be self-serving in bargaining situations (Babcock et al. (1995)). Second, we assume that the counterfactual profits are the additional profits the retailer would have earned if the lower marginal price in the adjacent block were applied to the current block. Third, counterfactual profits are generated only if the counterfactual lower marginal price was actually paid (for units in the next adjacent block) by the retailer. These latter assumptions are consistent with the finding that counterfactuals are more likely to be generated when the decision-maker is closer to the desired outcome.

We can illustrate our operationalization of the retailer’s utility function with a numerical example. Suppose that in the two-block tariff, \( w_{1(2B)} \), \( w_{2(2B)} \) and \( x_{1(2B)} \) are 50, 30 and 20 respectively. Also, let us suppose that the retailer purchases 40 units of the product. In this case, the retailer earns 800 in actual profits. The counterfactual profits to the retailer in this example are \((50-30)*20=400\), as these are the additional profits she would have earned if she were to pay a marginal price of 30 instead of 50 for the first 20 units. If the counterfactual profits are weighted differently from the actual profits (say by a parameter \( \beta \)), then the retailer’s utility is simply \(800-\beta(400)\).

We proceed to express the retailer’s utility function mathematically. Let \( \pi_{R(2B)}^l \) and \( \pi_{R(2B)}^r \) denote the retailer’s profits for \( 0 < q_{(2B)} \leq x_{1(2B)} \) and \( q_{(2B)} > x_{1(2B)} \) respectively.
Then the retailer’s utility in the two-block tariff is given by

\[
U_R(2B) = \begin{cases} 
\pi^l_R(2B) & \text{if } 0 < q(2B) \leq x_1(2B) \\
\pi^r_R(2B) - \beta(w_1(2B) - w_2(2B))x_1(2B) & \text{if } q(2B) > x_1(2B) 
\end{cases}
\]

(4.1)

where \(0 \leq \beta \leq 1\) is the value of every counterfactual dollar and \((w_1(2B) - w_2(2B))x_1(2B)\) represents the counterfactual profits.

Similarly, in the three-block tariff, let \(\pi^o_R(3B)\), \(\pi^l_R(3B)\) and \(\pi^r_R(3B)\) denote the retailer’s profits for \(0 < q(3B) \leq x_0(3B)\), \(x_0(3B) < q(3B) \leq x_1(3B)\) and \(q(3B) > x_1(3B)\) respectively. The retailer’s utility can then be written as

\[
U_R(3B) = \begin{cases} 
\pi^o_R(3B) & \text{if } 0 < q(3B) \leq x_0(3B) \\
\pi^l_R(3B) - \beta(w_0(3B) - w_1(3B))x_0(3B) & \text{if } x_0(3B) < q(3B) \leq x_1(3B) \\
\pi^r_R(3B) - \beta(w_0(3B) - w_1(3B))x_0(3B) & \text{if } q(3B) > x_1(3B) \\
-\beta(w_1(3B) - w_2(3B))(x_1(3B) - x_0(3B)) & \text{if } q(3B) > x_1(3B) 
\end{cases}
\]

(4.2)

Again, \(0 \leq \beta \leq 1\) is the value of every counterfactual dollar. Note that different counterfactual profits are generated for different quantities purchased. If she purchases a quantity \(q(3B)\) between \(x_0(3B)\) and \(x_1(3B)\), then the counterfactual profits are given by \((w_0(3B) - w_1(3B))x_0(3B)\). If she purchases an amount greater than \(x_1(3B)\), the counterfactual profits are equal to \((w_0(3B) - w_1(3B))x_0(3B) + (w_1(3B) - w_2(3B))(x_1(3B) - x_0(3B))\). The first term represents the additional profits the retailer would have earned if she paid \(w_1(3B)\) instead of \(w_0(3B)\) for the first block of units, while the second term are the profits she would have obtained if the lower marginal price of \(w_2(3B)\) were applied to the second block of units (instead of \(w_1(3B)\)).

Given the manufacturer’s contract offer, the retailer accepts the contract only if \(U_R \geq V\), where \(V \geq 0\) is the retailer’s reservation utility. We assume that the manufacturer rationally anticipates the fact that the retailer cares about counterfactual profits. Also, we assume that the manufacturer does not engage in counterfactual cognition: hence, she maximizes her utility by maximizing her profit function subject to the retailer’s participation constraint.

We solve this strategic game by backward induction and characterize the equilibrium results for both contracts in Propositions 1 and 2.
**Proposition 1**: The two-block tariff and three-block tariff are not efficient. Specifically, when $\beta > 0$, both $\pi^*_T(2B)$ and $\pi^*_T(3B)$ are less than $\frac{(a-c)^2}{4}$. Also, total channel profits decrease in $\beta$. Moreover, both $w^*_2(2B)$ and $w^*_2(3B)$ are higher than the manufacturer’s marginal cost $c$ and are increasing in $\beta$. PROOF: See Appendix I.

**Proposition 2**: The two-block tariff and three-block tariff are neither revenue nor division equivalent. Specifically, when $\beta > 0$, we have $\pi^*_T(3B) > \pi^*_T(2B)$. Also, in general, $m^*_2(2B) \neq m^*_2(3B)$. PROOF: See Appendix I.

For the two-block tariff, the equilibrium predictions are\(^9\):

\[
\begin{align*}
 w^*_1(2B) & = \frac{c+\beta(a+c)}{1+2\beta} + \frac{(a-c)(1+\beta)}{1+2\beta} - \frac{4V}{(a-c)(1+\beta)} \\
 w^*_2(2B) & = \frac{a}{4} \\
 x^*_1(2B) & = \frac{a-c}{4} \\
 p^*_2(2B) & = \frac{a+c+\beta(3a+c)}{2(1+2\beta)} \\
 q^*_2(2B) & = \frac{(a-c)(1+\beta)}{2(1+2\beta)} \\
 \pi^*_M(2B) & = \frac{(a-c)^2(1+\beta)}{4(1+2\beta)} \frac{V}{1+\beta} \\
 \pi^*_R(2B) & = \frac{(a-c)^2\beta(1+\beta)}{4(1+2\beta)^2} + \frac{V}{1+\beta} \\
 \pi^*_T(2B) & = \frac{(a-c)^2(1+\beta)(1+3\beta)}{4(1+2\beta)^2} \\
 m^*_2(2B) & = \frac{1+2\beta}{1+3\beta} \left(1 - \frac{4V(1+2\beta)}{(a-c)^2(1+\beta)^2}\right)
\end{align*}
\]

The expressions for the equilibrium predictions for the three-block tariff are complicated. Here, we present the expressions for $w^*_2(3B)$ and $x^*_1(3B)$:

\[
\begin{align*}
 w^*_2(3B) & = \frac{a+\beta(c+a+c)-x_0(3B)(c+2\beta(a+c-x_0(3B)))}{(a+\beta)(1+2\beta)-x_0(3B)(1+4\beta)} \\
 x^*_1(3B) & = \frac{a-c}{4}
\end{align*}
\]

We compare the equilibrium predictions of the two-block tariff as a function of $\beta$ against those in the three-block tariff in Figure 5. The plots assume parameter values of

---

\(^9\)As mentioned earlier in this paper, $w^*_1$ and $x^*_1$ in both contracts are not uniquely determined in equilibrium. Here, we assume that $x^*_1(2B) = x^*_1(3B) = \frac{a-c}{4}$ since it is the single value that allows the manufacturer to capture all levels of surplus. Moreover, the data indicate that this value was the modal choice of $x_1$ in both treatments.
\(a = 100, c = 20, V = 200, w^*_0(3B) = 100 \) and \(x^*_0(3B) = 8\). To begin, note that when \(\beta = 0\), that is, when the retailer does not care about counterfactual payoffs, the equilibrium predictions ‘revert’ back to those in the standard economic model. For example, the first plot shows that \(w^*_2(2B) = w^*_2(3B) = c\) when \(\beta = 0\). Next, we note how the model explains the major empirical regularities in our experimental data. First, observe that both contracts are not fully efficient when \(\beta > 0\). As stated in Proposition 1, channel profits are below the efficient level of 1600 and declines as \(\beta\) increase. This result is driven by the fact that both \(w^*_2(2B)\) and \(w^*_2(3B)\) are higher than the marginal cost. Second, the contracts are not revenue-equivalent. The plots also show that the three-block tariff is more efficient than the two-block tariff: specifically, we observe that total channel profits are higher in the former. This is due to the fact that \(w^*_2(3B) < w^*_2(3B)\) and \(p^*_3(3B) < p^*_3(3B)\), all which are clearly highlighted in the plots. Finally, we note that in general, the contracts are not division-equivalent. Depending on the actual value of \(\beta\), the manufacturer’s share of channel profits in the two-block tariff may be higher or lower.

The intuition behind the reason the three-block tariff is more efficient than the two-block tariff is simple. In a nutshell, the presence of an additional block in the multi-block tariff reduces the amount of counterfactual profits generated by the retailer. Recall that in our earlier example, \(w_{1(2B)}, w_{2(2B)}\) and \(x_{1(2B)}\) are 50, 30 and 20 respectively. If the retailer purchases 40 units of the product, her actual profits are 800 and her counterfactual profits are 400. We can write an ‘equivalent’ three-block tariff by choosing \(w_0(3B)=60, x_0(3B)=10, w_1(3B)=40, x_1(3B)=20\) and \(w_2(3B)=30\). This contract is equivalent to our two-block tariff example because the retailer’s actual profits are also 800 for the same number of units purchased. However, note that her counterfactual profits in this case are only \((60-40)*10+(40-30)*(20-10)=300\), which are less than those in the two-block tariff. This reduction in the counterfactual profits generated by the retailer results in a lower level of distortion to the channel, thereby increasing channel efficiency.

### 4.2 Estimation

We proceed to estimate the value of the \(\beta\) using the experimental data for the two-block tariff and three-block tariffs. In addition, the econometric model specified also allows us to provide estimates of \(V\), the retailer’s reservation utility.
4.2.1 Econometric Model

Recall that in both multi-block tariff treatments, the manufacturer determined the decisions of \(w_1, w_2\) and \(x_1\). We shall denote the individual observations of these decisions by \(w_{1it}, w_{2it}\) and \(x_{1it}\). The subscripts \(i\) and \(t\) denote each manufacturer-retailer pair and the round number in the experiment respectively. We assume that the manufacturer’s decisions follow a trivariate normal density given by:

\[
\begin{pmatrix}
    w_{1it} \\
    w_{2it} \\
    x_{1it}
\end{pmatrix}
\sim N
\begin{pmatrix}
    \begin{pmatrix}
        w_1^* \\
        w_2^* \\
        x_1^*
    \end{pmatrix} \\
    \begin{pmatrix}
        \sigma^2_{w_1} & \rho_{12}\sigma_{w_1}\sigma_{w_2} & \rho_{13}\sigma_{w_1}\sigma_{x_1} \\
        \rho_{12}\sigma_{w_2}\sigma_{w_1} & \sigma^2_{w_2} & \rho_{23}\sigma_{w_2}\sigma_{x_1} \\
        \rho_{13}\sigma_{x_1}\sigma_{w_1} & \rho_{23}\sigma_{x_1}\sigma_{w_2} & \sigma^2_{x_1}
    \end{pmatrix}
\end{pmatrix}
\] (4.5)

The terms \(w_1^*, w_2^*\) and \(x_1^*\) are the equilibrium predictions derived in our model of counterfactual cognition. The errors for these decisions are distributed with zero means and variances \(\sigma^2_{w_1}, \sigma^2_{w_2}\) and \(\sigma^2_{x_1}\) respectively. We also allow the decision errors to be correlated. For notational brevity, we denote the correlation coefficients for the errors between \(w_1\) and \(w_2\), \(w_1\) and \(x_1\), \(w_2\) and \(x_1\), as \(\rho_{12}, \rho_{13}\) and \(\rho_{23}\) respectively. In particular, we expect \(\rho_{13}\) to be significant, since the manufacturer can trade-off the values of \(w_1\) and \(x_1\) in equilibrium.

Given the contract offer, the retailer effectively chooses among three utility options. If she rejects the offer, her utility is given by \(V\). In the two-block tariff, if she accepts the offer, she can choose either to purchase a quantity \(q_{(2B)} \leq x_{1(2B)}\) and pay a single marginal price of \(w_{1(2B)}\), or she can choose \(q_{(2B)} > x_{1(2B)}\) and pay both marginal prices \(w_{1(2B)}\) and \(w_{2(2B)}\). In the three-block tariff, since we set \(w_{0(3B)} = a\), the retailer will never choose \(q_{(3B)} < x_{0(3B)}\).\(^{10}\) This means that the retailer also faces two options if she accepts the contract: she can choose to purchase a quantity between \(x_{0(3B)}\) and \(x_{1(3B)}\) and pay marginal prices \(w_{0(3B)}\) and \(w_{1(3B)}\); alternatively, she can choose \(q_{(3B)} > x_{1(3B)}\) and pay all three marginal prices. To summarize, the retailer chooses among the three options of: 1) ‘Reject’ and enjoying \(V\), 2) ‘Left’ by purchasing a quantity less than or equal to \(x_1\) and enjoying \(U_{R}^l\), and 3) ‘Right’ by purchasing a quantity greater than \(x_1\), enjoying \(U_{R}^r\). We assume that the retailer’s decision errors follow an extreme value distribution.

\(^{10}\)This is also confirmed in the experimental data.
that results in a multinomial logit choice rule. With this decision rule, the probability of choosing ‘Right’ for every contract offer is given by:

\[
\frac{e^{\gamma U_{Rit}^r}}{e^{\gamma V} + e^{\gamma U_{Rit}^l} + e^{\gamma U_{Rit}^r}}
\]  
(4.6)

The parameter \(\gamma\) captures the retailer’s sensitivity to the differences in utilities. If \(\gamma\) is zero, then the retailer is randomly choosing among the three options; if \(\gamma\) is arbitrarily large, the probability that the retailer is selecting the option that yields the highest utility approaches unity.

For each contract offer of \(w_{1it}, w_{2it}\) and \(x_{1it}\), the utilities \(U_{Rit}^l\) and \(U_{Rit}^r\) are determined in the following way. In the two-block tariff, the retailer’s utility function can be re-expressed as:

\[
U_{Rit} = \begin{cases} 
U_{Rit}^l = \pi_{Rit}^l & \text{if } 0 < q_{it} \leq x_{1it} \\
U_{Rit}^r = \pi_{Rit}^r - \beta (w_{1it} - w_{2it})x_{1it} & \text{if } q_{it} > x_{1it}
\end{cases}
\]  
(4.7)

For the values of \(\pi_{Rit}^l\) and \(\pi_{Rit}^r\), we use the retailer’s actual profits if the option was chosen; if it was not, we computed the ‘local’ best-response profits using the following formulae:

\[
\pi_{Rit}^l = \begin{cases} 
\frac{(a - w_{1it})^2}{4} & \text{if } \frac{a - w_{1it}}{2} < x_{1it} \\
(a - x_{1it} - w_{1it})x_{1it} & \text{otherwise}
\end{cases}
\]  
(4.8)

\[
\pi_{Rit}^r = \begin{cases} 
\frac{(a - w_{2it})^2}{4} - (w_{1it} - w_{2it})x_{1it} & \text{if } \frac{a - w_{2it}}{2} > x_{1it} \\
(a - (x_{1it} + 1))(x_{1it} + 1) - w_{1it}x_{1it} - w_{2it} & \text{otherwise}
\end{cases}
\]  
(4.9)

Similarly, in the three-block tariff, the retailer’s utility can be written as:\n
\[
U_{Rit} = \begin{cases} 
U_{Rit}^l = \pi_{Rit}^l - \beta(w_0 - w_{1it})x_0 & \text{if } x_0 < q_{it} \leq x_{1it} \\
U_{Rit}^r = \pi_{Rit}^r - \beta(w_0 - w_{1it})x_0 & \text{if } q_{it} > x_{1it} \\
-\beta(w_{1it} - w_{2it})(x_{1it} - x_0)
\end{cases}
\]  
(4.10)

\footnote{Recall that we had \(a = 100, w_0 = 100\) and \(x_0 = 8\) in our experiments.}
and the ‘local’ best-response profits (if the option was not chosen) are:

\[
\pi^l_{Rit} = \begin{cases} 
\frac{(a - (x_0 + 1))(x_0 + 1) - w_0x_0 - w_{1it}}{4} & \text{if } \frac{a - w_{1it}}{2} < x_0 \\
(a - x_{1it})x_{1it} - w_0x_0 - w_{1it}(x_{1it} - x_0) & \text{if } x_0 < \frac{a - w_{1it}}{2} < x_{1it} \\
\end{cases}
\]

\[
\pi^r_{Rit} = \begin{cases} 
\frac{(a - w_{2it})^2 - (w_0 - w_{1it})x_0 - (w_{1it} - w_{2it})x_{1it}}{4} & \text{if } \frac{a - w_{2it}}{2} > x_{1it} \\
(a - (x_{1it} + 1))(x_{1it} + 1) - w_0x_0 & \text{otherwise}
\end{cases}
\]

Finally, assuming that the decision errors of the manufacturer and retailer are independent, the joint log-likelihood function can be written as:

\[
LL(\beta, V, \gamma, \sigma_{w_1}, \sigma_{w_2}, \sigma_{x_1}, \rho_{12}, \rho_{13}, \rho_{23}) = 
\sum_{i=1}^{N} \sum_{t=1}^{T} \left\{ -\frac{3}{2} \ln(2\pi) - \frac{1}{2} \ln |\Sigma| - \frac{1}{2}(\Omega' \Sigma^{-1} \Omega) + \text{Reject}_{it} \cdot \ln \left( \frac{e^{2V}}{e^{\gamma V} + e^{\nu_1^V} \text{Rej}_{Rit} + e^{\nu_2^V} \text{Rej}_{Rit}} \right) \right\}
\]

where \( \Sigma = \begin{pmatrix} 
\sigma_{w_1}^2 & \rho_{12}\sigma_{w_1}\sigma_{w_2} & \rho_{13}\sigma_{w_1}\sigma_{x_1} \\
\rho_{12}\sigma_{w_2}\sigma_{w_1} & \sigma_{w_2}^2 & \rho_{23}\sigma_{w_2}\sigma_{x_1} \\
\rho_{13}\sigma_{x_1}\sigma_{w_1} & \rho_{23}\sigma_{x_1}\sigma_{w_2} & \sigma_{x_1}^2 
\end{pmatrix} \) and \( \Omega = \begin{pmatrix} 
w_{1it} - w_1^* \\
w_{2it} - w_2^* \\
x_{1it} - x_1^*
\end{pmatrix} \).

From this econometric model, we obtain the maximum likelihood estimates of the parameters for each of the two contracts. The parameter that we are most interested in is \( \beta \), the value of every counterfactual dollar. Not only would we expect the estimates of \( \beta \) to fall between 0 and 1, we would also expect the values in both contracts to be close. Another parameter of interest is \( V \), the reservation utility of the retailer. Since the data shows that retailers receive only 35% of channel profits on average, we would expect \( V \) to be relatively small. Note that theoretically, we can also estimate \( V \) from the data in linear price treatment. However, since only 2 contract offers out of a total of 110 were rejected, there is insufficient variation in the data to enable us to obtain precise estimates\(^{12}\).

\(^{12}\)Indeed, the estimate of \( V \) was not significant (p=0.592) due to the large standard errors. The model...
4.2.2 Results

The results of the estimation are presented in Table 8. In addition to the model specified above, we also estimated a series of nested models where the parameters $\beta$ and $V$ are constrained to be zero. Columns 1 to 5 in the table reports the estimates for the two-block tariff, while the estimates for the three-block tariff are shown in columns 6 to 10.

In the two block tariff, the initial model estimated show that $\rho_{12}$ and $\rho_{23}$ are not significant. In the three-block tariff, $\rho_{12}$ is also not significant, while $\rho_{23}$ is only marginally significant ($p$-value=0.05). Hence, we leave both $\rho_{12}$ and $\rho_{23}$ out of the subsequent models by constraining their values to be zero.

The final estimates for the two-block tariff and three-block tariff are reported in columns 2 and 7 respectively. The most important result is that $\beta$ is highly significant (both $p$-values=0.000) in both the two-block tariff and three-block tariff contracts, taking respective values of 0.27 and 0.33. Not only do these estimates fall in the plausible range of 0 to 1, the similarity in their values suggest that $\beta$ is stable across contracts. Moreover, columns 3 and 8 show that the standard economic model is strongly rejected by the data. Overall, we can conclude that the value of every counterfactual dollar is roughly equivalent to 30 actual cents.

The estimates of $V$ in the two-block and three-block tariffs are 227.56 and 66.48 respectively. These values represent 14% and 4% of the maximum possible channel profits. However, the estimate of $V$ in the latter is marginally insignificant with a $p$-value of 0.06.

Finally, note that the estimates of $\gamma$ and $\rho_{13}$ are highly significant in both contracts.

\[ LL(V, \gamma, \sigma_w) = \sum_{i=1}^{N} \sum_{t=1}^{T} \left\{ -\frac{1}{2} \ln(2\pi) - \ln \sigma_w - \frac{(w_{it} - w^*)^2}{2\sigma_w^2} + \text{Reject}_{it} \cdot \ln \left( \frac{e^{\gamma V}}{e^{\gamma V} + e^{\gamma UR_{it}}} \right) + \left(1 - \text{Reject}_{it}\right) \cdot \ln \left( \frac{e^{\gamma UR_{it}}}{e^{\gamma V} + e^{\gamma UR_{it}}} \right) \right\} \]

where $U_{Rit} = \frac{(a - w_{it})^2}{4}$ and $w^* = \frac{a + \epsilon}{2}$

\[ (4.14) \]

\[13\] In an alternative specification where we assume $x_{it}$ to be exogenously predetermined and allow the manufacturer’s decisions of $w_1$ and $w_2$ to follow a bivariate normal density, the estimates of $\beta$ for the two-block and three-block tariffs are 0.31 and 0.27 respectively.
The first result indicates that the retailers are sensitive to differences in utilities and choose the option with the highest utility. Next, the negative correlation in the errors of $w_1$ and $x_1$ suggests that manufacturers trade-off these values, which is consistent with theory.

5 Alternative Theories

In this section, we investigate three alternative theories to our model of counterfactual cognition. The first two theories relax the assumptions in our model of counterfactual cognition, while the last incorporates notions of social preferences and cooperative bargaining. We will show that each of them cannot account for the major empirical regularities in the data.

5.1 Downward Counterfactual Cognition

The first alternative theory is that instead of generating upward counterfactuals and experiencing the concomitant disutility, the retailer may focus on the fact that a discount is being offered. For example, in the two-block tariff, the retailer may gain additional utility if she compares the offer of $w_{1(2B)}$, $w_{2(2B)}$ and $x_{1(2B)}$ with the worse scenario of being offered a linear price contract with a wholesale price of $w_{1(2B)}$. Mathematically, the retailer's utility can be written as:

$$U_{R(2B)} = \begin{cases} 
\pi_{R(2B)}^l & \text{if } 0 < q_{2B} \leq x_{1(2B)} \\
\pi_{R(2B)}^r + \phi \cdot (\pi_{R(2B)}^r - \pi_{R(LP)}(w_{1(2B)})) & \text{if } q_{2B} > x_{1(2B)} 
\end{cases} \quad (5.1)$$

where $0 \leq \phi \leq 1$ represents the weight on every counterfactual dollar and $\pi_{R(LP)}(w_{1(2B)})$ denotes the retailer’s profits in a linear price regime with a wholesale price of $w_{1(2B)}$.

As the model has no closed-form solution\textsuperscript{14}, we present the numerical solutions for a range of $\phi$ given parameter values of $a = 100$, $c = 20$ and $V = 200$ in Table 9. The results indicate that $w_{2(2B)}^*$ is below marginal cost for all values of $\phi$. The equilibrium

\textsuperscript{14}See Appendix I for details.
values of $w_1^{*}(2B)$, $\pi^{*}_{M(2B)}$ and $m^{*}_{(2B)}$ are increasing in $\phi$, while the opposite is true for $\pi^{*}_{R(2B)}$. Moreover, channel profits fall below the efficient level when $\phi > 0$. From these results, we can readily rule out the presence of downward counterfactual cognition as the experimental data clearly indicate that $w_{2(2B)}$ is above marginal cost.

5.2 Non-Adjacent Upward Counterfactual Cognition in Three-Block Tariffs

Another theory is that in the three-block tariff, instead of using the adjacent lower wholesale price to generate the counterfactual payoffs for each block, the retailer may use the lowest wholesale price of $w_{2(3B)}$ as the counterfactual marginal price for all blocks. In this alternative theory, the retailer’s utility can be written as\(^{15}\):

$$U_{R(3B)} = \begin{cases} 
\pi^{*}_{R(3B)} & \text{if } 0 < q_{(3B)} \leq x_{0(3B)} \\
\pi^{*}_{R(3B)} - \beta(w_{0(3B)} - w_{1(3B)})x_{0(3B)} & \text{if } x_{0(3B)} < q_{(3B)} \leq x_{1(3B)} \\
\pi^{*}_{R(3B)} - \beta(w_{0(3B)} - w_{2(3B)})x_{0(3B)} & \text{if } q_{(3B)} > x_{1(3B)} \\
-\beta(w_{1(3B)} - w_{2(3B)})(x_{1(3B)} - x_{0(3B)}) & \text{otherwise} \end{cases} \quad (5.3)$$

Here, the only difference from our proposed model is that when $q_{(3B)} > x_{1(3B)}$, the retailer wishes that the price of $w_{2(3B)}$ can be applied to those units for which she is paying $w_{0(3B)}$ (as well as for those for which she is paying $w_{1(3B)}$). This model yields the following equilibrium results\(^{16}\):

$$w^{*}_{2(3B)} = \frac{c+\beta(a+c)}{1+2\beta} \quad (5.4)$$
$$\pi^{*}_{T(3B)} = \frac{(a-c)^2(1+\beta)(1+3\beta)}{4(1+2\beta)^2}$$
$$m^{*}_{(3B)} = \frac{1+2\beta}{1+3\beta} \left( 1 - \frac{4V(1+2\beta)}{(a-c)(1+\beta)^2} \right)$$

\(^{15}\)Equivalently, under the interpretation that the counterfactual profits of the retailer are those that she would obtain if she were offered a linear price contract with a wholesale price of $w_{2(3B)}$, we can write the retailer’s utility for $q_{(3B)} > x_{1(3B)}$ as

$$U_{R(3B)} = \pi^{*}_{R(3B)} - \beta(\pi_{R(LP)}(w_{2(3B)}) - \pi^{*}_{R(3B)}) \quad (5.2)$$

\(^{16}\)The proof can be found in Appendix I.
which are identical to the expressions for $w^*_2(2B)$, $\pi^*_T(2B)$ and $m^*_2(2B)$ in our model of counterfactual cognition. Hence, if this alternative theory were applied, one would predict that the weak form of revenue equivalence and the property of division-equivalence would hold across the two-block and three-block tariffs. Since the experimental data show that $w_2(2B) > w_2(3B)$ and that the two contracts are neither revenue nor division equivalent, we can also rule out this alternative.

5.3 Social Preferences and Cooperative Bargaining

In our experiment, the manufacturer (Proposer) makes a take-it-or-leave it contract offer to the retailer (Responder). The structure of the game is very similar to the ultimatum and power-to-take games that have been widely studied in the field of experimental economics. In these games, researchers have focused on the inefficiency that results from the Responders rejecting Proposers’ offers. A common refrain is that the Responders have social preferences and care about the differences in payoffs. Recently, behavioral economists have begun to incorporate such preferences in modeling economic behavior (Rabin (1993), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), Charness and Rabin (2002)). To model social preferences in the retailer’s utility, we adapt Charness and Rabin’s (2002) formulation and write

$$U_R = \alpha\pi_M + (1 - \alpha)\pi_R$$

(5.5)

where $\alpha \leq 1$ and represents the weight the retailer places on the manufacturer’s payoffs. If $\alpha$ is positive, the retailer exhibits some form of altruism. If $\alpha$ is negative, then the retailer has competitive preferences. With these preferences, the equilibrium outcomes in the two-block and three-block tariffs are:

$$w^*_2(2B) = w^*_2(3B) = c$$

$$\pi^*_T(2B) = \pi^*_T(3B) = \frac{(a-c)^2}{4}$$

(5.6)

17See Camerer (2003) for a review of ultimatum games. For a description of the power-to-take game, see Bosman and van Winden (2002).

18The proof of the results can be found in Appendix I.
Hence, the model predicts that channel profits will be efficient in both contracts\textsuperscript{19}. In other words, the strong form of revenue equivalence is predicted to hold. This is clearly rejected in the experimental data. Similarly, cooperative bargaining models such as the Nash Bargaining Solution assume the property of Pareto optimality and hence cannot explain why channel profits are less than efficient\textsuperscript{20}.

6 Conclusion

Research has shown that various complex pricing contracts can be used to achieve the maximum possible channel profits in independent channels. More importantly, this research suggests that these contracts are equally effective in both generating the efficient level of profits and dividing them between the channel members. However, the revenue-equivalent and division-equivalent properties of these channel-coordinating contracts have not been empirically tested in the field.

This paper contributes to the understanding of channel contract design by providing an empirical test of these two properties using controlled laboratory experiments. We conducted a series of experiments on two widely-adopted contracts: the two-block and three-block tariffs. The results show that these two contracts are neither revenue nor division equivalent. Not only is channel efficiency lower in the two-block tariff, but the upstream firm in the channel also receives a lower share of channel profits. Overall, the results suggest that the number of blocks in a multi-block tariff can significantly influence the realized channel profits as well as its division and managers should prefer the three-block tariff to the two-block tariff.

We also propose a model that captures the major regularities in the experimental data. We assume that the downstream firm in the channel cares both about actual and counterfactual profits. These counterfactual profits are generated by the difference between

\textsuperscript{19}Cui et al (2004) adopts the ‘inequality aversion’ model of Fehr and Schmidt (1999) and show that quantity discounts can coordinate the channel even when channel members are averse to differences in payoffs.

\textsuperscript{20}The Nash Bargaining Solution was proposed in Jeuland and Shugan (1983) as plausible mechanism for dividing the channel profits.
the marginal wholesale prices in adjacent blocks of the multi-block tariff. The equilibrium predictions show that the two-block and three-block tariffs are neither revenue nor division equivalent. Furthermore, we estimate the weight of these counterfactual profits from the experimental data using maximum likelihood methods. The results indicate that every counterfactual dollar is approximately equivalent to 30 actual cents. Finally, we also considered three alternatives to our model and show that the equilibrium predictions of these alternative theories are incongruent with the experimental results.

There are several directions for future research. First, we can extend the revenue and division equivalence hypotheses to other channel-coordinating contracts such as the all-units discount and quantity floor contracts. Second, it would be interesting to test these hypotheses in alternative settings that include asymmetric information and stochastic demand. Furthermore, this research can be extended to the consumer setting where customers’ preferences for price plans can be experimentally studied. Finally, we have alluded to the fact that the structure the game in this paper is similar to the ultimatum and power-to-take games. It may be useful to explore these links more deeply in future experiments.
References


7 Appendix I - Proofs

7.1 Proof of Equilibrium Results in the Model of Counterfactual Cognition

We begin with the two-block tariff. The retailer’s utility function is given by:

\[ U_{R(2B)} = \begin{cases} 
\pi^l_{R(2B)} & \text{if } 0 < q_{(2B)} \leq x_{1(2B)} \\
\pi^r_{R(2B)} - \beta \left( w_{1(2B)} - w_{2(2B)} \right) x_{1(2B)} & \text{if } q_{(2B)} > x_{1(2B)} 
\end{cases} \]  

(7.1)

where \( 0 \leq \beta \leq 1 \) is the retailer’s value of every counterfactual dollar and \( (w_{1(2B)} - w_{2(2B)})x_{1(2B)} \) represents the counterfactual profits.

We focus on the case where \( q_{(2B)} > x_{1(2B)} \). The retailer’s utility expands into

\[ U_{R(2B)} = p_{(2B)}(a - p_{(2B)}) - w_{1(2B)}x_{1(2B)} - w_{2(2B)}(a - p_{(2B)})x_{1(2B)} - \beta(w_{1(2B)} - w_{2(2B)})x_{1(2B)} \]

Differentiating with respect to \( p_{(2B)} \), we obtain

\[ p_{(2B)} = \frac{a + w_{2(2B)}}{2} \]

Substituting this back into the utility function and expressing in terms of \( w_{1(2B)} \) and \( w_{2(2B)} \), we obtain

\[ U^r_{R(2B)} = \frac{(a - w_{2(2B)})^2}{4} - (1 + \beta)(w_{1(2B)} - w_{2(2B)})x_{1(2B)} \]  

(7.2)

The retailer’s participation constraint can be re-expressed as

\[ w_{1(2B)} = w_{2(2B)} + \frac{(a - w_{2(2B)})^2}{4x_{1(2B)}(1 + \beta)} - \frac{V}{x_{1(2B)}(1 + \beta)} \]  

(7.3)

The equilibrium value of \( w^*_{2(2B)} \) can be obtained by substituting (7.7) into the manufacturer’s profit function and differentiating with respect to \( w_{2(2B)} \) once.

For the three-block tariff, the retailer’s utility when \( q_{(3B)} > x_{1(3B)} \) is given by

\[ U^r_{R(3B)} = \pi^r_{R(3B)} - \beta(w_{0(3B)} - w_{1(3B)})x_{0(3B)} - \beta(w_{1(3B)} - w_{2(3B)})(x_{1(3B)} - x_{0(3B)}) \]  

(7.4)

Expanding the above and differentiating with respect to \( p_{(3B)} \), we obtain

\[ p_{(3B)} = \frac{a + w_{3(3B)}}{2} \]
This yields
\[ q_{(3B)} = \frac{a - w_{3(3B)}}{2} \]

The utility function then becomes
\[
U^r_{R(3B)} = \frac{(a - w_{2(3B)})^2}{4} - (1 + \beta) (w_{0(3B)} - w_{1(3B)}) x_{0(3B)} - (1 + \beta) (w_{1(3B)} - w_{2(3B)}) x_{1(3B)} + \beta (w_{1(3B)} - w_{2(3B)}) x_{0(3B)}
\]

Substituting \( w_{0(3B)} = a \), the participation constraint can be written as
\[
w_{1(3B)} = \frac{1}{4} \frac{(a - w_{2(3B)})^2 - V + w_{2(3B)} x_{1(3B)} (1 + \beta) - ax_{0(3B)} (1 + \beta) - \beta w_{2(3B)} x_{0(3B)}}{x_{1(3B)} (1 + \beta) - x_{0(3B)} (1 + 2\beta)}
\]

The manufacturer’s profit function in this case is
\[
\pi_{M(3B)} = a x_{0(3B)} + w_{1(3B)} (x_{1(3B)} - x_{0(3B)}) + w_{2(3B)} (q_{(3B)} - x_{1(3B)}) - c q_{(3B)}
\]

Substitute the constraint into the manufacturer’s profit function and differentiating with respect to \( w_{2(3B)} \), we obtain (after setting \( x^*_{1(3B)} = \frac{a - c}{4} \))
\[
w^*_{2(3B)} = \frac{a - c (c + \beta (a + c) - x_{0(3B)} (c + 2\beta (a + c - x_{0(3B)})))}{\frac{a - c}{4} (1 + 2\beta) - x_{0(3B)} (1 + 4\beta)}
\]

The other equilibrium predictions of the model for both the two-block and three-block tariffs can be derived from \( w^*_{2(2B)} \) and \( w^*_{2(3B)} \) respectively.

### 7.2 Proof of Results for Alternative Explanations

#### 7.2.1 Proof of Results for the Model with Downward Counterfactual Cognition

We present of the results for the two-block tariff. The retailer’s utility for \( q_{(2B)} > x_{1(2B)} \) is given by:
\[
U^r_{R(2B)} = \pi^r_{R(2B)} + \phi (\pi^r_{R(2B)} - \pi_{R(LP)} (w_{1(2B)}))
\]

The retailer’s counterfactual profits are
\[
\pi_{R(LP)} (w_{1(2B)}) = \frac{(a - w_{1(2B)})^2}{4}
\]
Expanding the retailer’s utility function and differentiating with respect to $p_{(2B)}$, we obtain

\[ p_{(2B)} = \frac{(a + w_{2(2B)})}{2} \]

\[ q_{(2B)} = \frac{(a - w_{2(2B)})}{2} \]

The binding constraint then becomes

\[ (1 + \phi) \left[ \frac{(a - w_{2(2B)})^2}{4} - (w_{1(2B)} - w_{2(2B)})x_{1(2B)} \right] - \phi \frac{(a - w_{1(2B)})^2}{4} = V \]  

\[ (7.11) \]

There is no closed-form solution to the model. We solve the model numerically for a range of $\phi$ given the parameter values $a = 100$, $c = 20$ and $V = 200$. The results are presented in Table 9.

### 7.2.2 Proof of Results for the Model with Non-Adjacent Counterfactual Cognition

For $q_{(3B)} > x_{1(3B)}$, the retailer’s utility function is

\[ U_{R(3B)} = \pi_{R(3B)} - \beta(w_{0(3B)} - w_{2(3B)})x_{0(3B)} - \beta(w_{1(3B)} - w_{2(3B)})(x_{1(3B)} - x_{0(3B)}) \]  

\[ (7.12) \]

Differentiating with respect to $p_{(3B)}$, the first order conditions yield

\[ q_{(3B)} = \frac{a - w_{2(3B)}}{2} \]

The expression for the retailer’s utility can be re-expressed as

\[ U_{R(3B)} = \frac{(a - w_{2(3B)})^2}{4} - (1 + \beta)(w_{0(3B)} - w_{1(3B)})x_{0(3B)} - (1 + \beta)(w_{1(3B)} - w_{2(3B)})x_{1(3B)} \]  

\[ (7.13) \]

Substituting $w_{0(3B)} = a$ and re-arranging, the binding constraint becomes

\[ w_{1(3B)} = \frac{(a - w_{2(3B)})^2 - V + (1 + \beta) w_{2(3B)}x_{1(3B)} - (1 + \beta) ax_{0(3B)}}{(1 + \beta)(x_{1(3B)} - x_{0(3B)})} \]  

\[ (7.14) \]

The manufacturer’s profit function for $q_{(3B)} > x_{1(3B)}$ is given by

\[ \pi_{M(3B)} = ax_{0(3B)} + w_{1}(x_{1(3B)} - x_{0(3B)}) + w_{2(3B)}(q_{(3B)} - x_{1(3B)}) - cq_{(3B)} \]  

\[ (7.15) \]

Substituting the constraint into the above and differentiating with respect to $w_{2(3B)}$, we obtain

\[ w_{2(3B)}^* = \frac{c + \beta(a + c)}{1 + 2\beta} \]  

\[ (7.16) \]
which equals $w_{2(2B)}^*$ in our model of counterfactual cognition. From this, we can derive the equilibrium outcomes

$$
\pi_{T(3B)}^* = \frac{(a-c)^2(1+\beta)(1+3\beta)}{4(1+2\beta)^2},
$$

$$
m_{T(3B)}^* = \frac{1+2\beta}{1+\beta} \left( 1 - \frac{4V(1+2\beta)}{(a-c)(1+\beta)^2} \right).
$$

(7.17)

### 7.2.3 Proof of Results for the Model with Social Preferences

We present the proof of results for the two-block tariff. The retailer’s utility is written as

$$
U_R(2B) = \alpha \pi_M(2B) + (1 - \alpha) \pi_R(2B)
$$

(7.18)

where $\alpha \leq 1$ and represents the weight the retailer places on the manufacturer’s payoffs. Again, we focus on the case where $q(2B) > x_{1(2B)}$. Expressing the above as a function of the retail price $p(2B)$ yields the first-order condition

$$
(1 - \alpha)(a + w_{2(2B)} - 2p(2B)) - \alpha(w_{2(2B)} - c) = 0
$$

Rearranging, we obtain

$$
p(2B) = \frac{a + w_{2(2B)}}{2} - \frac{\alpha}{2(1 - \alpha)}(w_{2(2B)} - c)
$$

(7.19)

The binding constraint becomes

$$
\frac{(a(\alpha - 1) + \alpha c + w_{2(2B)} - 2\alpha w_{2(2B)})^2}{4(1 - \alpha)} - (1 - 2\alpha)(w_{1(2B)} - w_{2(2B)})x_{1(2B)} = V
$$

(7.20)

Substituting this into the manufacturer’s profit function and differentiating with respect to $w_{2(2B)}$, we have the following first-order condition

$$
2c(1 - 2\alpha)^2 - 2w_{2(2B)}(1 - 2\alpha)^2 = 0
$$

which gives us

$$
w_{2(2B)}^* = c
$$

(7.21)

The proof for the three-block tariff is identical.
Appendix II: Instructions for the Two-Block Tariff Treatment

1. INTRODUCTION

This is an experiment in decision-making. 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. Different people may earn different amounts of cash. What you earn today partly depends on your decisions, partly on the decisions of others, and partly on chance. It is important that you do not look at the decisions of others, and that you do not talk, laugh, or make noises during the experiment. You will be warned if you violate this rule the first time. If you violate this rule twice, you will be asked to leave, and you will not be paid. That is, your earnings will be $0.

There are 11 people in this experiment and there will be 11 decision rounds. In each round, each player will be randomly and anonymously matched with another player. There will be 5 pairs of players (total 10 players) in each round. One of you will sit out for that round. Consequently, each of you will play 10 decision rounds. You will be matched with each of the other players only once; that is, you will be matched with a different player in each round and you will never be matched with the same person more than once. The sequence in which players are matched has been randomly determined prior to the experiment. We will read the instructions together carefully and go through some exercises to familiarize you with the steps in each round. During these exercises, you will also be given a chance to ask any questions you might have. Then we will begin Round 1.

2. OVERVIEW OF EXPERIMENT

In each round, you will either be a RED or BLUE player. This assignment has been pre-determined randomly and has been given to you. RED owns a product that she produces at a unit cost of 20. RED sells the product to BLUE, who in turn sells it to a group of customers. The decision steps are as follows:

1. RED has to choose a wholesale price contract that offers a quantity discount. We will explain the quantity discount contract in detail in the following section.

2. After observing RED’s offer, BLUE must decide whether to ACCEPT or REJECT this contract. If she ACCEPTs, she must choose the PRICE at which she wants to sell the product to the customers. The PRICE chosen determines the actual QUANTITY sold, which in turn determines the earnings for both players.
3. DECISION STEPS

The following steps will be repeated in each round:

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

RED’s decision is to **choose prices X, Y and a quantity “breakpoint” BREAK**, that forms a quantity discount contract based on the following rules:

1. If BLUE sells a quantity from 1 to BREAK units, the **unit price** to BLUE is X. (If BLUE sells 0, she pays nothing).
2. If BLUE sells a quantity greater than BREAK, that is, from BREAK+1 to 100 units, the **unit price** to BLUE for the first BREAK units is X, and the **unit price** of subsequent units (BREAK+1 unit onwards) is Y.
3. X must be greater than Y. BREAK is an integer between 0 to 100.

Suppose RED chooses X = 60, Y = 25 and BREAK = B. If BLUE sells 10 units and if this quantity is below B, the revenue to RED is 60*(10) = 600. If BLUE sells 50 units, the revenue to RED is 60*(B) + 25*(50 – B). If B is 30 for example, the revenue to RED is 2300. These examples are illustrated in the figure below. In no way are we suggesting that you should choose these values – they are solely for illustrative purposes.

![Graph showing total cost to BLUE with X = 60, Y = 25, and BREAK = B]

**RED’s Earnings**

For each unit sold to BLUE, the cost to RED is 20. Hence, RED’s payoffs are as follows:

If QUANTITY ≤ BREAK,

**RED’s earnings = (X-20) * QUANTITY**
If QUANTITY > BREAK, 

**RED’s earnings** = \(X \times \text{BREAK} + Y \times (\text{QUANTITY} - \text{BREAK}) - (20 \times \text{QUANTITY})\) 

The actual number of units sold, QUANTITY, depends on BLUE’s decision, which will be described in step 2.

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

After learning X, Y and BREAK chosen by RED, BLUE can either ACCEPT or REJECT the offer.

1. If she ACCEPTs, she decides on the PRICE, an integer from 0 to 100, to sell to a group of customers. This PRICE determines the actual QUANTITY sold according to the formula \(\text{QUANTITY} = 100 - \text{PRICE}\). Examples: if PRICE is 70, QUANTITY is 30. If PRICE is 56, QUANTITY is 44. These examples are for illustrative purposes only; in no way are we suggesting that you should choose these numbers.

3. If she REJECTs, then the round ends.

**4. POINT EARNINGS AND CASH PAYMENT**

After Steps 1 and 2, both players will have known X, Y, BREAK (RED’s decision), BLUE’s decision on whether ACCEPT or REJECT, and the PRICE if BLUE chooses to ACCEPT. Based on this information, both players should be able to compute the actual QUANTITY sold and their point earnings. We ask that you record all decisions and point earnings in the Table provided. We have also prepared an Excel spreadsheet to help you perform your calculations.

**POINT EARNINGS**

Recall that for each unit sold to BLUE, the cost to RED is 20.

1. If BLUE ACCEPTs:

A. If QUANTITY \(\leq\) BREAK,

**RED’s earnings** = \([X - 20] \times \text{QUANTITY}\) 

**BLUE’s earnings** = \([\text{PRICE} - X] \times \text{QUANTITY}\)
B. If QUANTITY > BREAK,

**RED’s earnings** = \[X \times \text{BREAK}] + [Y \times \text{(QUANTITY} – \text{BREAK})] – [20\times\text{QUANTITY}]

**BLUE’s earnings** = [\text{PRICE} \times \text{QUANTITY} – [X \times \text{BREAK}] – [Y \times \text{(QUANTITY} – \text{BREAK})]

2. If BLUE REJECTs, both RED and BLUE earn 0 points.

**Cash Payment**

We will sum up your point earnings across all 10 rounds to determine your cash payoff. Your cash payoff is your total point earnings multiplied by $0.002 (every 100 points you earn is worth 20 cents). This amount will be paid to you privately immediately after the experiment.

**EXERCISE**

To check that you understand the procedures correctly, let’s do a simple exercise using the Excel spreadsheet before we begin the experiment.

Note that these values of RED’s quantity discount pricing schedule X, Y and BREAK and BLUE’s PRICE are chosen for illustrative purposes only. Please fill in the blanks below and compare your solutions with the answers announced later.

<table>
<thead>
<tr>
<th>Round</th>
<th>Your role (BLUE/RED)</th>
<th>RED’s Decisions</th>
<th>BLUE’s Decisions</th>
<th>BLUE’s Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>Y</td>
<td>BREAK</td>
</tr>
<tr>
<td>RED</td>
<td></td>
<td>40</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>BLUE</td>
<td></td>
<td>40</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>RED</td>
<td></td>
<td>80</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>BLUE</td>
<td></td>
<td>80</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>RED</td>
<td></td>
<td>100</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
# RECORD TABLE

**NOTE:**

1. X and Y are integers greater than or equal to 0. \( X \text{ must be greater than } Y \).
2. BREAK is an integer between 0 to 100.
3. PRICE is an integer between 0 to 100.
4. If BLUE REJECTS, both RED AND BLUE earn 0 points.

Your name______________________________   Player Number __________

<table>
<thead>
<tr>
<th>Round</th>
<th>Your role (BLUE/RED)</th>
<th>RED’s Decisions</th>
<th>BLUE’s Decisions</th>
<th>QUANTITY</th>
<th>Point Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>X</td>
<td>Y</td>
<td>BREAK</td>
<td>Accept?</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Point Earnings =

Total Cash Payment = Total Point Earnings \( \times 0.002 = \)
Figure 1 – Double-Marginalization and Channel Coordination

Manufacturer’s Profits

\[
\frac{(a - c)^2}{4}
\]

Retailer’s Profits

\[
\frac{(a - c)^2}{8}
\]

A – Profits in the linear price regime

Efficient Frontier

\[
\frac{(a - c)^2}{16}
\]  \hspace{1cm} \frac{(a - c)^2}{4}

Figure 2 – Two-Block Tariff and Three-Block Tariff
Table 1 – Instruments for Channel Coordination

<table>
<thead>
<tr>
<th>Contract</th>
<th>Efficiency</th>
<th>Surplus Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-Block Tariff</td>
<td>$w_{2(2B)}^* = c$</td>
<td>$w_{1(2B)}^* \in (c,a]$ $x_{1(2B)}^* = \frac{a-c}{4}$</td>
</tr>
<tr>
<td>(2B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three-Block Tariff</td>
<td>$w_{2(3B)}^* = c$</td>
<td>$\frac{w_{0(3B)}^* x_{0(3B)}^* + w_{1(3B)}^* (x_{1(3B)}^* - x_{0(3B)}^<em>)}{x_{1(3B)}^</em>} \in (c,a]$ $x_{1(3B)}^* = \frac{a-c}{4}$</td>
</tr>
<tr>
<td>(3B)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 3 – Revenue Equivalence

Manufacturer’s Profits

\[
\frac{(a - c)^2}{4}
\]

Retailer’s Profits

\[
\frac{(a - c)^2}{4}
\]
Figure 4 – Division Equivalence

Manufacturer’s Profits

Retailer’s Profits

0

\[
\frac{(a - c)^2}{4}
\]

\[
\frac{(a - c)^2}{4}
\]
Table 2 – Theoretical Predictions for the Experiments

\( a = 100, c = 20, q = 100 - p \)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Linear Price (LP)</th>
<th>2-Block Tariffs (2B)</th>
<th>3-Block Tariffs (3B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer’s Decisions</strong></td>
<td>( w_{(LP)} = 60 )</td>
<td>( w_{2(2B)} = w_{2(3B)} = 20 )</td>
<td>( p_{(2B)} = p_{(3B)} = 60 )</td>
</tr>
<tr>
<td><strong>Retailer’s Decisions</strong></td>
<td>( p_{(LP)} = 80 )</td>
<td>( q_{(2B)} = q_{(3B)} = 40 )</td>
<td>( p_{(2B)} = p_{(3B)} = 60 )</td>
</tr>
<tr>
<td><strong>Channel Profits</strong></td>
<td>( \pi_{T(LP)} = 1200 )</td>
<td>( \pi_{T(2B)} = \pi_{T(3B)} = 1600 )</td>
<td>( \pi_{T(2B)} = \pi_{T(3B)} = 1600 )</td>
</tr>
<tr>
<td><strong>Manufacturer’s Share of Profits</strong></td>
<td>( \pi_{M(LP)} = 800 )</td>
<td>( m_{(2B)} = m_{(3B)} )</td>
<td>( \pi_{M(2B)} = \pi_{M(3B)} = 1600 - V )</td>
</tr>
</tbody>
</table>

\( V \) is the retailer’s reservation utility
Table 3 - Comparison of Mean Values of Decisions and Outcomes Across Experiments

<table>
<thead>
<tr>
<th>Variables</th>
<th>Undergrad N=110</th>
<th>MBA N=36</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_1$</td>
<td>64.1 (12.1)</td>
<td>62.5 (11.8)</td>
<td>0.72</td>
<td>0.475</td>
</tr>
<tr>
<td>$w_2$</td>
<td>31.9 (10.2)</td>
<td>39.9 (10.6)</td>
<td>-3.98*</td>
<td>0.000</td>
</tr>
<tr>
<td>$x_1$</td>
<td>25.0 (10.2)</td>
<td>28.7 (15.4)</td>
<td>-1.31</td>
<td>0.196</td>
</tr>
<tr>
<td>$p$</td>
<td>73.7 (11.6)</td>
<td>74.8 (7.1)</td>
<td>-0.64</td>
<td>0.526</td>
</tr>
<tr>
<td>Efficiency#</td>
<td>80.0% (26.1)</td>
<td>83.2% (12.7)</td>
<td>-0.95</td>
<td>0.343</td>
</tr>
<tr>
<td>$m$#</td>
<td>64.6% (13.9)</td>
<td>67.5% (10.3)</td>
<td>-1.27</td>
<td>0.207</td>
</tr>
</tbody>
</table>

# The measures of Efficiency and $m$ reported are conditional on acceptance of the contract.
* denotes statistical significance at the 5 percent level.
## Table 4 – Mean Values of Decisions and Outcomes

<table>
<thead>
<tr>
<th>Decisions</th>
<th>Linear Price (LP)</th>
<th>Two-Block Tariff (2B)</th>
<th>Three-Block Tariff (3B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>w</td>
<td>60.3 (7.4)</td>
<td>63.7 (12.0)</td>
<td>57.3 (15.0)</td>
</tr>
<tr>
<td>w&lt;sub&gt;1&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w&lt;sub&gt;2&lt;/sub&gt;</td>
<td></td>
<td>33.9 (10.8)</td>
<td>29.9 (11.3)</td>
</tr>
<tr>
<td>x&lt;sub&gt;1&lt;/sub&gt;</td>
<td></td>
<td>25.9 (12.9)</td>
<td>20.6 (6.9)</td>
</tr>
<tr>
<td>p</td>
<td>82.3 (6.0)</td>
<td>74.0 (10.6)</td>
<td>66.2 (6.4)</td>
</tr>
<tr>
<td>Rejection Rate</td>
<td>2.0%</td>
<td>11.0%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>66.6% (18.5)</td>
<td>80.8% (23.4)</td>
<td>95.1% (7.1)</td>
</tr>
<tr>
<td>m</td>
<td>64.2% (9.0)</td>
<td>65.3% (13.1)</td>
<td>72.7% (13.8)</td>
</tr>
<tr>
<td>Entire Sample</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency#</td>
<td>65.4% (20.4)</td>
<td>71.9% (33.6)</td>
<td>80.4% (35.1)</td>
</tr>
<tr>
<td>m#</td>
<td>63.9% (9.1)</td>
<td>63.6% (13.2)</td>
<td>69.2% (15.1)</td>
</tr>
</tbody>
</table>

Figures in parentheses represent the standard deviation.

# For rejected contract offers, Efficiency is coded as 0% while the manufacturer’s share of profits is coded as 50%.
### Table 5 – Double-Marginalization Problem

<table>
<thead>
<tr>
<th>Tests</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_{LP} = 60$</td>
<td>0.13</td>
<td>0.894</td>
</tr>
<tr>
<td>$p_{LP} = 80$</td>
<td>4.07*</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Conditional on Acceptance**
- Efficiency (LP) = 75%
  - t-statistic: -4.69*, p-value: 0.000
- $m(LP) = 66.67$
  - t-statistic: -2.90*, p-value: 0.005

**Entire Sample**
- Efficiency (LP) = 75%
  - t-statistic: -4.92*, p-value: 0.000
- $m(LP) = 66.67$
  - t-statistic: -3.19*, p-value: 0.002

*denotes significance at the 5 percent level.
Table 6- Revenue Equivalence Hypothesis

<table>
<thead>
<tr>
<th>Tests</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_{2(2B)} = 20$</td>
<td>14.88*</td>
<td>0.000</td>
</tr>
<tr>
<td>$w_{2(3B)} = 20$</td>
<td>7.74*</td>
<td>0.000</td>
</tr>
<tr>
<td>$w_{2(2B)} = w_{2(3B)}$</td>
<td>2.81*</td>
<td>0.005</td>
</tr>
<tr>
<td>$p_{(2B)} = 60$</td>
<td>15.07*</td>
<td>0.000</td>
</tr>
<tr>
<td>$p_{(3B)} = 60$</td>
<td>9.40*</td>
<td>0.000</td>
</tr>
<tr>
<td>$p_{(2B)} = p_{(3B)}$</td>
<td>6.85*</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Conditional on Acceptance**

| Efficiency (2B) = 75%          | 2.82*       | 0.006   |
| Efficiency (3B) = 75%          | 27.14*      | 0.000   |
| Efficiency (2B) = Efficiency (3B) | -6.55*    | 0.000   |
| Efficiency (2B) = Efficiency (LP) | 5.24*     | 0.000   |
| Efficiency (3B) = Efficiency (LP) | 14.73*   | 0.000   |

**Entire Sample**

| Efficiency (2B) = 75%          | -1.10       | 0.271   |
| Efficiency (3B) = 75%          | 1.61        | 0.111   |
| Efficiency (2B) = Efficiency (3B) | -1.94    | 0.053   |
| Efficiency (2B) = Efficiency (LP) | 1.92     | 0.056   |
| Efficiency (3B) = Efficiency (LP) | 3.86*    | 0.000   |

*denotes significance at the 5 percent level.
## Table 7 – Division Equivalence Hypothesis

<table>
<thead>
<tr>
<th>Tests</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conditional on Acceptance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m(2B) = m(3B)$</td>
<td>-4.03*</td>
<td>0.000</td>
</tr>
<tr>
<td>$m(2B) = m(LP)$</td>
<td>0.80</td>
<td>0.423</td>
</tr>
<tr>
<td>$m(3B) = m(LP)$</td>
<td>5.11*</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Entire Sample</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m(2B) = m(3B)$</td>
<td>-3.07*</td>
<td>0.002</td>
</tr>
<tr>
<td>$m(2B) = m(LP)$</td>
<td>-0.19</td>
<td>0.849</td>
</tr>
<tr>
<td>$m(3B) = m(LP)$</td>
<td>3.14*</td>
<td>0.002</td>
</tr>
</tbody>
</table>

*denotes significance at the 5 percent level.
Figure 5 – Equilibrium Predictions of Model of Counterfactual Cognition (against $\beta$)

($a = 100, c = 20, w_{0(3B)}^* = 100, x_{0(3B)}^* = 8, V = 200$)
TABLE 8 - Estimation Results

<table>
<thead>
<tr>
<th>Estimated Parameters</th>
<th>Two-Block Tariff</th>
<th>Three-Block Tariff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Estimation</td>
<td>Full Model</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.28 ( (10.19) )</td>
<td>0.27 ( (10.52) )</td>
</tr>
<tr>
<td></td>
<td>0.27 ( (10.52) )</td>
<td>0.36 ( (14.80) )</td>
</tr>
<tr>
<td>( V )</td>
<td>224.12 ( (6.08) )</td>
<td>227.56 ( (6.29) )</td>
</tr>
<tr>
<td></td>
<td>( 227.56 ) ( (6.29) )</td>
<td>-</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>0.0039 ( (5.18) )</td>
<td>0.0039 ( (5.28) )</td>
</tr>
<tr>
<td></td>
<td>( 0.0039 ) ( (5.28) )</td>
<td>0.0035 ( (5.83) )</td>
</tr>
<tr>
<td>( \sigma_{w1} )</td>
<td>12.67 ( (14.16) )</td>
<td>12.68 ( (14.58) )</td>
</tr>
<tr>
<td></td>
<td>( 12.68 ) ( (14.58) )</td>
<td>15.50 ( (11.53) )</td>
</tr>
<tr>
<td>( \sigma_{w2} )</td>
<td>10.77 ( (14.94) )</td>
<td>10.77 ( (15.31) )</td>
</tr>
<tr>
<td></td>
<td>( 10.77 ) ( (15.31) )</td>
<td>11.12 ( (14.51) )</td>
</tr>
<tr>
<td>( \sigma_{x1} )</td>
<td>14.10 ( (27.11) )</td>
<td>14.09 ( (28.44) )</td>
</tr>
<tr>
<td></td>
<td>( 14.09 ) ( (28.44) )</td>
<td>14.09 ( (28.60) )</td>
</tr>
<tr>
<td>( \rho_{12} )</td>
<td>-0.07 ( n.s. ) ( (-0.79) )</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-0.07 ( n.s. ) ( (-0.79) )</td>
<td>-</td>
</tr>
<tr>
<td>( \rho_{13} )</td>
<td>-0.29 ( -4.42 )</td>
<td>-0.29 ( -4.79 )</td>
</tr>
<tr>
<td></td>
<td>-0.29 ( -4.79 )</td>
<td>-0.45 ( -5.15 )</td>
</tr>
<tr>
<td>( \rho_{23} )</td>
<td>-0.11 ( n.s. ) ( (-1.08) )</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-0.11 ( n.s. ) ( (-1.08) )</td>
<td>-</td>
</tr>
</tbody>
</table>

The figures in parentheses represent the t-statistics. All parameters estimates are significant except where indicated. The superscripts n.s. indicate that the estimate is not significant at the 5 percent level.

*The model is significantly different from the Full Model at the 5 percent level.

| LL            | -1854.8 | -1856.5 | -1945.7 | -1877.6 | -2052.9 | -1314.8 | -1317.9 | -1373.8 | -1320.4 | -1463.4 |
| B.I.C.        | 1877.2  | 1873.9  | 1960.6  | 1892.6  | 2065.3  | 1335.9  | 1334.4  | 1387.9  | 1334.5  | 1475.2  |
| LR test       | -178.4* | 42.30*  | 392.84* | -111.70* | 4.96*  | 291.0*  |
Table 9 - Numerical Predictions for Model of Downward Counterfactual Cognition
\( (c=20, \ V=200, \ q=100-p) \)

<table>
<thead>
<tr>
<th>( \phi )</th>
<th>( w_2^* )</th>
<th>( w_1^* )</th>
<th>( \pi_M^* )</th>
<th>( \pi_R^* )</th>
<th>( \pi_T^* )</th>
<th>( m^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>19.99</td>
<td>90.01</td>
<td>1400</td>
<td>200</td>
<td>1600</td>
<td>0.875</td>
</tr>
<tr>
<td>0.25</td>
<td>18.57</td>
<td>93.34</td>
<td>1437</td>
<td>162</td>
<td>1599</td>
<td>0.899</td>
</tr>
<tr>
<td>0.5</td>
<td>18.21</td>
<td>95.06</td>
<td>1463</td>
<td>135</td>
<td>1598</td>
<td>0.916</td>
</tr>
<tr>
<td>0.75</td>
<td>18.17</td>
<td>96.08</td>
<td>1478</td>
<td>116</td>
<td>1594</td>
<td>0.927</td>
</tr>
<tr>
<td>1.00</td>
<td>18.23</td>
<td>96.74</td>
<td>1498</td>
<td>101</td>
<td>1599</td>
<td>0.937</td>
</tr>
</tbody>
</table>