# The Effects of a Two-Stage Ordering Process and Quantity Discounts on Vertical Channel Relationships: Theory and Evidence 

Desmond (Ho-Fu) Lo<br>Doctoral Student of Marketing<br>University of Michigan hofulo@umich.edu<br>Mrinal Ghosh<br>Associate Professor of Marketing<br>University of Arizona<br>mghosh@email.arizona.edu<br>and<br>Stephen Salant<br>Professor of Economics<br>University of Michigan ssalant@umich.edu

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#### Abstract

Manufacturers often devise contractual mechanisms that enable downstream dealers to earn economic profit. One such mechanism is the two-stage ordering process with quantity discounts used by MNCs in their international distribution and other contexts. The authors theoretically and empirically demonstrate how an upstream profit-maximizing manufacturer can use the mechanism to ensure that its downstream dealers earn economic profits. They first construct a theory model that shows how it enables the manufacturer to control indirectly the intensity of downstream competition between its dealers. The authors then match the results of their model to a novel longitudinal data obtained from "Computec," a leading Chinese manufacturer of a key computer accessory, and use the data to estimate the unobserved final retail prices, the price-cost markups, and the profits earned by their dealers over a one-year period. The authors show empirically that the ordering arrangement indeed is economically profitable for the dealers. The authors discuss the implications for research and practice in channel design and management.


Key words: Contracting; Distribution Channels; Manufacturer-Dealer Relationships; Vertical Restraints; Quantity Discounts.

## INTRODUCTION

In long term relationships between a manufacturer and its channel members, the upstream firm often uses economic incentives as a control mechanism (e.g. Heide 1994). ${ }^{\text {i }}$ These economic incentives serve as self-enforcing contracts (e.g., Dutta, Bergen, \& John 1994; Kaufmann and Lafontaine 1994; Klein and Murphy 1988) in a sense that they discourage shirking and encourage non-contractible promotional activities by the dealers, especially in conditions where monitoring is costly. Towards this end, theoretical research has proposed a variety of "vertical restrictions" including minimum resale price maintenance - RPM - (e.g. Telser 1960), territorial restrictions (e.g. Matthewson and Winter 1984) and slotting allowances (e.g. Shaffer 1991) to incentivize dealers. Likewise, empirical research has shown that fixed fee transfer mechanisms like franchise fees (e.g., Kaufmann and Lafontaine 1994) are indeed used strategically to let dealers earn supra-normal profits.

Imposing vertical restrictions, however, can be costly and/or infeasible in many institutional contexts. Territorial restrictions, for instance, involve significant bureaucratic and monitoring costs (Matthewson and Winter 1984) and are difficult to adapt to new circumstances whereas minimum RPM was considered per se illegal in the US and other countries. In turn, manufacturers desiring to lower the intensity of downstream competition have attempted to devise alternative mechanisms. One such alternative mechanism that is used by MNCs like Hewlett-Packard and Toshiba in their international distribution and publishing and media sales sectors in the U.S. is the two-stage ordering process with quantity discounts. A similar arrangement is used by Computec ${ }^{\mathrm{ii}}-\mathrm{a}$ leading Chinese manufacturer of a key computer accessory sold in China. Consider the details of Computec's channel structure.

In-depth field interviews with Computec's top management revealed that Computec sells its products through 60 independent dealers without any exclusive dealing, territorial restrictions,
fixed-fee transfer, or RPM clauses. The most distinctive feature of the channel is its sales and ordering process. Sales to dealers are organized into well-defined quarterly sales cycles which always consist of two distinct stages as shown in Figure 1. The first week of each cycle constitutes the order-taking stage. Computec announces a schedule of quantity discounts below a given wholesale price and its 60 dealers pay in full for the quantities they want to "preorder" at a discount. The second, or order-fulfillment, stage immediately follows the order-taking stage and last approximately three months. Computec ships the scheduled preorders during this stage. As orders are fulfilled, dealers compete in price but also provide some value-added services such as pre-sale education to consumers and trade credit to second-tier retailers. Significantly, dealers can order additional quantities in this stage; however these additional quantities do not qualify for any quantity discounts. Computec's management believed that this channel arrangement has provided both flexibility and a "satisfying" amount of profits to their dealers. This arrangement is however not unique to Computec. In-depth interviews with two independent industry experts ascertained that Computec's major competitors used an identical 2-stage process.
<Insert Figure 1 about here>
In this paper we formally study the two-stage ordering process with quantity discounts and its implications on downstream outcomes by asking two questions. How does this mechanism affect downstream competition and thus dealer profits? And, do dealers of firms employing this mechanism actually earn economic profits? As such, our paper has two specific goals. First, we build a game-theoretic model of channel interaction between a monopolistic manufacturer and her two dealers to theoretically show how the specific ordering process should enable the profitmaximizing manufacturer to control the intensity of downstream competition and thus the profits earned by the dealers. Second, we use the insights drawn from the model, in conjunction with the specific institutional details observed at Computec, to set up an econometric model along the lines
used in the New Empirical Industrial Organization (NEIO) literature (e.g., Reiss and Wolak 2005) to estimate the unobserved retail price. These estimated prices, together with the cost information we collected, enable us to calculate the economic profits that Computec actually leaves on the table for its heterogeneous group of dealers.

Our paper makes three principal contributions. First, on the theory side, our analysis of the 2-stage ordering process builds on the literature on capacity-constrained pricing games (e.g., Kreps and Scheinkman 1983; Maggi 1996), but extends to show that via the endogenous choice of the profit-maximizing manufacturer on its quantity discounts, in the game that dealers choose their quantity orders first and then set prices according to Bertrand competition, Cournot outcomes can be equilibrium. In particular we show that under a 2-stage ordering process, if the manufacturer offers no quantity discount the downstream competition would be equivalent to that of a one-shot Bertrand game (i.e. dealers choose prices to maximize profits); in contrast, if the manufacturer offers a strictly positive discount the downstream competition would be equivalent to that of a oneshot Cournot game (i.e. dealers choose quantities to maximize profits). The dealer profits are higher in the latter condition; hence this 2 -stage ordering process in essence enables the manufacturer to indirectly influence the intensity of downstream competition which in turn affects the economic profits earned by the dealers.

Second, our econometric specification and analysis, based on our theory model and the institutional details of Computec's arrangement, demonstrates that Computec's dealers indeed earn substantial economic profits. Our work, hence, shows a workable mechanism that manufacturers can use to generate downstream profits. More crucially, our paper addresses a major gap between theory and empirical research in channel settings. Specifically, several empirical studies have demonstrated the existence of positive downstream price-cost markups; however, except Chintagunta (2002), these studies do not test a specific vertical arrangement and instead focus on
inferring the extent of competition and/or market structure from estimated parameters (e.g., Chen, John, and Narasimhan 2006; Kadiyali, Chintagunta, and Vilcassim 2000; Villas-Boas and Zhao 2005; Villas-Boas 2007). As such, even when a positive markup is identified in some setting, its source remains unclear; i.e. these downstream profits cannot be tied to any specific manufacturer devised arrangement. Our study, to the best of our knowledge, is the first to model analytically a specific channel arrangement and to link this arrangement to assembled field data for systematic empirical analyses on downstream markups.

Our third principal contribution is methodological in nature and arises out of the limitations of the available data. As is indeed the case in many sale-resale contexts (e.g., business-business sales), Computec did not have data on the final retail prices but had archival data on wholesale prices and discounts, quantities ordered and supplied to dealers, plus its marketing expenses. As a result, our estimation problem is quite different from that observed in most NEIO research on pricecost markups in that these studies observe final prices but the marginal costs are unknown whereas we observe the marginal costs but the final prices are unknown. In this paper, we develop a procedure that using longitudinal data shows how the unobserved final prices can be recovered to calculate retail markups. In particular, we begin with estimating the demand function using a fixed effect model in which the observed net wholesale prices act as a "proxy" for the final prices. Simultaneously, based on the insights from our formal model and institutional details, we specify $a$ priori the inferred type of dealer-side competition in the supply-side relationship. We then use the estimated slope of the demand function and this specified supply relation to calculate the final prices. We believe that our novel procedure should enable manufacturers lacking downstream data to use a more structural approach for estimating retail side outcomes like prices and profits.

The paper proceeds as follows. In next section, we formulate and solve the model of the two-stage ordering process with quantity discounts and use the model to deduce the consequences
of this specific institutional arrangement. We then present our statistical methodology and estimation results for final prices and economic rent. We conclude with a discussion of our results, the limitations of our analysis, and directions for future work.

## A MODEL OF A TWO-STAGE ORDERING PROCESS WITH QUANTITY DISCOUNTS

## Related Research

Although neither Computec nor its dealers is capacity constrained, our analysis of its twostage ordering process complements the literature on capacity-constrained price games initiated by Kreps and Scheinkman (1983) who show that when firms compete in prices after a prior stage of capacity building, the price and quantities arising in the subgame-perfect equilibrium coincide under specified circumstances with one-shot Cournot competition. Maggi (1996) extends their work to the case of differentiated products and allows expansion of production capacity in the second stage, albeit at a higher marginal cost.

We add to this stream of research by endogenizing the intensity of downstream competition via the manufacturer's choice of quantity discount schedule. Specifically, in the game that dealers choose their quantities in the first stage and prices according to Bertrand competition in the second, Cournot outcomes ensue when the profit-maximizing manufacturer offers a positive discount in the first stage. Our results suggest that Cournot competition might be more common in channel settings than is commonly recognized. In addition, our analysis demonstrates the importance of taking account of the institutional details (the ordering process in our case) when studying vertical channels.

## Model Structure and Set-Up

Consider a monopolistic manufacturer who sells its product to consumers through two competing, but symmetric, dealers. Figure 2 details the information structure and decision sequence. In stage 0 , the manufacturer sets a wholesale price and the quantity discount schedule. In stage $1-$
the order-taking stage - the dealers independently and simultaneously place their orders for number of units to be purchased taking into consideration the wholesale price and the discount schedule. In stage 2 - the order-fulfillment stage - the manufacturer delivers the products to the dealers, each dealer observes both amounts delivered, and simultaneously sets his retail price. If demand for his product exceeds the preordered amount, the dealer can order additional units from the manufacturer, in stage 2, at the undiscounted wholesale price. If demand falls short of the preordered amount, the dealer may not return the excess to the manufacturer for a refund; for simplicity, we assume that the dealers cannot store merchandise for sale in a subsequent sales cycle. We also assume that there is no uncertainty in demand, that demand is common knowledge, and that both manufacturer and dealers maximize profits. This model structure closely resembles the institutional arrangement observed at Computec.

## <Insert Figure 2 about here>

Below, we show how this ordering process can be summarized in reduced form by either a static Cournot or Bertrand game. This insight is then used to show how the manufacturer could vary the intensity of downstream competition by varying the discount schedule offered in stage 0 .

Let $\mathrm{k}_{\mathrm{i}}$ be the quantity ordered by dealer i in stage 1 (preorders). At the time of placing his order, the dealer pays an amount $\left(\mathrm{w}-\mathrm{d} \cdot \mathrm{k}_{\mathrm{i}}\right)$ per unit preordered, where w is the fixed wholesale price and $d$ is the dollar discount per unit. ${ }^{\text {iii }}$ This linear discount schedule for pre-ordered quantities closely approximates the actual discount schedule used by Computec and has been used in previous studies (e.g., Ingene and Parry 1995). ${ }^{\text {iv }}$ The manufacturer's total cost of production is $m \cdot\left(k_{1}+k_{2}\right)$. The marginal cost of selling for each dealer, without loss of generality, is kept at zero. All other fixed costs are also assumed to be zero. We assume that the dealer's demand functions are linear and given by:

$$
\begin{equation*}
\mathrm{D}_{\mathrm{i}}\left(\mathrm{p}_{\mathrm{i},} \mathrm{p}_{\mathrm{j}}\right) \equiv \mathrm{q}_{\mathrm{i}}=\mathrm{a}-\mathrm{p}_{\mathrm{i}}+\mathrm{b} \mathrm{p}_{\mathrm{j}} \tag{1}
\end{equation*}
$$

with $0 \leq \mathrm{b}<1, \mathrm{i}=1,2$, and $\mathrm{i} \neq \mathrm{j}$. b indexes the level of substitutability between the two dealers.
We start by characterizing the marginal costs faced by each dealer. Having committed to (i.e. paid for without refund) a pre-ordered quantity $\mathrm{k}_{\mathrm{i}}$, if dealer $i$ sells $\mathrm{q}_{\mathrm{i}}$ units in stage 2 , his "shortrun" marginal cost of sales $\left(q_{i}\right.$ for $\left.i=1,2\right)$ is given by:

$$
\begin{aligned}
\mathrm{MC}_{\mathrm{i}} & =0 & & \text { for } \mathrm{q}_{\mathrm{i}}<\mathrm{k}_{\mathrm{i}} \\
& =\mathrm{w} & & \text { for } \mathrm{q}_{\mathrm{i}}>\mathrm{k}_{\mathrm{i}} .
\end{aligned}
$$

This is because for every unit beyond $\mathrm{k}_{\mathrm{i}}$ the dealer will have to pay the manufacturer an undiscounted wholesale price $w$. Hence, the total cost to dealer $i$ of selling $q_{i}$ units in stage 2 is kinked at $\mathrm{q}_{\mathrm{i}}=\mathrm{k}_{\mathrm{i}}$ and the marginal cost is undefined at $\mathrm{q}_{\mathrm{i}}=\mathrm{k}_{\mathrm{i}}$ (the left and right marginal cost are 0 and $w$, respectively). At the beginning of stage 1 , the total cost of preordering $k_{i}$ units is given by $\left(\mathrm{w}-\mathrm{d} \cdot \mathrm{k}_{\mathrm{i}}\right) \mathrm{k}_{\mathrm{i}}$. The dealer's "long-run" marginal cost, i.e. his marginal cost for pre-ordering a quantity $\mathrm{k}_{\mathrm{i}}$, can then be obtained by differentiating his total costs with respect to $\mathrm{k}_{\mathrm{i}}$. The dealer's "long-run" marginal cost is hence given by ( $\mathrm{w}-2 \mathrm{~d} \cdot \mathrm{k}_{\mathrm{i}}$ ). Below, we determine the subgame-perfect Nash equilibrium using backward induction, beginning with stage 2 in Figure 2 and working backward through stage 0 .

## Stage 2: Dealers' Pricing Decisions.

In stage 2, the two dealers observe the amounts preordered ( $\mathrm{k}_{1}, \mathrm{k}_{2}$ ) and engage in Bertrand competition; i.e. each dealer chooses his own price to maximize profits given the inherited preorders and his conjecture about his rival's price. Figure 3 depicts the situation from dealer i's perspective.

## <Insert Figure 3 about here>

Given dealer j's price, dealer i faces a linear demand curve and his linear marginal revenue curve declines at twice the discount rate. His marginal cost of selling less than his preordered quantities is zero. His marginal cost of selling strictly more than his preordered quantities is the
undiscounted wholesale price (w). The profit-maximizing amount to sell $\left(\mathrm{q}_{\mathrm{i}}\right)$ occurs where marginal revenue and marginal cost are equal. Dealer i's best price response - his reaction function - is given by $p_{i}=R_{i}\left(p_{j}, k_{i}\right)$, is continuous, is dependent on $i$ 's preorder, but is independent of $j$ 's preorders. The best reply consists of three linear segments as shown in bold in Figure 4. Consider an intuitive explanation of each in turn.
<Insert Figure 4 about here>
Part 1: If the price charged by dealer $\mathrm{j}, \mathrm{p}_{\mathrm{j}}$, is low, the demand for dealer i 's merchandise is weak and selling less than his preordered quantities is profit-maximizing for him, i.e. $q_{i}<k_{i}$. This occurs when the marginal revenue curve of dealer $i$ crosses his marginal cost curve to the left of $\mathrm{k}_{1}$ in Figure 3. Note that his marginal cost in this segment is zero. Dealer $i$ then chooses $p_{i}$ to solve $\max _{\mathrm{p}} \pi_{\mathrm{i}}=\mathrm{p}_{\mathrm{i}} \mathrm{q}_{\mathrm{i}}$, where $\mathrm{q}_{\mathrm{i}}=\mathrm{a}-\mathrm{p}_{\mathrm{i}}+\mathrm{b} \mathrm{p}_{\mathrm{j}}$ and his best response to $\mathrm{p}_{\mathrm{j}}$ is:

$$
\begin{equation*}
\mathrm{r}^{\mathrm{i}}\left(\mathrm{p}_{\mathrm{j}}\right)=\frac{\mathrm{a}+\mathrm{b} \mathrm{p}_{\mathrm{j}}}{2} \tag{2}
\end{equation*}
$$

Part 2: If dealer j sets an intermediate price, the demand for dealer i's merchandise shifts to the right in Figure 3 and he finds it optimal to sell exactly the amount he preordered. This occurs when the marginal revenue curve crosses the vertical segment of the marginal cost curve at $q_{i}=k_{i}$. Define $p_{i} \equiv s^{i}\left(p_{j}, k_{i}\right)$. Thus, the dealer charges an optimal price that creates a downstream demand $q_{i}$ that exactly equals $\mathrm{k}_{\mathrm{i}}$. The dealer's reaction function in this segment is hence obtained by directly substituting $\mathrm{k}_{\mathrm{i}}$ for $\mathrm{q}_{\mathrm{i}}$ in equation (1) to get:

$$
\begin{equation*}
\mathrm{s}^{\mathrm{i}}\left(\mathrm{p}_{\mathrm{j}} ; \mathrm{k}_{\mathrm{i}}\right)=\mathrm{a}+\mathrm{b} \mathrm{p}_{\mathrm{j}}-\mathrm{k}_{\mathrm{i}} . \tag{3}
\end{equation*}
$$

 profit-maximizing for him to supplement his preorder even though the additional quantities are charged an undiscounted wholesale price. This occurs when his marginal revenue curve intersects
the marginal cost curve to the right of $\mathrm{k}_{\mathrm{i}}$ in Figure 3. His best response to $\mathrm{p}_{\mathrm{j}}$ can then be determined by maximizing his profit $\max _{\mathrm{p}} \pi_{\mathrm{i}}=\mathrm{p}_{\mathrm{i}} \cdot \mathrm{k}_{\mathrm{i}}+\left(\mathrm{p}_{\mathrm{i}}-\mathrm{w}\right) \cdot\left(\mathrm{q}_{\mathrm{i}}-\mathrm{k}_{\mathrm{i}}\right)$ and given by:

$$
\begin{equation*}
\mathrm{r}^{\mathrm{i}}\left(\mathrm{p}_{\mathrm{j}} ; \mathrm{w}\right)=\frac{\mathrm{a}+\mathrm{b} \mathrm{p}_{\mathrm{j}}}{2}+\frac{\mathrm{w}}{2} . \tag{4}
\end{equation*}
$$

The intersection of the two best responses constitutes a pure-strategy Nash equilibrium in the subgame indexed by the inherited preorder pair $\left(k_{1}, k_{2}\right)$. It can be verified from Figure 4 that since the two best replies intersect exactly once, each of these subgames has a unique Nash equilibrium. More precisely, for each preorder pair $\left(\mathrm{k}_{1}, \mathrm{k}_{2}\right)$, the best response of dealer 1 has a slope which is always strictly larger than $1(2 / b, 1 / b$, and $2 / b ; b<1$; for the 3 segments respectively) while the best response of dealer 2 has a slope which is always strictly smaller than $1(b / 2, b / 1$, and $b / 2 ; b<1$; respectively). Since the best reply of dealer 1 starts out below that of dealer 2 , the former will intersect the latter once and will never cross it again.

This unique intersection can, however, occur on any of the three segments of each reaction function. Hence, depending on the preorder pair $\left(\mathrm{k}_{1}, \mathrm{k}_{2}\right)$ inherited from stage 1 , nine qualitatively distinct types of behavior can arise in the Nash equilibrium in a price subgame: the best response of dealer 1 may be to sell (1) strictly less than, (2) strictly more than, or (3) exactly what he preordered and, at the same time, dealer 2 himself may find any of these actions to be profit maximizing. We hence turn to analyzing the preorder decisions in stage 1.

## Stage 1: Dealers' Preorder Decisions.

As we have seen, the prices and sales in stage 2 depend on preorder quantities in stage 1 . In turn, these preorders are influenced by the discount schedule offered by the manufacturer. If $d=0$, the dealers are indifferent when to order. In contrast, if $d>0$, dealers face two counterbalancing motivations. No dealer will preorder so little in stage 1 that purchasing more at an undiscounted price in stage 2 will be profit-maximizing. Likewise, neither dealer would preorder so much in
stage 1 that leaving goods unsold in the stage 2 becomes profit-maximizing. Hence, although for an arbitrary preorder pair $\left(\mathrm{k}_{1}, \mathrm{k}_{2}\right)$ nine qualitatively distinct kinds of behavior may occur, for a profitmaximizing preordering, only one type of behavior occurs in any subgame-perfect equilibrium: each dealer chooses to preorder only what he can sell, nothing more and nothing less. We prove this below.

To prove that no firm will preorder less in stage 1 than it sells in stage 2, assume the contrary. That is, assume one of the dealers, dealer 1 for concreteness, preorders less than what he can sell. Given the difference in his costs of ordering in stage 1 versus 2 , suppose in stage 1 he unilaterally increased his preorder by one unit. This would have no effect on the retail price either dealer would charge in the stage 2. Intuitively, dealer 2's price is still his best response given dealer 1's price since his marginal revenue and marginal cost curves in Figure 3 have not shifted. In terms of the reaction functions in Figure 4, dealer 2's best response would not shift. Similarly, dealer 1's price remains his best response given dealer 2's price; the only change involved is an infra-marginal shift to the right of the vertical segment of his marginal-cost curve---by assumption, to the left of the intersection point of the marginal revenue (MR') and marginal-cost curve (the upper portion of MC). This means that in Figure 4, the bolded section of $\mathrm{r}^{1}\left(\mathrm{p}_{2} ; \mathrm{w}\right)$ does not change while the bolded section of $s^{1}\left(p_{2} ; k_{1}\right)$ shifts marginally upwards; that is dealer 1 's best response $R^{1}\left(p_{2} ; k_{1}\right)$ would shift marginally only in the middle segment. However, since $\mathrm{q}_{1}>\mathrm{k}_{1}$, by assumption, the intersection point between the two response functions, i.e. the bolded sections of $r^{1}\left(p_{2} ; w\right)$ and $R^{2}\left(p_{1} ; k_{2}\right)$, would be in the outer segment where no change has occurred. Said otherwise, the two dealers will set the same prices even though dealer 1 marginally increased his preorder by 1 unit; as a consequence dealer 1 will reduce his supplemental purchases by an offsetting amount. This unilateral deviation is always more profitable for dealer 1 since he earns the same revenue but acquires the last unit at the discounted instead of the undiscounted wholesale price and he would continue doing so until the
two costs have equalized, i.e. at $\mathrm{q}_{1}=\mathrm{k}_{1}$. A parallel argument establishes that in any subgameperfect equilibrium dealer 2 will also never preorder so little in stage 1 that he would want to augment it in stage 2 .

Along similar lines one can show that, in equilibrium, no dealer will preorder more than what he can sell. To prove, assume the contrary. That is, assume that one of the dealers, dealer 1 for concreteness, preorders more in stage 1 than he sells in stage 2 . Now suppose in stage 1 this dealer unilaterally decreases his preorders by one unit. This would not affect the pair of retail prices chosen in stage 2 . To verify this, note that given $\mathrm{p}_{1}$, dealer 2's marginal revenue and marginal cost in Figure 3 are unchanged and his best response in Figure 4 would be unaffected. Given $\mathrm{p}_{2}$, dealer 1's marginal revenue curve would also remain unchanged; the only change involved is an inframarginal shift to the right of the vertical segment of his marginal-cost curve---by assumption, to the right of the intersection point of the marginal revenue (MR') and marginal-cost curve (the lower portion of MC). This means that in Figure 4, the bolded section of $r^{1}\left(p_{2}\right)$ does not change while the bolded section of $s^{1}\left(p_{2} ; \mathrm{k}_{1}\right)$ shifts marginally downwards; that is dealer 1 's best response $\mathrm{R}^{1}\left(\mathrm{p}_{2} ; \mathrm{k}_{1}\right)$ would shift marginally only in the middle segment. Since $\mathrm{q}_{1}<\mathrm{k}_{1}$, by assumption, the intersection of the response functions i.e. the bolded sections of $\mathrm{r}^{1}\left(\mathrm{p}_{2}\right)$ and $\mathrm{R}^{2}\left(\mathrm{p}_{1} ; \mathrm{k}_{2}\right)$, will be in the inner segment where no change has occurred. Said otherwise, the two dealers would still charge the same price and sell the same quantities. By deviating, therefore, dealer 1 would earn the same revenue; however, his costs would fall since he would preorder less merchandise. He would hence continue doing so till there is no further reduction in costs; i.e. until $\mathrm{q}_{1}=\mathrm{k}_{1}$. A parallel argument establishes that dealer 2 will also never preorder more in stage 1 than he sells in stage 2 .

In effect, the above analysis shows that in any subgame-perfect Nash equilibrium the intersection of the two reaction functions in Figure 4 always occurs in their middle segments where $q_{i}=k_{i}$. We summarize these results in the following Lemma:

Lemma 1. In any subgame-perfect equilibrium, if $d>0, k_{i}=q_{i}=D_{i}\left(p_{i}, p_{j}\right), i=1,2 .{ }^{\mathrm{v}}$
We have shown above that neither dealer will preorder more or less than required in stage 2 . We now turn to determine the optimal preorder quantities for a given discount schedule. Both dealers simultaneously preorder based on their conjecture about their rival's preorders. Given $\mathrm{k}_{\mathrm{j}}$, dealer $\mathrm{i}, \mathrm{i}=1,2$ knows that if he preorders any amount less than some threshold, $\mathrm{k}_{\mathrm{i}}^{\min }$, he will have to supplement his preorder so that the final quantities sold remain unchanged. Hence, for any preorders below this threshold the second-stage prices are not expected to change. Similarly, dealer $i$ knows that if he preorders any amount more than some larger threshold, $k_{i}^{\max }\left(\geq \mathrm{k}_{\mathrm{i}}^{\text {min }}\right)$, he will be expected to sell an unchanged amount and to leave the remainder of the preorder unsold. Hence, for preorders above the larger threshold, the subsequent price will be unaffected.

Given $\mathrm{k}_{\mathrm{j}}$, dealer $i$ 's smallest credible quantity $\mathrm{k}_{\mathrm{i}}^{\text {min }}$ and the associated maximal price $p_{i}^{\text {max }}$ (for $\mathrm{i}=1,2$ ) can be determined, along with dealer j 's price, by solving three equations: the two demand curves with $D_{j}\left(p_{i}^{\text {max }}, p_{j}\right)=k_{j}$ and $\left.D_{i}\left(p_{i}^{\text {max }}, p_{j}\right)=k_{i}^{\text {min }}\right)$ and the best response of dealer i assuming that he acts as a Bertrand competitor with marginal cost of additional orders $w$ $\left(p_{i}^{\max }=\frac{a+b p_{j}}{2}+\frac{w}{2}\right)$. Similarly, dealer i's largest credible quantity, $\mathrm{k}_{\mathrm{i}}^{\text {max }}$ and minimal price $\mathrm{p}_{\mathrm{i}}^{\min }$ (for $\mathrm{i}=1,2$ ) can be determined. Specifically, given $\mathrm{k}_{\mathrm{j}}$, dealer i 's largest credible quantity $\mathrm{k}_{\mathrm{i}}^{\text {max }}$ and the associated minimal price $p_{i}^{\text {min }}$ (for $\mathrm{i}=1,2$ ) can be determined, along with dealer j 's price, by solving three equations: the two demand curves $\left(\right.$ with $D_{j}\left(p_{i}^{\min }, p_{j}\right)=k_{j}$ and $\left.D_{i}\left(p_{i}^{\min }, p_{j}\right)=k_{i}^{\text {max }}\right)$ and the best response of dealer i assuming that he acts as a Bertrand competitor with marginal cost of additional orders being zero $\left(p_{i}^{\min }=\frac{a+b p_{j}}{2}\right)$.

Given any $\mathrm{k}_{\mathrm{j}} \in\left[\mathrm{k}_{\mathrm{j}}^{\text {min }}, \mathrm{k}_{\mathrm{j}}^{\text {max }}\right]$, larger preorders by dealer $i$ will result in a lower price when $\mathrm{k}_{\mathrm{i}} \in\left[\mathrm{k}_{\mathrm{i}}^{\min }, \mathrm{k}_{\mathrm{i}}^{\max }\right]$. The resulting price $\left(\mathrm{p}_{\mathrm{i}}\right)$ can then be determined by setting the two demand functions respectively to dealer i's chosen preorder $\left(\mathrm{k}_{\mathrm{i}}\right)$ and to his conjecture about the preorder of dealer j . This situation confronting dealer $i$ can be depicted graphically as follows in Figure 5:

## <Insert Figure 5 here>

If the marginal cost curve has a shallow slope ( $\mathrm{MC}^{\prime}$ ), then dealer i's optimal preorder is $\mathrm{k}_{\mathrm{i}}^{\min }$. On the other hand, if the marginal cost curve has a steeper slope (MC), his optimal preorder is $\mathrm{k}_{\mathrm{i}}\left(<\mathrm{k}_{\mathrm{i}}^{\text {max }}\right)$ and occurs where the marginal revenue curve intersects the marginal cost curve. In other words, his optimal preorder quantities increase as the marginal cost curve becomes steeper (because the discount (d) gets larger). For any $d>0$, there exists a unique pair of preorders in the first stage, each of which is optimal given the other. To see this, suppose $d$ induces each dealer to preorder an amount much larger than his minimal preorder. If the manufacturer had offered a smaller discount (d), each dealer would reduce his preorder and charge a higher price in the stage 2. Eventually d can be reduced to the point where each dealer is preordering its minimal amount (respectively, $\mathrm{k}_{\mathrm{i}}^{\text {min }}$ and $\mathrm{k}_{2}^{\text {min }}$ ). The marginal cost curve $\mathrm{MC}^{\prime}$ corresponds to this d . If the manufacturer reduced the discount any further, its dealers would each recognize that preordering even less would leave prices in the last stage unchanged and they would continue to preorder their minimum amount.

It turns out that both the Bertrand and Cournot prices play critical roles as benchmarks in the characterization of the subgame-perfect equilibrium of this three-stage game. The Bertrand price pair, denoted as $\left(p_{1}^{B}(w), p_{2}^{B}(w)\right)$, is obtained by solving $r_{1}^{B}\left(p_{2} ; w\right)$ and $r_{2}^{B}\left(p_{1} ; w\right)$ and shown as point B in Figure 6. The Cournot price for dealer $i$ is the price that corresponds to the quantity that solves the maximization problem for the dealer given rival j's quantity. Assuming the rival's quantity to be
fixed at $k_{j}$, the corresponding Cournot price response function for dealer $i, r_{i}^{C}\left(k_{j} ; w-2 d k_{i}\right)$, is given by the solution to the following constrained maximization problem:
(5) $\quad \max _{\mathrm{p} .} \mathrm{i}_{\mathrm{i}}=\left(\mathrm{p}_{\mathrm{i}}-\left(\mathrm{w}-\mathrm{d}\left(\mathrm{a}-\mathrm{p}_{\mathrm{i}}+\mathrm{b} \mathrm{p}_{\mathrm{j}}\right)\right)\right)\left(\mathrm{a}-\mathrm{p}_{\mathrm{i}}+\mathrm{b} \mathrm{p}_{\mathrm{j}}\right)$, subject to, $\mathrm{k}_{\mathrm{j}}=\mathrm{a}-\mathrm{p}_{\mathrm{j}}+\mathrm{b} \mathrm{p}_{\mathrm{i}}$.

The intersection of $\mathrm{r}_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{k}_{\mathrm{j}} ; \mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{i}}\right)$ and $\mathrm{r}_{\mathrm{j}}^{\mathrm{C}}\left(\mathrm{k}_{\mathrm{i}} ; \mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{j}}\right)$ provides the Cournot price pair denoted by $\left(\mathrm{p}_{1}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{i}}\right), \mathrm{p}_{2}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{i}}\right)\right)$ for a given discount d and shown as point C in Figure 6. Appendix A provides the closed-form solutions of these outcomes.
<Insert Figure 6 here>
Having defined the benchmark Bertrand and the Cournot prices, we now graphically characterize how the depth of quantity discount $d$ affects the equilibrium prices. For $d$ above some threshold, as argued earlier, if the dealer preorders more than $\mathrm{k}_{\mathrm{i}}^{\text {max }}$, some part of his preorders would remain unsold with prices being unaffected. Essentially, the equilibrium will remain at point A in Figure 6, which itself is a Cournot price pair and where $k_{i}=k_{i}^{\max }$. As d decreases from this threshold, the equilibrium price pair moves away from A along the diagonal line AB since the average net wholesale price to the dealer increases and hence, the amount of preorder decreases. C is such a point. In Figure 6, decreasing d implies $s^{1}$ shifts downwards and $s^{2}$ upwards. As d further decreases, the equilibrium point C moves towards B along the diagonal line until it reaches B . This is where the price outcomes shift from Cournot to Bertrand. We call the largest $d$ that induces the price pair at B the critical discount and denote it as $\delta$. $\delta$ is implicitly defined in $\mathrm{p}_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{w}-2 \delta \mathrm{k}_{\mathrm{i}}\right)=\mathrm{p}_{\mathrm{i}}^{\mathrm{B}}(\mathrm{w})$ and the uniquely feasible critical discount is given by $\delta=\frac{\mathrm{b}^{2}}{2\left(1-\mathrm{b}^{2}\right)}$ (see Appendix A for proof). At $\mathrm{d}=0$, preorders in the first stage are indeterminate but the sales quantities and prices in the second stage are determinate. The following lemma formally states this result. A proof is included in Appendix B.

Lemma 2: The optimal price, quantity, and profit for the dealers depends on the quantity discount chosen by the manufacturer. Specifically,
$i$ : If $0<d \leq \delta=\frac{\mathrm{b}^{2}}{2\left(1-\mathrm{b}^{2}\right)}$, then:
Prices: $\mathrm{p}_{1}^{\mathrm{B}}(\mathrm{w})=\mathrm{p}_{2}^{\mathrm{B}}(\mathrm{w})=\frac{\mathrm{a}+\mathrm{w}}{2-\mathrm{b}} ;$ Quantities: $\mathrm{k}_{1}^{\mathrm{B}}=\mathrm{k}_{2}^{\mathrm{B}}=\mathrm{q}_{1}^{\mathrm{B}}(\mathrm{w})=\mathrm{q}_{2}^{\mathrm{B}}(\mathrm{w})=\frac{\mathrm{a}(1-\mathrm{b}) \mathrm{w}}{2-\mathrm{b}}$
Profits: $\pi_{\mathrm{i}}^{\mathrm{B}}\left(\mathrm{w}-2 \mathrm{~d}_{\mathrm{i}}\right)=\frac{(1-\mathrm{d})(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})^{2}}{(2-\mathrm{b}+2 \mathrm{~d}-2 \mathrm{~b} \mathrm{~d})^{2}}, \mathrm{i}=1,2$.
ii: If $d>\delta=\frac{\mathrm{b}^{2}}{2\left(1-\mathrm{b}^{2}\right)}$, then:
Prices: $\mathrm{p}_{1}^{\mathrm{c}}\left(\mathrm{w}-2 \mathrm{~d}_{1}\right)=\mathrm{p}_{2}^{\mathrm{c}}\left(\mathrm{w}-2 \mathrm{~d}_{2}\right)=\frac{\mathrm{a}\left(1-2\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)+\left(1-\mathrm{b}^{2}\right) \mathrm{w}}{(1-\mathrm{b})\left(2+\mathrm{b}-2\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)}$
Quantities: $\left.\mathrm{k}_{1}^{\mathrm{C}}=\mathrm{k}_{2}^{\mathrm{C}}=\mathrm{q}_{1}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d}_{1}\right)=\mathrm{q}_{2}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d}_{2}\right)\right)=\frac{(1+\mathrm{b})(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})}{\left(2+\mathrm{b}-2\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)}$
Profits: $\pi_{1}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{1}\right)=\pi_{2}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d}_{2}\right)=\frac{(1+\mathrm{b})\left(1-\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})^{2}}{(1-\mathrm{b})\left(2+\mathrm{b}-2 \mathrm{~d}\left(1-\mathrm{b}^{2}\right)\right)^{2}}$.
iii: $\quad$ If $d=0$, then:
Prices: $\mathrm{p}_{1}^{\mathrm{B}}(\mathrm{w})=\mathrm{p}_{2}^{\mathrm{B}}(\mathrm{w})=\frac{\mathrm{a}+\mathrm{w}}{2-\mathrm{b}}$; Quantities: $\mathrm{k}_{1}^{\mathrm{B}}=\mathrm{k}_{2}^{\mathrm{B}}=\mathrm{q}_{1}^{\mathrm{B}}(\mathrm{w})=\mathrm{q}_{2}^{\mathrm{B}}(\mathrm{w})=\frac{\mathrm{a}(1-\mathrm{b}) \mathrm{w}}{2-\mathrm{b}}$
Profits: $\pi_{1}^{\mathrm{B}}(\mathrm{w})=\pi_{2}^{\mathrm{B}}(\mathrm{w})=\frac{(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})^{2}}{(2-\mathrm{b})^{2}}$.
The intuition for the results is as follows. In this game, the size of the preorders fundamentally determines the mode of competition. If the preorders are small, each dealer will realize that the rival will place additional orders in stage 2 . In this circumstance, the threat to sell only the preordered quantity is not credible. Consequently, the equilibrium price and quantity of the two-stage game would be the same whether or not dealers could observe the quantity preordered by the rival in stage 1 . Hence, the price-quantity pair arising in the equilibrium of the two-stage game
must coincide with that of a one-stage game where prices are chosen simultaneously by dealers with marginal cost w . We refer to this as the "Bertrand regime".

In contrast, if the preorders are large, each dealer realizes that the rival has no incentive to supplement his preorder. Here, the threat to sell no more than the preordered quantity is credible and the price-quantity pair arising in the equilibrium of the two-stage game must coincide with that of a one-stage game where preordered quantities are chosen simultaneously by dealers with decreasing marginal costs $\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{i}}\right)$. We refer to this as the "Cournot regime". ${ }^{\text {vi }}$ The size of the preorders depends on the magnitude of the manufacturer's discount. If it is very small, the amount preordered is sufficiently small so that Bertrand competition ensues (point B); if it is sufficiently large, the amount preordered is sufficiently large and Cournot competition ensues (e.g., points A and C). In sum, the manufacturer can choose $d$ to influence the downstream outcomes.

## Stage 0: Manufacturer's Choice of Discount

The manufacturer's problem in stage 0 is to choose an optimal quantity discount such that its profit is maximized:

$$
\max _{\mathrm{d} \geq 0} \pi_{\mathrm{m}}=\left(\mathrm{w}-\mathrm{m}-\mathrm{dk}_{1}\right) \mathrm{k}_{1}+\left(\mathrm{w}-\mathrm{m}-\mathrm{dk}_{2}\right) \mathrm{k}_{2},
$$

where $m$ is the manufacturer's marginal cost of production. We can show that the discount that maximizes the manufacturer's profit, namely the optimal discount $\mathrm{d}^{*}$, is either zero or strictly larger than the critical discount, $\delta$. For $0 \leq \mathrm{d}<\delta$, the highest profit for the manufacturer is always at $d=0$ (which generates Bertrand profit for the manufacturer). This is because as noted earlier, for any discount below the critical discount $\delta$, each dealer's preorders are not credible and each dealer chooses prices for the undiscounted wholesale price w. As such, in the range $0 \leq \mathrm{d}<\delta$, the manufacturer profits are largest at $\mathrm{d}=0$. We denote the corresponding quantity discount and manufacturer's profit as $d_{B}^{*}$ and $\pi_{\mathrm{m}}^{\mathrm{B}}$ respectively. For $\mathrm{d}>\delta$, the equilibrium outcomes are Cournot
and we denote the Cournot optimal discount and profit for the manufacturer as $\mathrm{d}_{\mathrm{C}}^{*}$ and $\pi_{\mathrm{m}}^{\mathrm{C}}$. The manufacturer compares its Bertrand profit $\pi_{\mathrm{m}}^{\mathrm{B}}$ and the Cournot profit $\pi_{\mathrm{m}}^{\mathrm{C}}$ and chooses the discount, i.e. either at zero or at $\mathrm{d}_{\mathrm{C}}^{*}$, that gives it a higher profit. The corresponding discount is the optimal discount, $d^{*}$. Table 1 summarizes the algebraic expressions of these solutions. Therefore, in the two-stage ordering process, we have established the following lemma:

Lemma 3: In the two-stage ordering process, (1) if the manufacturer chooses $d^{*}=0$, then downstream competition is in the Bertrand regime and the manufacturer's profit is given by $\pi_{\mathrm{m}}^{\mathrm{B}}=\frac{2(\mathrm{w}-\mathrm{m})(\mathrm{a}-\mathrm{w}(1-\mathrm{b}))}{2-\mathrm{b}}$; (2) if the manufacturer chooses $d^{*}=\mathrm{d}_{\mathrm{C}}^{*}$ in stage 0 such that $\mathrm{d}_{\mathrm{C}}^{*}>\delta$, then downstream competition is in the Cournot regime and the manufacturer's profit is given by $\pi_{\mathrm{m}}^{\mathrm{c}}=\frac{(1+\mathrm{b})(\mathrm{a}-\mathrm{m}(1-\mathrm{b}))^{2}}{4\left(2-\mathrm{b}-\mathrm{b}^{2}\right)}$.

## Linking Computec and the Two-Stage Ordering Game

As we can see from Figures 1 and 2, Computec's channel arrangement essentially mirrors the two-stage ordering game. This close resemblance between theory and institution should enable us to test for consistency between some observable implications from the theory model and corresponding facts from Computec's channel. Indeed, we observe a match on two critical aspects that enable us to deduce the type of downstream competition between the dealers.

Specifically, Lemma 3 suggests that under the 2-stage game, the manufacturer should either offer zero or positive discounts, and if they offer positive discounts the downstream competition would be Cournot. Lemma 1, in turn, suggests that if discounts are positive neither dealer will order additional units in stage 2 ; in essence they would set prices to clear the preorders. The data obtained from Computec (details in next section) shows support for both propositions. First, Computec always offers positive discounts to its dealers using the 2 -stage ordering process. Second,
throughout our longitudinal data, none of the 60 dealers supplemented their order in stage 2 at the undiscounted wholesale list price, indicating that their preorders were in fact credible and binding. Based on this match between theory and observation we infer that the downstream competition between dealers is most likely in the Cournot regime.

Why does this inference matter? We use this inference on the outcomes of game being played by the dealers (Cournot regime) to a priori setup our econometric specification that estimates the unobserved retail prices, the price-cost markups and economic profits earned by the dealers. Our approach contrasts with, and complements, extant NEIO-based work on this topic. Specifically, existing studies estimate a "conduct parameter" from data and use it to infer ex post the type of competition and/or vertical game being played. As Reiss and Wolak (2005, pp.49-52) argue in their influential critique, even when positive markups are identified using this approach, in most cases they cannot be tied back to a specific rent-generating arrangement or market structure. In contrast, rather than estimate the conduct parameter from data, we use our knowledge obtained from the institutional structure and theory to set the conduct parameter a priori and then estimate the markups. This approach enables us to tie the estimated markups to the specific vertical arrangement set by the manufacturer. We turn to this task below.

## METHOD: ESTIMATING THE ECONOMIC PROFIT

## Empirical Context

The empirical analysis is conducted using data obtained from one firm - Computec -a leading Chinese manufacturer of a key computer accessory sold in China. Computec sells its products through a network of 60 independent dealers grouped into 8 geographic sales regions. Computec has assigned a regional manager for each region who is responsible for the achieving sales quotas and coordinating marketing activities with the dealers in their region. Each dealer sells multiple brands within this product-line. Dealers operate in regional territories without any
territorial restrictions or RPM clauses imposed by any of the competing manufacturers. Dealers compete in price but also provide some value-added services like pre-sale education to consumers and trade credit to second-tier retailers.

The distinctive 2-stage ordering process used by Computec and its major competitors is already detailed in the introduction. The manufacturers, with the intent of preventing the dealer's from stockpiling, change their discount schedules from cycle to cycle. Company executives and industry experts assert that this is quite effective because dealers do not seem to engage in such behavior. In essence, the interaction between the manufacturer and dealers is a static game repeated each quarterly cycle with a different discount schedule.

## Data

The proprietary data were collected onsite at Computec's headquarters in China It covers a period of 12 months from December 2004 to November 2005 and comprises of 4 quarterly sales cycles. The archival data contained details about the quarterly quantity discount schedules and wholesale prices offered by Computec, the monthly quantities delivered to dealers, and monthly marketing expenses of Computec. The monthly data allow us to exploit the variations arising out of seasonality. Computec's marketing expenses consisted of spending on advertising, public relations, and other promotional activities. This data was organized at the national, regional, and individual dealer levels. We could not get data on marketing expenditure of the dealers; however company officials believed such amounts were minimal. We provide a description of these measures below. Table 2 provides the descriptive statistics and correlations. Note that for confidentiality purposes, all prices, costs/expenses, and quantities have been re-scaled. A fictitious monetary unit, $\mathrm{Y} \$$, is created as a result of this rescaling.

- Quantity: Monthly quantity delivered by Computec to each of its 60 dealers.
- Net wholesale price: Individual dealer's cost of goods (in Y\$), net of the quantity discounts, for each quarterly sales cycle.
- Wholesale market prices of competing manufacturers: We do not have direct access to this data; hence we used the monthly selling prices (in Y\$) in the Beijing wholesale market for products of Computec's top 3 competitors. Beijing is the largest wholesale market of computer related products in China and has the lowest wholesale market prices in the nation. We have a total of 12 dealer-invariant observations for each competing brand.
- National advertising expenses: Computec's monthly advertising expenses (in million Y\$) in the national media. We have a total of 12 dealer-invariant data points.
- National Public relations (PR) expenses: Computec's monthly expenses on public relation activities such as press conference, exhibitions, and media relations (in million $\mathrm{Y} \$$ ). We have a total of 12 dealer-invariant data points.
- Regional marketing expenses: Computec's expenses (in million Y\$) in outdoor displays, dealer conferences, display materials for retail outlets, and other promotional activities in each of the 8 specific regions. This data is obtained at a monthly level.
- Dealer-level marketing expenses: Computec's expenses (in million Y\$) in promotional activities such as outdoor displays, dealer conferences, display materials for retail outlets, and other promotional activities at a particular dealer. We have monthly observations for each of the 60 dealers.
<Insert Table 2 about here>


## Estimation Technique

To calculate the economic rent/profits earned by Computec's dealers, we need information on retail prices, costs, and quantities. When company data are available, these profits can be calculated directly (e.g., Kaufmann and Lafontaine 1994). Often times, however, data on one of
these components (e.g., dealer's costs) is not available. A structural estimation approach (e.g., Kadiyali 1996; Sudhir 2001) is then used to impute these unobservable costs and final margins. We however have a situation where the dealer's costs are observable to the manufacturer but the retail prices (defined as the price Computec's dealers charge consumers and other second-tier re-sellers) are not. This problem is quite common in a variety of contexts and could be a result of lack of appropriate tracking techniques and/or strategic unwillingness on the part of the dealer to reveal retail prices. Our estimation problem is hence quite different from that observed in most NEIO research on price-cost markups.

We develop a technique that uses longitudinal data to recover these unobserved final prices. Specifically, we first estimate the demand function using a fixed effect model in which the observed net wholesale prices act as a "proxy" for the final prices. At the same time, based on the insights from our formal model and institutional details, we specify a priori the supply-side dealer competition to be Cournot. We then use the estimated slope of the demand function and this specified supply relation to calculate the final prices.

We start with a linear demand specification that is frequently used in estimating structural models (e.g., Dube and Manchanda 2005; Kadiyali 1996). Specifically, the linear demand function for the product sold by dealer $i$ at time $t$ is taken to be:

$$
\begin{equation*}
\mathrm{q}_{\mathrm{it}}=\alpha_{0}+\alpha_{1} \mathrm{p}_{\mathrm{it}}+\alpha_{2} \mathrm{p}_{-\mathrm{it}}+\sum_{\mathrm{r}=1}^{3} \alpha_{\mathrm{r}+2} \mathrm{p}_{\mathrm{it}}^{\mathrm{r}}+\alpha_{6} \mathrm{X}_{\mathrm{it}}+\sum_{\mathrm{m}=1}^{3} \alpha_{\mathrm{m}+6} \mathrm{X}_{\mathrm{t}}^{\mathrm{m}}+\alpha_{10} \mathrm{X}_{\mathrm{i}}+\varepsilon_{\mathrm{it}}, \mathrm{i} \neq \mathrm{j}, \tag{6}
\end{equation*}
$$

where $\mathrm{q}_{\mathrm{it}}$ is quantity demanded, $\mathrm{p}_{\mathrm{it}}$ is own retail price, $\mathrm{p}_{-\mathrm{it}}$ is the average retail price of i's rival dealers located in the same region, $\mathrm{p}_{\mathrm{it}}^{\mathrm{r}}$ is a vector of retail prices for the three competing brands sold by dealer $i, X_{i t}$ is Computec's marketing expenses on dealer $i, X_{t}^{m}$ is a vector of Computec's national-level advertising and public relations expenses and regional-level marketing expenses, $X_{i}$ is a vector of dealer time invariant characteristics such as the number of retail outlets and dealership
tenure, $\alpha$ 's are demand parameters to be estimated, and $\varepsilon_{\mathrm{it}}$ is the error term ${ }^{\text {vii. }}$. The coefficients of $\mathrm{p}_{\mathrm{it}}$ and the $\mathrm{p}_{\text {-it }}$ represent own-price effect and peer- (or intra-brand price-) effect respectively on quantity demand for each dealer. We define peer-effect as: $p_{-i t}=\frac{1}{N_{g}-1} \sum_{-i=1}^{N-1} p_{-i t}$, where $N_{g}$ is the number of dealers located in region $g$ (Bresnahan 1987, p.1046; Wooldridge 2002, p.331).

Since $p_{i t}, p_{-i t}$ and the $p_{i t}^{r}$ 's are unobserved, we cannot directly estimate (6). To solve this problem, we take advantage of the longitudinal nature of our data and use a fixed-effect model along with the following two assumptions on individual dealers' mark-ups. First, we assume that for competing manufacturers' products, each dealer adds a dealer-specific markup, $\theta_{\mathrm{i}}$, to the observed wholesale market prices, $p_{t}^{r}$, to arrive at his final retail price, i.e. $p_{i t}^{r}=p_{t}^{r}+\theta_{i}^{r}$. Second, we write the unobserved own price as a function of wholesale price and its associated dealer-specific markup, $\delta_{\mathrm{i}}$, i.e. $\mathrm{p}_{\mathrm{it}}=\omega_{\mathrm{it}}+\delta_{\mathrm{i}}$, where $\omega_{\mathrm{it}}$ is the net wholesale price (after accounting for the discounts). This additive, rather than multiplicative, specification of dealer markups has been used previously (e.g., Kadiyali et al 2000) and more crucially for us, fits the pricing rules used by dealers. Indeed, our field interviews revealed that the dealers markup their costs by a fixed amount, and not by a percentage. Using the additive pricing rule on own price, we can then express peer-effect as

$$
\mathrm{p}_{-\mathrm{it}}=\frac{1}{\mathrm{~N}_{\mathrm{g}}-1} \sum_{-i=1}^{\mathrm{N}-1} \mathrm{p}_{-\mathrm{it}}=\frac{1}{\mathrm{~N}_{\mathrm{g}}-1} \sum_{-\mathrm{i}=1}^{\mathrm{N}-1}\left(\omega_{-i t}+\delta_{-i}\right)=\bar{\omega}_{-i t}+\bar{\delta}_{-\mathrm{i}} .
$$

Our markups, which can be viewed as a measure of a dealer's pricing power, are also time invariant. This, we believe, is a reasonable assumption because our field interviews revealed that the number of dealerships used by the leading manufacturers is fairly stable. We do not restrict the relative magnitude $\operatorname{of} \theta_{\mathrm{i}}^{\mathrm{r}}$ 's and $\delta_{\mathrm{i}}$; this allows the dealers to add different markups for different brands. Substituting the three expressions of final prices into (6), mean-differencing the transformed
equation to remove the markup terms and other time-invariant variables, and adding a sales cycle intercept, $\tau$, to capture any time-trend effects gives:

$$
\begin{aligned}
\mathrm{q}_{\mathrm{it}}-\overline{\mathrm{q}}_{\mathrm{i}}= & \tau+\alpha_{1}\left(\omega_{\mathrm{it}}-\bar{\omega}_{\mathrm{i}}\right)+\alpha_{2}\left(\bar{\omega}_{-\mathrm{it}}-\overline{\bar{\omega}}_{-\mathrm{i}}\right)+\sum_{\mathrm{r}=1}^{3} \alpha_{\mathrm{r}+2}\left(\mathrm{p}_{\mathrm{t}}^{\mathrm{r}}-\overline{\mathrm{p}}^{\mathrm{r}}\right)+\alpha_{6}\left(\mathrm{X}_{\mathrm{it}}-\overline{\mathrm{X}}_{\mathrm{i}}\right)+\sum_{\mathrm{m}=1}^{3} \alpha_{\mathrm{m}+6}\left(\mathrm{X}_{\mathrm{t}}^{\mathrm{m}}-\overline{\mathrm{X}}_{\mathrm{i}}^{\mathrm{m}}\right) \\
& +\left(\varepsilon_{\mathrm{it}}-\bar{\varepsilon}_{\mathrm{i}}\right) .
\end{aligned}
$$

Notice that this specification removes any potential omitted variable bias caused by unobserved markups which are correlated with prices and marketing activities (e.g., Lal and Narasimhan 1996). Renaming the transformed variables, we then estimate:

$$
\begin{equation*}
\ddot{\mathrm{q}}_{\mathrm{it}}=\tau+\alpha_{1} \ddot{\omega}_{\mathrm{it}}+\alpha_{2} \ddot{\bar{\omega}}_{-\mathrm{it}}+\sum_{\mathrm{r}=1}^{3} \alpha_{\mathrm{r}+2} \ddot{\mathrm{p}}_{\mathrm{t}}^{\mathrm{r}}+\alpha_{6} \ddot{\mathrm{X}}_{\mathrm{it}}+\sum_{\mathrm{m}=1}^{3} \alpha_{\mathrm{m}+6} \ddot{\mathrm{X}}_{\mathrm{t}}^{\mathrm{m}}+\ddot{\varepsilon}_{\mathrm{it}} \tag{7}
\end{equation*}
$$

Note that the mean-centered wholesale prices, $\ddot{\omega}_{\mathrm{it}}$, are uncorrelated with the demand errors, $\ddot{\varepsilon}_{\text {it }}$ (Berry 1994). This is supported by the results of tests for endogeneity. We also tried semi-log and $\log$-log demand specifications and found similar fit to data relative to the linear specification in (7). To take into account regional differences, we incorporate an interaction of $\ddot{\omega}_{\mathrm{it}}$ with the regional dummies to obtain estimates of region-specific dealer-level slopes of demand, namely $\hat{\alpha}_{1 g}$. Regionspecific estimates of peer-effect and Computec's marketing expenses on a specific dealer are obtained similarly. Nevertheless, we do not use regional dummies to interact with cross-brand prices and regional- and national-level marketing expenses because of their limited numbers of observations (see Table 2). This is because Computec does not have any regional expenses in most of the months, which makes the "effective" number of observations quite small. The estimated region-specific slopes of the demand function, $\hat{\alpha}_{1 g}$ 's, are used in the supply side formulation to compute the unobserved final prices.

First-order condition of dealer's profit maximization yields the following price-cost markup relation:

$$
\begin{equation*}
p_{i t}=\operatorname{MC}\left(q_{i t}\right)-\lambda_{i t} \frac{\partial p_{i t}}{\partial q\left(p_{i t}, p_{-i t}, p_{i t}^{r}\right)} q_{i t}\left(p_{i t}, p_{-i t}, p_{i t}^{r}\right), \tag{8}
\end{equation*}
$$

where $\mathrm{MC}(\cdot)$ is the marginal cost function, $\mathrm{q}(\cdot)$ is the dealer's demand function which takes both intra- and inter-brand competition into account, and $\lambda_{\mathrm{it}}$ is the conduct parameter for intra-brand competition. The partial derivative with respect to own quantity on the right hand side of (8) is the inverse of the slope of the individual dealer's demand curve. However, because of our short-panel, we can only estimate the region-specific slope for demand and not the dealer-specific slope for demand for a representative dealer in that region. We account for such limitation in calculating individual dealers' final prices by assuming a dealer's markup equals to the markup of the representative dealer located in the same region (e.g. Reiss and Wolak 2006).

The close match between our theory and institutional context suggests that the downstream dealer competition is most likely to be Cournot. We use this inference to set $\lambda_{\mathrm{it}}=1$ for all i's and t's (Bresnahan 1989). Now assuming that the discounted wholesale price, $\omega_{\mathrm{it}}$, is the only marginal cost, and approximating an individual dealer's markup with the average markup corresponding to his located region, we can calculate the final price, $\hat{\mathrm{p}}_{\mathrm{it}}$, for all dealer i 's in region g , as:

$$
\begin{equation*}
\hat{\mathrm{p}}_{\mathrm{it}}=\omega_{\mathrm{it}}-\frac{1}{\mathrm{~N}_{\mathrm{g}} \cdot \hat{\alpha}_{1 \mathrm{~g}}} \mathrm{Q}_{\mathrm{gt}}, \tag{9}
\end{equation*}
$$

where $\hat{\alpha}_{1 \mathrm{~g}}$ is the slope of the demand function in region $\mathrm{g}, \mathrm{N}_{\mathrm{g}}$ the number of dealers in region g , and $\mathrm{Q}_{\mathrm{gt}}$ is the aggregate regional quantity in month t . This formulation of final prices results in a pattern of regional-level price dispersion that is equivalent (to be precise, affine-transformed) to that of dealers' net wholesale prices. This clearly requires an assumption about the nature of intra-brand competition in that region, i.e. large dealers sell at lower prices than smaller ones because the former has lower average wholesale prices than the latter. This is reasonable because the two types
of dealers for Computec focus on different customer segments: second-tier re-sellers for the large dealers versus retail for the small dealers.

On the other hand, note that our measure of marginal cost in (9) follows a more precise definition per economic theory and excludes costs that do not vary with each additional unit sale (e.g., Pindyck and Rubinfeld 2001). As such, we assume that employees' wages are short-run fixed costs and thus, the marginal selling cost is negligible. Our field interviews revealed that almost all the sales people hired by dealers are paid either pure salary or a combination of fixed salary and semi-annual or annual bonus based on company-wide profitability; hence, a sales person's incentives are not set at the unit margin. Moreover, dealers usually do not offer overtime pay even if their sales people work overtime occasionally; instead such overtime work effort by sales people is taken into account for the bonus considerations.

Finally, we calculate the gross and net economic profit earned by dealer i over the 12 months of data as $\Pi_{\mathrm{i}}=\sum_{\mathrm{t}=1}^{12}\left(\hat{\mathrm{p}}_{\mathrm{it}}-\omega_{\mathrm{it}}\right) \cdot \mathrm{q}_{\mathrm{it}}$ and $\Pi_{\mathrm{i}}=\sum_{\mathrm{t}=1}^{12}\left(\hat{\mathrm{p}}_{\mathrm{it}}-\omega_{\mathrm{it}}\right) \cdot \mathrm{q}_{\mathrm{it}}-\mathrm{F}_{\mathrm{i}}$ respectively, where $\mathrm{F}_{\mathrm{i}}$ includes employee salary/wages, the entrepreneur's opportunity cost of time (proxied by their second-best job), and the office/outlet rental charges. The first two items are considered as shortrun fixed costs and as discussed above, are not part of the marginal cost. We calculate these 3 costs as follows. We used the China Provincial Statistical Yearbooks (2004, 2005) ${ }^{\text {viii }}$ to obtain information on the wages earned by computer engineers. Computer engineers were among the highest paid jobs across all occupations that were surveyed by the Yearbooks and we assume that the opportunity cost of the entrepreneur's time equals a computer engineer's wage in that corresponding city. The same Statistical Yearbooks also provide information on wages earned by wholesale/retail workers. Since the employees of Computec's dealers engage in wholesale and/or retail business in the computer industry, we assume that their compensation is equal to the mean
wage of the computer engineers and wholesale/retail workers. The total employee wage expense of a dealer is then calculated by multiplying this wage by the number of sales people and technical support staff he hires. Estimates of the dealers' rental fees were provided by the regional managers. The sum of the entrepreneur's opportunity cost, employee wages, and rental fees is finally weighted by the share of dealer's total business that is Computec's sales to obtain the dealer's fixed costs incurred for selling Computec's product. These costs however exclude tax- and interest expenses; hence the estimate of economic profits should be considered as pre-tax and pre-interest profit.

## Empirical Results

Table 3 provides the pooled regional demand estimates. The own-price coefficients are significant and directionally consistent in all the 8 regions. Also note that dealers in Beijing, the East, and the South - the three most developed regions in the country - have significantly larger coefficient estimates on price, i.e. higher own price sensitivity, than those of the five less developed regions suggesting that competition is more intense in these 3 regions. The competitive intensity in these 3 regions is also evident from the large significant and positive estimates of peer-effects. We also find that demand for Computec's product is significantly impacted by the price for competing brands \# 2 and \#3. We also find that as per expectations, national-level advertising, national-level public relations campaigns and regional-level marketing expenses are quite effective in generating demand. Finally, the marketing resources Computec spends on individual dealers also seem to be effective in 4 of the 8 regions.
<Insert Table 3 about here>
The estimated demand from Table 3 and equation (9) are used to compute the average final retail price for each region. Table 4 provides the estimates. According to Computec executives, our estimates are generally consistent with their expectation which is based on anecdotal evidence on the average purchased prices obtained from the second-tier retail shops. The average prices are the
lowest in the 3 most developed regions - Beijing, East, and South - which is per expectation because both intra-brand and inter-brand competition is stiffer in these regions. Using the recovered final prices and observed quantities, we find that an average dealer in Beijing, the East, the South, or the North have higher demand elasticities (with the highest being in Beijing: $\sim 12$ ) while a representative dealer in the Central or the Northwest has the lowest $(\sim 7)$.
<Insert Table 4 about here>
Based on our estimates of the final prices and individual quantities at each dealer, we calculate the gross and net economic profit earned by each dealer in the fiscal year 2004-2005. Table 5 presents these results by region. Our results show that the average gross and net economic profit earned by a typical dealer from selling Computec's product are $\mathrm{Y} \$ 6.54$ million and $\mathrm{Y} \$ 4.48$ million respectively. The net economic profit of $Y \$ 4.48$ million, approximately $\$ 30,000$, over a one-year period, shows that the two-stage ordering mechanism is quite effective in generating downstream profits. As Computec does not use any fixed-fee transfer mechanism to extract any part of these profits from the dealers, the dealer's ex post rent equals his ex ante rent ${ }^{\mathrm{ix}}$. The existence of this residual profit stream is also circumstantially supported by the observation that there is always a "queue" of potential dealers hoping to land a dealership from Computec (e.g., Mathewson and Winter 1985, Kaufmann and Lafontaine 1994).
<Insert Table 5 about here>

## An Assessment of the Effectiveness of the Two-Stage Ordering Mechanism

Computec's two-stage ordering process seems to be designed to generate economic incentives for its independent dealers and anecdotal evidence from both internal and external sources provides support to the effectiveness of this arrangement. Our in-depth field interviews with company officials revealed that before the deployment of the current two-stage ordering process, dealer markups were much lower than our estimates. Unfortunately, we could not compile
data that would enable us this pre- and post-arrangement comparison. Hence, we compared the profitability of Computec's dealers to that of other information-technology (IT) distributors in China. Specifically, we use the profitability of the two largest IT distributors in China - Digital China and $\mathrm{PCI}-$ as benchmarks. According to their company reports, their operating margins, i.e. profit margins before interest and taxes are $1.89 \%$ (fiscal year 2005-6) and $1.35 \%$ (first 3 quarters of 2006) for Digital China and PCI respectively ${ }^{\mathrm{x}}$. These numbers are significantly lower than the net profit margin of $6.52 \%$ for an average Computec dealer that can be obtained from Tables 1,4 , and 5 .

## DISCUSSION

Manufacturers often devise contractual mechanisms that enable dealers to earn economic profit. In this paper we first develop a formal model to show how manufacturers can use a twostage ordering process with quantity discounts enables her to control the intensity of downstream competition between, and profits earned by, its dealers. We then match the decision structure and results of the model with actual contractual arrangements and novel data obtained from a Chinese manufacturer of a computer accessory marketed in China to setup a structural model that estimates the unobserved final prices and hence the economic profit earned by the dealers over a one-year period. We find that the manufacturer indeed leaves significant "money on the table" across a heterogeneous group of dealers. Our paper makes important contributions to research and managerial practice. Consider each in turn below.

## Implications for Research

Our paper makes four important contributions to research in the study of vertical channel management. First, we show how crucial an understanding of institutional context is to both theory building and interpretation of data. In particular, without knowing the institutional details of the 2 stage ordering process, a casual observer of Computec's dealers would reasonably conclude that these dealers engage in Bertrand-Nash price competition. By developing a theory model that
explicitly embeds this institutional detail, we show that the downstream dealer behavior is fundamentally altered. Specifically, a positive discount offered under the 2 -stage ordering process could result in a downstream competition where dealers choose quantities in stage 1 to maximize profits and then choose prices in stage 2 to clear these quantities; in effect resulting in a Cournot rather than a Bertrand outcome even though the downstream dealers seem to compete in price. As such, the appropriate choice variable in formulating the supply relation in this setting is quantity rather than price. Without taking account of these institutional details, a researcher might incorrectly surmise the downstream competition to be Bertrand and reach wrong conclusions.

Second, our approach enables us link the dealer markups/profits to a specific vertical arrangement designed by the manufacturer. Specifically, we use the consistency between theory and factual observations at Computec to infer and set a priori the conduct parameter in our structural estimation of the unobserved retail prices. This contrasts with existing empirical studies that focus on using the estimated conduct parameter to infer the type of vertical game being played ex post. As Reiss and Wolak (2005) argue, interpreting most of these estimated conduct parameters to mean a certain form of vertical game or market structure is problematic. The advantage of our approach is the ability to unequivocally link these two. To the best of our knowledge, this is the first study to model analytically a specific channel arrangement and to link this arrangement to assembled field data for systematic empirical analyses on downstream markups.

Third, we extend the literature on capacity-constrained pricing games (e.g., Kreps and Scheinkman 1983; Maggi 1996) to show that via a high enough quantity discount offered by the profit-maximizing manufacturer in the two-stage game that dealers choose their quantity orders first and then set prices, Cournot outcomes ensue. We show that under a 2 -stage ordering process, if the manufacturer offers no (positive) quantity discount the downstream competition would be equivalent to that of a one-shot Bertrand (Cournot) game where dealers choose prices (quantities) to
maximize profits. Given the popularity of quantity discounts in channel settings, our results suggest that Cournot competition might be more common in channel settings than is commonly recognized.

Finally, we develop a procedure to recover the unobserved retail prices using longitudinal data. We start with estimating the demand function using a fixed effect model in which the observed net wholesale prices act as a "proxy" for the final prices. We then use theory/institutional insights to a priori specify the supply relation (Cournot/Bertrand/Monopoly etc.) in conjunction with the estimated demand slope to calculate the final prices. Our novel procedure should enable researchers to model settings where the downstream prices are not observed.

## Implications for Managerial Practice

One of the major channel management problems besetting manufacturers worldwide is how to reduce the intensity of downstream competition so that dealers can earn "satisfying" levels of profits and continue to support the manufacturer's products. Mechanisms like RPM, territorial restrictions, and fixed fee transfers are not feasible in many circumstances. We show that by combining quantity discounts with a two-stage ordering process the manufacturer can influence the intensity of downstream competition. Thus, we identify an alternative mechanism that not only creates downstream economic profits but is easy to implement, adaptable (e.g., note the cyclical change in discount schedules to prevent stockpiling behavior), and not difficult to monitor. Second, in many contexts (e.g., business-to-business sales), downstream members might be reluctant to reveal their pricing information because of strategic considerations. For instance, revealing one's profit margin is likely to weaken one's bargaining position in vertical relationships. Currently, lacking such cooperation, these manufacturers can only have anecdotal or small sample data on downstream prices. Our novel estimation technique should help manufacturers recover these unobserved downstream prices. Our method requires information on contractual arrangements, wholesale prices, quantities, and number of assigned dealers; such information is likely to be readily
available in company records. Therefore, our model should appeal to those manufacturers who want to adopt a more structural way to alleviate the asymmetric information problem.

## Limitations and Directions for Future Research

Our paper obviously has limitations. On the theory side, our model is limited to the simplest setup involving three players, one manufacturer and two dealers. Permitting inter-brand competition and allowing each manufacturer to have more than two dealers would improve the realism of the model. ${ }^{\text {xi }}$ Another extension would be to permit dealers to carry inventories from one ordering cycle to the next as the year progresses. Most importantly, in future work we plan to compare formally the two-stage ordering process to alternative institutions which the manufacturer chose not to adopt. On the estimation side, our analysis was limited by lack of data on the dealer-level wholesale prices and discount schedules for competing brands. Hence, we cannot study issues like heterogeneity of responses across dealer and brand types that would be of substantive interest to marketing managers. All these limitations point to specific avenues for future research.

Studying the rationale for leaving "money on the table" for downstream channel partners is both important and challenging. It is important because, as theory suggests, these potential economic profits can motivate dealers to perform and to limit their undesirable behaviors. It is challenging because there is a lack of formal theory regarding rent creation and its relationship to self-enforcing contracts. In addition, empirical analyses require extremely detailed firm level data. As insights accumulate on the economic rationale for leaving downstream rent, it will become possible to give more valuable advice to companies about how to organize their distribution activities efficiently and to antitrust authorities about how to formulate more effective competition policies.

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TABLE 1: OPTIMAL QUANTITY DISCOUNTS AND OUTCOMES FOR SYMMETRIC DEALERS ( $\left.a_{i}=a_{i}=a\right)$
34
TABLE 2: DESCRIPTIVE STATISTICS AND CORRELATIONS TABLE

|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1. Quantity ('000) | - |  |  |  |  |  |  |  |  |
| 2. Net wholesale price (Y\$) | -0.41* | - |  |  |  |  |  |  |  |
| 3. Wholesale market price for competing brand \# 1 | 0.03 | -0.24* | - |  |  |  |  |  |  |
| 4. Wholesale market price for competing brand \# 2 | 0.06 | 0.06 | -0.24* | - |  |  |  |  |  |
| 5. Wholesale market price for competing brand \# 3 | -0.00 | 0.17* | -0.71* | 0.14* | - |  |  |  |  |
| 6. National advertising expenses (mil Y\$) | 0.14* | -0.14* | 0.74* | -0.18* | -0.53* | - |  |  |  |
| 7. National PR expenses (mil Y\$) | 0.02 | -0.07 | 0.42* | 0.07 | -0.47* | 0.13* | - |  |  |
| 8. Regional marketing expenses (mil Y\$) | 0.32* | -0.04 | -0.11* | 0.17* | 0.09* | 0.06 | -0.15* | - |  |
| 9. Dealer-level marketing expenses (mil Y\$) | 0.20* | -0.11* | 0.02 | 0.07 | 0.06 | 0.12* | -0.07 | -0.05 | - |
|  |  |  |  |  |  |  |  |  |  |
| Mean | 41.28 | 1410.82 | 1221.17 | 1185.75 | 2446.58 | 3.94 | 5.17 | 0.033 | 0.034 |
| Standard deviation | 86.69 | 72.18 | 33.90 | 27.89 | 49.33 | 3.48 | 3.83 | 0.14 | 0.15 |
| Number of observations | 720 | 720 | 12 | 12 | 12 | 12 | 12 | 96 | 720 |

*: significant at 0.05 .
TABLE 3: DEMAND ESTIMATION: POOLED REGIONAL ESTIMATES Dependent Variable: Quantity (in '000)

| Independent Variables | Region |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | (1) <br> Beijing | (2) <br> North-east | (3) <br> North | (4) <br> North-west | (5) <br> East | (6) <br> South | (7) <br> Central | (8) <br> South-west |
| Net wholesale price | $\begin{gathered} -.82 * * * \\ (.26) \end{gathered}$ | $\begin{aligned} & -.10^{*} \\ & (.06) \end{aligned}$ | $\begin{gathered} -.07 * * \\ (.03) \end{gathered}$ | $\begin{gathered} -.14^{*} \\ (0.07) \end{gathered}$ | $\begin{gathered} \hline-.26^{* * *} \\ (.07) \end{gathered}$ | $\begin{gathered} -.47 * * * \\ (.15) \end{gathered}$ | $\begin{gathered} -.08^{*} * \\ (.04) \end{gathered}$ | $\begin{gathered} -.11 * * \\ (.05) \end{gathered}$ |
| Competing dealers’ brand price | 1.15*** <br> (.44) | $\begin{gathered} .02 \\ (.16) \end{gathered}$ | $\begin{aligned} & .17^{*} \\ & (.09) \end{aligned}$ | $\begin{gathered} .02 \\ (.15) \end{gathered}$ | $\begin{aligned} & .43^{* *} \\ & (.18) \end{aligned}$ | $\begin{aligned} & .83^{*} \\ & (.49) \end{aligned}$ | $\begin{gathered} .04 \\ (.11) \end{gathered}$ | $\begin{aligned} & -.26 \\ & (.17) \end{aligned}$ |
| Dealer-level marketing ${ }^{\text {t }}$ | \# N.A. | $\begin{gathered} 6.86 \\ (26.23) \end{gathered}$ | $\begin{aligned} & 44.15^{*} \\ & (26.75) \end{aligned}$ | $\begin{gathered} 37.88 \\ (48.23) \end{gathered}$ | $\begin{aligned} & -15.93 \\ & (47.50) \end{aligned}$ | $\begin{gathered} 150.72^{* * *} \\ (35.07) \end{gathered}$ | $\begin{gathered} 51.26^{* *} * \\ (15.83) \end{gathered}$ | $\begin{gathered} 61.43 * * * \\ (18.27) \end{gathered}$ |
| Wholesale price for competing brand \# 1 | $\begin{aligned} & .15 \\ & (.23) \end{aligned}$ |  |  |  |  |  |  |  |
| Wholesale price for competing brand \# 2 | $\begin{gathered} .14^{* *} \\ (.07) \end{gathered}$ |  |  |  |  |  |  |  |
| Wholesale price for competing brand \# 3 | $\begin{gathered} .36^{* * *} \\ (.12) \end{gathered}$ |  |  |  |  |  |  |  |
| Regional marketing ${ }^{\text {t }}$ | $\begin{gathered} 137.15^{* * *} \\ (50.98) \end{gathered}$ |  |  |  |  |  |  |  |
| National advertising***** | $\begin{gathered} 4.11^{* * *} \\ (1.07) \end{gathered}$ |  |  |  |  |  |  |  |
| National PR ${ }^{*}$ | $\begin{gathered} 2.56 * * * \\ (.63) \end{gathered}$ |  |  |  |  |  |  |  |
| Sales cycle effects | Yes*** |  |  |  |  |  |  |  |
| $\mathrm{R}^{2}$ | . 33 |  |  |  |  |  |  |  |
| Number of Dealers | 11 | 7 | 11 | 3 | 10 | 4 |  | 6 |
| No. of observations | 720 |  |  |  |  |  |  |  |

TABLE 4: ESTIMATED FINAL PRICES AND ECONOMIC RENT BY REGION

|  | Final Prices (Y\$) |  |
| :--- | :---: | :---: |
| Region | Mean | SD |
| (1) Beijing | 1511.72 | 38.72 |
| (2) Northeast | 1690.60 | 51.82 |
| (3) North | 1749.36 | 52.93 |
| (4) Northwest | 1732.53 | 75.20 |
| (5) East | 1580.29 | 33.48 |
| (6) South | 1612.41 | 52.78 |
| (7) Central | 1860.52 | 88.26 |
| (8) Southwest | 1626.36 | 103.22 |
| National average | 1663.31 | 126.83 |

TABLE 5: ESTIMATED GROSS AND NET ECONOMIC RENT

|  | Gross Rent $^{\dagger}$ |  | Net Rent $^{\ddagger}$ |  |
| :--- | :---: | :---: | :---: | :---: |
| Region | Mean | SD | Mean | SD |
| (1) Beijing | 11.86 | 12.89 | 7.67 | 9.65 |
| (2) Northeast | 3.56 | 2.56 | 2.13 | 2.03 |
| (3) North | 2.88 | 2.03 | 1.40 | 1.85 |
| (4) Northwest | 7.21 | 9.69 | 5.10 | 9.66 |
| (5) East | 6.03 | 7.49 | 4.08 | 8.40 |
| (6) South | 11.71 | 13.60 | 8.61 | 10.01 |
| (7) Central | 7.09 | 5.70 | 6.00 | 5.26 |
| (8) Southwest | 3.33 | 2.65 | 2.61 | 2.94 |
| National average | 6.54 | 8.18 | 4.48 | 6.78 |

${ }^{\dagger}$ Gross rent is calculated by $\Pi_{\mathrm{i}}=\sum_{\mathrm{t}=1}^{12}\left(\hat{\mathrm{p}}_{\mathrm{it}}-\quad{ }_{\mathrm{it}}\right) \cdot \mathrm{q}_{\mathrm{it}}$.
${ }^{\dagger}$ Net rent is calculated by $\Pi_{i}=\sum_{\mathrm{t}=1}^{12}\left(\hat{\mathrm{p}}_{\mathrm{it}}-{ }_{\mathrm{it}}\right) \cdot \mathrm{q}_{\mathrm{it}}-\mathrm{F}_{\mathrm{i}}$

## FIGURE 1: TIMELINE OF COMPUTEC'S QUARTERLY SALES CYCLE



FIGURE 2: SEQUENCE OF MOVES

| Stage 0 | The profit-maximizing manufacturer announces <br> wholesale price and a quantity discount schedule |
| :---: | :---: |
| Stage 1 | Dealers simultaneously make (and pay for) orders based <br> on manufacturer's wholesale price and quantity discount <br> schedule |
| Stage 2 | Dealers receive shipped orders. Amounts of orders <br> become common knowledge. Dealers simultaneously set <br> prices to maximize profits. They can order additional <br> units. |
| Note: dealers' demand functions are common knowledge throughout the game. |  |

FIGURE 3: DEALER i's PRICING DECISION IN STAGE 2


FIGURE 4: PRICE REACTION CURVES


FIGURE 5: DEALER i's PREORDERING DECISION IN STAGE 1


FIGURE 6: BERTRAND AND COURNOT PRICES


Bertrand Prices, Quantities, and Profits for Dealers

## APPENDIX A: BERTRAND AND COURNOT BENCHMARKS

Solving $\mathrm{r}_{1}^{\mathrm{b}}\left(\mathrm{p}_{2} ; \mathrm{w}\right)$ and $\mathrm{r}_{2}^{\mathrm{b}}\left(\mathrm{p}_{1} ; \mathrm{w}\right)$, we obtain the Bertrand price pair:
$p_{i}^{B}(w)=\frac{a+w}{2-b}, i=1,2$.
Substituting the prices into the demand functions $D_{i}\left(p_{i,} p_{j}\right) \equiv q_{i}=a_{i}-p_{i}+b p_{j}$, we obtain the Bertrand quantities pair:
$q_{i}^{B}(w)=\frac{a-(1-b) w}{2-b}, i=1,2$.
Further substituting the prices and quantities into dealer's profit function $\pi_{i}=\left(p_{i}^{B}-w\right) q_{i}^{B}$, we obtain the Bertrand profits for dealers for $0<\mathrm{d} \leq \delta$ as

$$
{ }_{\mathrm{i}}^{\mathrm{B}}\left(\mathrm{w}-2 \mathrm{~d}_{\mathrm{i}}\right)=\frac{(1-\mathrm{d})(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})^{2}}{(2-\mathrm{b}+2 \mathrm{~d}-2 \mathrm{bd})^{2}}, \mathrm{i}=1,2 .
$$

Moreover, when $\mathrm{d}=0, \pi_{\mathrm{i}}^{\mathrm{B}}\left(\mathrm{w}-2 \mathrm{~d}_{\mathrm{i}}\right)=\frac{(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})^{2}}{(2-\mathrm{b})^{2}}, \mathrm{i}=1,2$.

## Cournot Prices, Quantities, and Profits for Dealers

Cournot prices can be obtained by solving dealer's profit maximization problem: $\max _{p_{\text {. }}}{ }_{i}=\left(p_{i}-\left(w-d\left(a_{i}-p_{i}+b p_{j}\right)\right)\right)\left(a_{i}-p_{i}+b p_{j}\right)$, subject to $k_{j}=a_{j}-p_{j}+b p_{i}$.

Substituting the constraint into the profit function and using the first order conditions, we work out the Cournot price reply functions in terms of competing dealer's preorder $\mathrm{k}_{\mathrm{j}}$ :
$\mathrm{r}_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{k}_{\mathrm{j}} ; \mathrm{w}-2 \mathrm{~d}_{\mathrm{i}}\right)=\frac{\left(1-2\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)\left(\mathrm{a}+\mathrm{ab}-\mathrm{bk}^{2}\right)+\left(1-\mathrm{b}^{2}\right) \mathrm{w}}{2\left(1-\mathrm{b}^{2}+\left(1-\mathrm{b}^{2}\right)^{2} \mathrm{~d}\right)}, \mathrm{i}=1,2 ; \mathrm{i} \neq \mathrm{j}$. Using Lemma 1 and substituting $k_{j}=a_{j}-p_{j}+b p_{i}$ into it, we get the Cournot price reply functions in terms of competing dealer's price $p_{j}: r_{i}^{c}\left(p_{j} ; w-2 d k_{i}\right)=\frac{\left(1-2\left(1-b^{2}\right) d\right)\left(a+b p_{j}\right)+\left(1-b^{2}\right) w}{2(1-d)-b^{2}(1-2 d)}, i=1,2 ; i \neq j$.

Solving the last set of reply functions, the Cournot price pair are given by:
$p_{i}^{c}\left(w-2 d k_{i}\right)=\frac{a\left(1-2\left(1-b^{2}\right) d\right)+\left(1-b^{2}\right) w}{(1-b)\left(2+b-2\left(1-b^{2}\right) d\right)}, i=1,2$.

Substituting the prices into the demand function $D_{i}\left(p_{i,} p_{j}\right) \equiv q_{i}=a_{i}-p_{i}+b p_{j}$, the Cournot quantities are given by:
$\mathrm{q}_{\mathrm{i}}^{\mathrm{c}}\left(\mathrm{w}-2 \mathrm{dk}_{\mathrm{i}}\right)=\frac{(1+\mathrm{b})(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})}{\left(2+\mathrm{b}-2\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)}, \mathrm{i}=1,2$.
Finally, the Cournot profits given by the profit functions are:
$\pi_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{dk}_{\mathrm{i}}\right)=\frac{(1+\mathrm{b})\left(1-\left(1-\mathrm{b}^{2}\right) \mathrm{d}\right)(\mathrm{a}-(1-\mathrm{b}) \mathrm{w})^{2}}{(1-\mathrm{b})\left(2+\mathrm{b}-2 \mathrm{~d}\left(1-\mathrm{b}^{2}\right)\right)^{2}}, \mathrm{i}=1,2$.

## Critical Discount

Fromp $p_{i}^{C}\left(w-2 \delta k_{i}\right)=p_{i}^{B}(w)$, we can solve for $\delta: \delta=\frac{b^{2}}{2\left(1-b^{2}\right)}$.
We assume that the manufacturer can only offer a unified discount schedule for all dealers.
Therefore, $\delta=\frac{\mathrm{b}^{2}}{2\left(1-\mathrm{b}^{2}\right)}$ is the uniquely feasible solution and we call it the critical discount. It is straightforward to show that $\left.\frac{\partial p_{i}^{c}}{\partial d}\right|_{d}<0$. Therefore, at $\delta$, the Cournot price $p_{i}^{c}\left(c+w-2 \delta k_{i}\right)$ cuts the Bertrand price $p_{i}^{b}(c+w)$ from below, which is expected.

## APPENDIX B: PROOF OF LEMMA 2

Notice that the best response function in $\mathrm{k}_{\mathrm{i}}$, for $\mathrm{i}=1,2$, is given by $\mathrm{k}_{\mathrm{i}}\left(\mathrm{k}_{\mathrm{j}}\right)=\mathrm{D}\left(\mathrm{p}_{\mathrm{i}}\left(\mathrm{k}_{\mathrm{j}}\right)\right.$, $\left.\mathrm{p}_{\mathrm{j}}\left(\mathrm{k}_{\mathrm{j}}\right)\right)$, where $\left(\mathrm{p}_{\mathrm{i}}\left(\mathrm{k}_{\mathrm{j}}\right), \mathrm{p}_{\mathrm{j}}\left(\mathrm{k}_{\mathrm{j}}\right)\right)$ satisfies

$$
\begin{align*}
& \underset{p_{1}}{\operatorname{Max}}\left(p_{i}-w+d k_{i}\right) \cdot k_{i} \quad \text { subject to }  \tag{a1}\\
& k_{j}=a-p_{j}+b p_{i} \\
& r^{i}\left(p_{j}\right) \leq p_{i} \leq r^{i}\left(p_{j} ; w\right) .
\end{align*}
$$

(a2) and (a3) are direct implications from the lemma: $\mathrm{k}_{\mathrm{i}}=\mathrm{q}_{\mathrm{i}}=\mathrm{D}_{\mathrm{i}}\left(\mathrm{p}_{\mathrm{i}}, \mathrm{p}_{\mathrm{j}}\right)$, for $\mathrm{i}=1$, 2. (a2) says that the optimal price response must lie on Part 2 of rival's reaction function. (a3) mandates that the best response price falls between the range that is under the conditions of $\mathrm{k}_{\mathrm{i}}>\mathrm{q}_{\mathrm{i}}$ and $\mathrm{k}_{\mathrm{i}}<\mathrm{q}_{\mathrm{i}}$.

We can divide our analysis into three cases:
(1) $d>\delta$. As we showed in Section 3 and using the lemma, (a1) and (a2) give rise the Cournot price $\mathrm{p}_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d}_{\mathrm{i}}\right) \cdot \mathrm{p}_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{i}}\right)$ also satisfies (a3) (see Figure 4). $\mathrm{q}_{\mathrm{i}}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{\mathrm{i}}\right)$ is the optimal quantity and by the lemma, this is also the optimal preorder size $k_{i}$ in the first stage. Given small discount, specifically with $\mathrm{d}<1$, the second order condition of the constrained optimization problem of (a1) and (a2), i.e. $-2\left(1-b^{2}\right)(1-d)<0$, is also satisfied. Together with the fact that the first order condition gives a unique maximum, the optimal solution is unique. The same reasoning is also true for the other dealer. Hence, the Cournot price pair $\left(p_{1}^{C}\left(w-2 d k_{1}\right), p_{2}^{C}\left(w-2 d k_{2}\right)\right)$ is optimal. Dealers' preorders $\left(k_{i}, k_{j}\right)$ that equals the corresponding Cournot quantity pair $\left(\mathrm{q}_{1}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d}_{1}\right), \mathrm{q}_{2}^{\mathrm{C}}\left(\mathrm{w}-2 \mathrm{~d} \mathrm{k}_{2}\right)\right)$ implement these
prices. Graphically, Point C is at the intersection of Part 2 of the two reaction functions at which each dealer reaches the highest possible Cournot profit.
(2) $0<\mathrm{d} \leq \delta$. At $\mathrm{d}=\delta$, the solution to (a1) to (a3) coincides with the intersection point of the two curves $r_{1}^{B}\left(p_{2} ; w\right)$ and $r_{2}^{B}\left(p_{1} ; w\right)$, which is the Bertrand price pair $\left(p_{1}^{B}(w), p_{2}^{B}(w)\right)$ or point B in Figure 4. For discounts that fall into the range $0<d \leq \delta$, dealer i still preorders $k_{i}=q_{i}^{B}(w)$. A smaller preorder shifts the $s_{i}$ curve downward and thus its intersection point with $r_{i}^{B}\left(p_{j} ; w\right)$ is beneath B. To satisfy (a2), the equilibrium point that intersects Part 2 of his rival's reaction curve lies on Part 3 of his reaction curve; in other words the dealer will supplement his preorders in Stage 2. But this contradicts the lemma. Notice that at B , the dealer receives the highest possible profit. The same reasoning applies to the other dealer. Therefore, preorders $\left(\mathrm{k}_{\mathrm{i}}, \mathrm{k}_{\mathrm{j}}\right)$ that equal to $\left(q_{1}^{\mathrm{C}}(\mathrm{w}), \mathrm{q}_{2}^{\mathrm{C}}(\mathrm{w})\right)$ implement the Bertrand price pair. Note that the total cost of ordering $\mathrm{k}_{\mathrm{i}}$ is $\left(\mathrm{w}-\mathrm{d} \mathrm{k}_{\mathrm{i}}\right) \cdot \mathrm{k}_{\mathrm{i}}$ in the relevant range of discount values.
(3) Finally at $\mathrm{d}=0$, the two-stage game is equivalent to a one-stage Bertrand game.

Equilibrium price and quantity pairs are $\left(\mathrm{p}_{1}^{\mathrm{B}}(\mathrm{w}), \mathrm{p}_{2}^{\mathrm{B}}(\mathrm{w})\right)$ and $\left(\mathrm{q}_{1}^{\mathrm{C}}(\mathrm{w}), \mathrm{q}_{2}^{\mathrm{C}}(\mathrm{w})\right)$ respectively. However, the sizes of dealers' preorders are indeterminate because the Bertrand price can be implemented by any preorders with $k_{1} \in\left[0, q_{1}^{B}(w)\right]$ and $k_{2} \in\left[0, q_{2}^{B}(w)\right]$.Q.E.D.

## Endnotes

> ${ }^{i}$ Henceforth, we will refer to the upstream and downstream channel members as a manufacturer and a dealer respectively.

${ }^{\text {ii }}$ To preserve confidentiality, we use the pseudonym Computec to refer to the manufacturer who provided the context and data used in this paper.
iii We assume that the manufacturer does not entertain orders so large that the net wholesale price drops to zero. Moreover, we assume that d is small enough to assure positive equilibrium prices. In fact, as we will see later, the upper bound for $d$ is implicitly defined in the equilibrium Cournot price (See Appendix A).
${ }^{\text {iv }}$ The linear discount schedule can be regarded as a first-degree approximation of the multi-tier, all-quantity discounts that is widely observed. All unit-discount contracts are pricing arrangements in which the wholesale price on every unit purchased is lowered when the purchase quantity is equal to or above some threshold (Kolay, Shaffer, and Ordover 2004). Kolay et al (2004) offer a model that involves single-tier all-unit discounts. Multiple-tier discounts have multiple, rather than just one, levels of quantity thresholds that correspond to different realized discounted prices.
${ }^{\mathrm{v}}$ Notice that at $\mathrm{d}=0$, preorders are indeterminate since both dealers are indifferent to preordering any quantity between 0 and $q_{i}$.
${ }^{\text {vi }}$ Baye and Ueng (1998) show that in an alternating-moving price game with differentiated products, the steady-state Markov equilibrium prices are strictly higher than one-shot Bertrand prices. This commitment effect is true even for an infinite number of periods.
${ }^{\text {vii }}$ Like previous studies (e.g., Chintagunta and Desiraju 2005, Sudhir 2001), we lack data on the full set of marketing expenses; hence we assume that the marketing expenses of the competing brands are absorbed by dealer- specific, time-invariant characteristics. Nevertheless, the inclusion of the marketing expenses by the focal brand (Computec) in our specifications improves our estimation by significantly reducing the (own) price endogeneity problem (e.g., Chintagunta 2002, Lal and Narasimhan 1996).
${ }^{\text {viii }}$ China Statistics Press (2004, 2005), Provincial Statistical Yearbooks.
${ }^{\text {ix }}$ Ex post rent is the expected stream of profits after the dealers commence marketing the product and can be different from the ex ante rent which is the expected profit before they choose to market the product. For example, in a two-part tariff where the manufacturer extracts all the profits through a fixed fee, the ex ante rent is the amount of fixed fee and ex post rent is zero.
${ }^{\mathrm{x}}$ See www.digiticalchina.com.hk and www.ecs.com.sg. Accessed on December 5, 2007. ECS Singapore is a major shareholder of PCI China. The companies use the accounting term "operating margin" or "operating profit" in their financial statements.
${ }^{\text {xi }}$ This is not problematic in our case because all of Computec's major competitors, regardless of size, use a qualitatively similar two-stage ordering process with their dealers. As such, strategic inter-brand rivalry motives are less likely to explain the adoption of this practice.

