Assessing the Economic Value of Distribution Channels: An Application to the PC Industry

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Abstract

Evaluating proposed changes in channels of distribution and matching products to channels in multi-channel product markets is a hard task for the management of any company. Such policy-oriented issues cannot be addressed by methods such as controlled experiments in test markets – methods that are feasible for evaluating pricing and advertising decisions. In this paper, we measure the economic value of distribution channels in a multi-channel setting by estimating a structural model of demand across channels. We then use this model to simulate changes in the channel and product mix and measure their consequences for economic value. We provide an application of this policy simulation approach to the PC industry, which is characterized by multiple firms competing via a variety of channels. Using this approach we are able to assess the economic value of each channel to each firm and to its customers. Further, our analysis provides an economic rationale for different channel actions observed in this marketplace. We also simulate the effects of the HP-Compaq merger but go beyond a standard merger analysis by evaluating the effects of various potential channel actions co-incident with the merger.

Keywords: Economic Value, Distribution Channels, Mergers, Policy Simulation, Mixed Logit, PC Industry
I. Introduction

In July 1996, Dell Computer Corporation began selling its products over the Internet and established an online store where customers could browse its offerings and customize computer configurations to suit their needs. The response to this new channel of distribution was overwhelming, with hundreds of thousands of customers visiting the website each week and generating millions of dollars of revenues for Dell (Rangan and Bell 1998). A few years previously, Dell had made a foray into offline retailing and started selling computers through outlets such as CompUSA and Staples. That channel strategy however, was not successful and the losses incurred forced Dell to act decisively and exit that retail channel. Around the same time, industry observers were chastising Compaq Computer Corporation to re-evaluate its distribution strategy and decide how much business it should take “direct” and how it must redefine its relationships with other channel partners (Cassmir 1997).

Another aspect of the multi-channel distribution strategies of firms in the PC industry is the recognition that firms often vary their product mix across different channels. This is due to the fact that appropriately matching products with distribution channels is an important aspect of implementing a firm’s customer segmentation and targeting strategy (Kotler 2000). Therefore, changes in channel decisions are also often accompanied by changes in the product mix offered through different distribution channels and thus an analysis of policy changes in those two areas must be considered jointly.

The issue of managing multiple channels, along with multiple product lines is a particularly noteworthy aspect of the market for personal computers (PCs) because all PC makers offer multiple product lines through multiple distribution channels, and most customers, typically the highest value customers use multiple channels for shopping and purchasing (Yulinsky 2000). As Forrester Research points out, “The ability to effectively support multi-channel marketing and sales will become more important as consumers gradually gravitate to the Internet and as catalogs take on a different type of importance” (Harwick 2002). PC manufacturers have been pushed to come up with strategies that allow them to participate in the world of e-commerce without alienating their “brick and mortar” partners. The question therefore, is how to strike the right balance among the different options for the selection of
distribution channels and to be able to evaluate the financial implications of changing the structure of distribution channels or removing and/or shifting a given product line from one channel to another.

Evaluating proposed changes in channels of distribution and the corresponding matching of products to channels is a hard task for the management of any company. Unlike changes in other elements of the marketing mix like price, advertising and many forms of promotions, one cannot easily determine the likely consequences of changes in distribution channel structure by running localized experiments. Setting up distribution channels involves outside parties and firms are often bound by contractual obligations that cannot be easily changed. The problem is made more difficult because historical sales/profit/margin data are of limited value because such data would not answer the question as to what would happen were a distribution channel to be eliminated. To answer that question, one needs to be able to determine how much of the sales from the channel to be eliminated would transfer to the company’s products in other distribution channels or to other companies’ products.

Yet, as we noted previously such policy-oriented questions cannot be answered by trying out small changes in the marketplace. What then is the solution? In two recent papers (Franses 2005 and Bronnenberg et al. 2005), the authors argue that researchers in marketing should build appropriate models that allow for policy simulations with respect to changes in marketing actions. Bronnenberg et al. go on to outline the advantages of building “structural models” for policy simulations and lament the inadequate attention that has been paid in the marketing research literature to the issue of policy simulations.

The goal of this paper is to address the challenge posed by Franses and Bronnenberg et al. and develop a structural model that will allow firms in the PC market to simulate changes in their distribution channels and product mix and determine which of their channel options add the most economic value and what the consequences are to both firms and customers of changes in distribution channels. Prior to that, we provide a brief survey of the extant literature on the use of structural models for policy simulations and identify the shortcomings that must be addressed to capture the institutional aspects of the PC market.

Researchers have used structural models to conduct a variety of policy simulations. For example, Kadiyali, Chintagunta and Vilcassim (2000) examine manufacturer-retailer channel interactions and the

The previously mentioned studies however, do not involve manufacturer interactions across different or multiple-types of channels, nor do they study the issue of matching appropriately the firms’ product lines with the different distribution channels. Such multi-channel multi-product approaches are some of the defining institutional aspects of the personal computer market. For example, a firm like Compaq sells through both direct (sales force) and indirect channels (dealers/VARs) and offers largely different product lines through different channels (the Presario line through retailers and the DeskPro line through VARs). As argued by Reiss and Wollak (2003), if the analyses of firms’ policy changes in such a market are to be meaningful, any model developed must include in a reasonable manner such institutional realities. Therefore, in the development of the model, we (1) include manufacturer interactions across direct and indirect distribution channels and (2) account for vertical interactions between manufacturers and downstream firms in the indirect channels (albeit in a limited fashion).

Another issue of interest when analyzing the PC market is the understanding of the economic consequences of likely mergers, like that say, between HP and Compaq. Such analysis has been quite popular in the recent literature. For example, Nevo (2000) examines the implications of mergers in the ready-to-eat cereal markets using aggregate data. Manuszak (2001) evaluates the impact of upstream mergers in the petroleum industry on downstream retail gasoline markets and on consumer welfare. Dubé (2004) simulates the competitive impact of mergers in the soft drink industry on equilibrium prices and quantities and consumer welfare using household level data, while Genakos (2004) examines mergers in
the PC market. We differ from these merger studies in that we do not simply investigate the profit and welfare implications of mergers in the PC industry, but combine merger with firms’ channel and product mix options as in the HP-Compaq example.

In the PC market, the different distribution channels collectively serve both business and household segments. These distribution channels differ in price, promotion, assortment, convenience, sales tax and services like availability of information, ease of customization, security of transaction, timeliness of delivery and ease of return (e.g. Brynjolfsson and Smith 2000, Goolsbee 2000, 2001, Pan, Ratchford and Shankar 2002). Consumers derive utilities from different channels for the same product and therefore shop across channels. Thus, changes in the channels and / or product mix and variations in their matching will impact consumer welfare and understanding the implications of such changes will be important to the firms. While customers in the business segment have access to all the channels in our data, the same is not true for the household segment. Instead of modeling the two segments separately, we assume that consumers in the market are heterogeneous in their channel preferences.

We follow recent developments in the area of structural modeling when setting the framework for our policy simulations. We start with a random coefficients logit model that is derived from individual consumers’ utility maximizing behavior. We thus account for consumer heterogeneity in preferences for brand, product attributes and price response. Given our characteristics approach, any correlation between unobserved product attributes and the econometric error term will generate a potential endogeneity bias. We apply a standard instrumental variables procedure to correct for the endogeneity bias in the estimation. With our demand model we are able to estimate a flexible substitution pattern across brands and channels.

Our pricing model accounts for horizontal interactions and vertical interactions. Manufacturers play a Bertrand-Nash pricing game, maximizing product line profits by simultaneously choosing wholesale prices for all PC models across all channels. Since we only observe retail prices while manufacturers set wholesale prices, we utilize the unique channel structure in the data – all manufacturers use both direct and indirect channels to sell their products – to infer wholesale prices, marginal costs and downstream
markups from the pricing equations. The key identifying assumptions here are that brand model-level marginal costs are symmetric across direct and indirect channels and that downstream firms use a simple (but unknown) markup rule for each brand model, which we estimate from the data.

Using the estimated demand parameters, marginal costs and downstream markups, we first estimate the economic value of each channel to firms and consumers. We next conduct a series of policy simulations, each of which requires us to solve for the equilibrium retail and wholesale prices and market shares under the new channel-product profile, to determine how the policy changes affect firms’ profits and consumer welfare. The policy simulations we conduct are the following: (1) dropping a channel or a product line from a firm’s distribution system; (2) adding a channel to a firm’s distribution system; and (3) merger between Compaq and Hewlett-Packard, together with shifts in the channel mix.

Our main findings are as follows. Channels with high (low) historical sales and profits do not necessarily have high (low) economic value to firms. For example, in the case of Compaq, although VARs account for a higher share of its sales relative to retailers, the retail channel has a higher economic value. As we will see later, this result is in part driven by the substitution pattern across the different channels of distribution. We also find that Dell’s decision to exit the retail channel and Compaq’s to go direct were economically justified, but Compaq needed to carefully handle its relationships with channel partners. Although our data are limited to the inception of the Internet as a channel for PC distribution, we still find that Gateway would have been better off redirecting its retailing efforts towards Internet selling.

The rest of the paper is organized as follows. We present our data structure and summary statistics in section II and build our demand and pricing models in section III. We discuss some estimation issues in Section IV and present the estimation results of basic demand and policy simulations in Section V. We conclude and provide directions for future research in Section VI.

II. Data

The U.S. PC industry represents a huge market with total sales of $498 billion for the years 1995 through 1998, of which about 68% was accounted for by business consumers. We have annual PC data for the U.S. market for these four years. The data contain manufacturer shipments, broken down by brand,
microprocessor, form factor (desktop, laptop or ultra-portable) and distribution channel. Shipments are the net total of all PC units leaving a manufacturer’s facility for delivery to a sales channel, distributor or end customer and are adjusted for returns and cross shipping. We assume that inventory effects are negligible and thus assume that total shipments equal total units sold. We confirmed with the data provider that shipments are treated as being equivalent to final sales by the industry. The data also contain the retail price for each product.

Our data structure is as follows. At the top are manufacturers like Dell, Compaq and Gateway. Each manufacturer has several brands, which are defined by their distinct brand names, and each brand has a series of PC models, which together form a product line. For instance, the Dell brand includes Dimension, Inspiron, Latitude, Optiplex and Precision Workstation, and we therefore have the Dimension line, the Latitude line, the Optiplex line, etc. The Dimension line includes different models like Dimension 3000, Dimension 4600 and Dimension 8400, and the Latitude line includes Latitude D600, Latitude D800, Latitude X300, etc.‡

We focus on the top ten (by volume) PC manufacturers. The top ten PC manufacturers in the US market were Compaq, NEC/Packard Bell, IBM, Dell, HP, Apple, Toshiba, Acer, Gateway and Micron. Together, they accounted for 71% of all PC unit sales and 89% of branded PC sales. Compaq had the largest PC sales with 21% market share, followed by NEC/Packard Bell (14%), Dell (13%), IBM (12%) and Gateway (10%). The manufacturers experienced different sales trends over the years. Compaq, Gateway, and in particular Dell increased their market shares by a large amount, while shares of NEC/Packard Bell and Apple dropped substantially (Table 1).

There are 74 PC brands or product lines in our data and they vary substantially in shares. There are six distribution channels, direct outbound, direct inbound, dealer/VAR/SI, retail, Internet and others. The direct outbound channel represents sales by the product manufacturer to the end user, including sales by a manufacturer’s sales force, agents or representatives. The direct inbound channel captures sales by the

‡ Alternatively, we can define all of a manufacturer’s products as belonging to a corporate brand like the Dell brand, and all products with distinct names under the corporate brand as sub-brands like Dell Dimension, Dell Optiplex, etc. Under each sub-brand are a series of PC models like Dimension 3000, Dimension 4600 and Dimension 8400 that together form a product line. We use the definitions given by the data provider.
manufacturer to the end user via telesales or telemarketing methods, including manufacturer catalogs. Firms that offer value with the PC sales beyond price and availability characterize the Dealer/VAR/SI distribution channel. Dealer/VAR/SI’s tend to focus on sales to a smaller set of customers with a higher volume of PC purchase, generally ranging from small offices to Fortune 500 accounts. Examples of Dealer/VAR/SI channel categories include corporate account resellers, computer specialty dealers, value added resellers (including application VARs and network integrators), and system integrators. The retail channel is primarily characterized by store-front businesses which sell to a large number of unrelated customers. Examples of the retail channel categories include mass merchants, consumer electronics retailers, office products superstores, computer products superstores, software retailers, manufacturer stores, PC shops, membership club stores and Internet retailers. An Internet direct sale is one that has been initiated and completed via the World Wide Web and payment received via electronic means.

Indirect channels reflect the bulk of PC sales: 35% PCs are sold through dealer/VAR/SI and 31% in the retail channel. Direct inbound and direct outbound channels account for 28% PC sales. From 1995 to 1998, dealer/VAR/SI shares dropped from 38% to 31% and retail shares went down from 37% to 28%, meanwhile direct outbound shares increased from 8% to 12% and direct inbound shares went up from 15% to 20%. Internet sales started in 1998 and had less than 1% total PC sales. Given the low penetration of the Internet in our data combined with its sales for only one year, our conclusions regarding this channel are necessarily limited.

All manufacturers used multiple channels to market their products, but different manufacturers focused on different channels. Dell, Gateway and Micron primarily used direct marketing channels with Dell focusing on direct outbound and the latter two on direct inbound. NEC/Packard Bell used the retail channel, and HP, IBM, Acer and Compaq focused on the dealer/VAR/SI channel (Table 2). While companies like IBM and HP have large salesforces, Table 2 indicates that these firms do not realize sales through the direct outbound channel. One reason for this is that final sales are routed through indirect channels, although the salesforce may have done a good part of the demand generating activities.

Sales breakdown by channel at the brand level reveals that each product line has a “primary” channel. For instance, Compaq sold all Starion PCs and 90% Presario PCs through retail, 85% HiNote via
dealer/VAR/SI and 99% ProSignia via catalog and Internet. The product line-channel arrangements on one hand help match the customer’s profile of the product line with that of the channel and on the other hand help reduce intra-brand competition across channels and coordinate channel relations.

At the individual manufacturer level, shifts in sales from one channel to another seem to coincide with price changes. For instance, from 1997 to 1998 Compaq’s dealer/VAR/SI share decreased from 45.9% to 44.5% and its retail share increased from 33.8% to 40.0%, meanwhile the mean prices in the two channels dropped by 4.8% and 10.5% respectively. IBM’s dealer/VAR/SI share decreased from 62.7% to 57.7% and its retail share increased from 18.1% to 22.9%, and its prices in these two channels increased by 22.5% and 12.3% respectively. Reflecting these trends, in its call for “integrated multi-channel retailing”, the IBM Institute for Business Value (Chu 2002) stresses the importance of “developing a unified understanding of a given customer’s wants and needs as consumers become increasingly fragmented in the channels they use”. The shifting patterns of sales and prices across channels and firms provide us with some justification for our model specification to follow.

III. Model Formulation

3.0 Model Setup

To assess the economic value of distribution channels to firms and consumers and to investigate profit and welfare implications of various channel and product line strategies, we require a demand system that possesses the following qualities:

1) Derived from individual consumer’s utility maximizing behavior so that the underlying structure of preferences recovered is invariant to changes in firms’ strategies. Such a “structural” model of demand would not be subject to the Lucas critique when used for policy simulations (see Lucas 1979 and also Franses 2005).

2) Reflects consumer preference heterogeneity for the different channels to allow for different access to the various channels for business and household consumers and also heterogeneity in preferences for attributes and in price sensitivities across consumers.
3) Generates a flexible pattern of channel and product substitutions so that meaningful policy simulations on channel and product line options can be carried out.

4) Parsimonious in the number of parameters to be estimated so that reliable estimates can be obtained without placing an undue burden on the data.

We use the random coefficient logit model developed by Berry (1994) as it meets these criteria (see Berry, Levinsohn and Pakes (1995) and Nevo (2000, 2001) for a full discussion).

As the data also include organizational buyers that may entail the purchase of several units, a discrete choice demand system may seem inappropriate. Since each unit purchased is used by a single employee of the firm, this issue is somewhat mitigated. Nevertheless, we recognize that we are not explicitly accounting for the quantity choice decision. Given the structure of our data previously described, one might also consider the nested logit model to be a viable specification. However, with aggregate data, the nested logit model only serves to provide a more flexible substitution pattern across alternatives as compared to the standard logit model. Since we achieve the same objective via the random coefficients specification, there are no significant benefits from using the nested logit in our case.

Retail prices (observed in the data) are the outcomes of vertical interactions among manufacturers and channel members (in the indirect channels) and horizontal interactions among manufacturers and among channel members. We assume a Stackelberg leader-follower relationship between manufacturers and members of the indirect channels. Hence, manufacturers set wholesale prices taking into account the reaction functions of downstream channel members who set retail prices as a function of wholesale prices. We assume that manufacturers maximize product line profits given their marginal costs and that the horizontal interaction among PC manufacturers is Bertrand-Nash pricing. The Bertrand-Nash assumption seems justified given the competitive nature of the PC industry (e.g. Economides 1999).

To obtain the reaction functions of the downstream firms, the typical assumption is that retailers set prices to maximize category profits given wholesale prices (see Sudhir (2001a) and Berto Villas-Boas (2004)). There are three reasons that preclude such an approach in the PC market. (1) Unlike supermarket retailers, it is not evident that in practice the intermediaries in this market use category management
systems for pricing. (2) As noted previously, there are a large number of downstream firms in this industry whose horizontal interactions with one another will have to be modeled. (3) The downstream problem is further complicated by the presence of exclusive and non-exclusive channel members that carry various subsets of the manufacturers’ products. This makes a uniform definition of the downstream firms’ profit maximization problem difficult to characterize. Rather than model their decisions explicitly, we assume instead that downstream firms in the indirect channels charge a (unknown) fixed brand-model specific markup.\(^6\) Plugging in this retailer pricing rule into the manufacturers’ pricing decisions, we can then write retail prices as depending upon manufacturers’ marginal costs and downstream firms’ markups, both of which are unobserved but can be estimated from the data.

How then do we infer these retail markups and manufacturers’ marginal costs? One unique feature of our data is that we observe retail prices and sales of the same PC models in both the direct and indirect channels. By assuming the same model-level manufacturer marginal costs across channels and using a simple (unknown but estimable) downstream markup rule, we are able to infer downstream markups (and thus wholesale prices for the indirect channels) and manufacturer marginal costs without explicitly modeling the downstream firms’ profit maximization problem. Since a vast majority although not all models are available both in the direct and indirect channels, we will need some further assumptions for a small set of brand-models as detailed in the estimation section.

3.1 Random coefficients logit demand model

As in Sudhir (2001a) and Berto Villas-Boas (2004), we assume consumers choose a model-channel combination. As described in the data section, a PC brand \(j\) together with a form factor \(f\) and a microprocessor \(k\) makes a PC model \(\omega\). Formally, we assume that in year \(t\), \(M_t\) consumers each select one of the \(\Omega\) PC models from one of the \(D\) distribution channels, or opt for the no-purchase alternative. Each

---

\(^6\) When is such a rule optimal from the downstream firm’s vantage point? If that firm maximizes profits separately for each brand-model, then retail prices = wholesale prices\(^*(1 + 1/(-\epsilon-1))\) where \(\epsilon\) is the price elasticity of demand. To account for deviations from single product profit maximization and for retail competition, we can write retail prices as wholesale prices\(^*(1 + \theta/(-\epsilon-1))\), where \(\theta\) reflects the effects of such deviations. So as long as the ratio \(\theta/(\epsilon+1)\) does not vary significantly with prices, the markup rule is optimal for the downstream firm. We note that cost plus pricing is still empirically the most commonly observed pricing rule (Hanson 1992). See also Anderson (1999) for a discussion of the optimality of simple pricing rules for channel members.
model \( \omega \) in channel \( d \) has attributes \((x_{\text{ext}}, \xi)\). The vector \( x \) includes variables for brand, microprocessor, form factor, distribution channel, time and retail price \( p_{\text{ext}} \). The vector \( \xi \) encompasses the effects of unobserved (to the econometrician) product attributes like manufacturer advertising and channel-specific promotions that vary across brand model and time and affect demand. While the variables brand, microprocessor, form factor and channel reflect product characteristics, we also include a year dummy variable to capture possible diffusion effects in the product category. The conditional indirect utility consumer \( i \) derives from purchasing model \( \omega \) from channel \( d \) in year \( t \) is given by (see also Sudhir 2001b):

\[
\begin{align*}
    u_{i\omega dt} &= x_{i\omega dt} \beta + \xi_{i\omega dt} + \epsilon_{i\omega dt} \\
    &= \alpha_i + \alpha_{ik} + \alpha_{if} + \alpha_{id} + \alpha_i + \beta_i (Y_{it} - p_{i\omega dt}) + \xi_{i\omega dt} + \epsilon_{i\omega dt}
\end{align*}
\]

(1)

Where,

\( i=1,...,I \), indexes individual consumer

\( \omega=0, 1,..., \Omega \), indexes PC model with 0 representing the outside good

\( j=1,...,J \), indexes brand

\( k=1,...,K \), indexes microprocessor

\( f=1,...,F \), indexes form factor.

\( d=1,...,D \), indexes distribution channel

\( t=1,...,T \), indexes year.

\( Y_{it} \) is consumer \( i \)'s income in year \( t \).

\( \epsilon_{i\omega dt} \) is consumer \( i \)'s idiosyncratic factor that affects utility. **

The effects of product attributes and the price coefficient vary across consumers as follows:

** We also tested a variety of interaction effects between channel and time, and between manufacturer and channel. The interaction effects between channel and time are not included for two reasons: (1) we cannot estimate interaction effects for the Internet since that channel was available only in 1998, and (2) the interaction effects for all other channels follow a very similar trend and thus do not help understand changes in consumers’ channel preferences. The interaction effects between manufacturer and channel are not included because they do not result in different substantive implications but require several additional parameters.
\[ \alpha_j \sim N(\bar{\alpha}_j, \sigma_j^2), \quad j \in v, j = 1,\ldots,J \]
\[ \alpha_k \sim N(\bar{\alpha}_k, \sigma_k^2), \quad k = 1,\ldots,K \]
\[ \alpha_f \sim N(\bar{\alpha}_f, \sigma_f^2), \quad f = 1,\ldots,F \]
\[ \alpha_d \sim N(\bar{\alpha}_d, \sigma_d^2), \quad d = 1,\ldots,D \]
\[ \beta_j \sim N(\bar{\beta}, \sigma_{\beta}^2) \]

As described in the data section, we have 74 brands (made by 10 manufacturers) which makes it infeasible to specify a full variance-covariance matrix for the brand preference intercepts \( \alpha_j \). We assume the brand intercepts follow independent but not identical normal distributions with brand-specific location parameters but manufacturer-specific scale parameters. That is, preferences for brands belonging to the same manufacturer \( v \) have the same standard deviation, \( \sigma_v^2 \) (for \( \forall j \in v \)). We use brand-specific mean preferences, \( \bar{\alpha}_j \) for two reasons: (1) it produces a better model fit, and (2) since we are examining manufacturer’s channel and product line options, using brand level parameter estimates will better quantify the impact of changes in product lines. Note that even with the above covariance structure, the aggregate substitution pattern across products will be quite flexible given that brand-models share manufacturers, microprocessors, form factors and distribution channels to varying degrees.

The utility of the outside good is:
\[ u_{i0t} = \alpha_{i0} + \beta_{i}Y_{it} + \epsilon_{i0t}. \] For identification purposes, we normalize \( \alpha_{i0} \) to 0. To simplify notation, we rewrite the consumer’s indirect utility in terms of mean tastes and deviations from the mean:
\[ u_{iadt} = \delta_{iadt} + \mu_{iadt} + \epsilon_{iadt} \]
Where \( \delta_{iadt} = \alpha_j + \bar{\alpha}_k + \bar{\alpha}_f + \bar{\alpha}_d + \alpha_t - \bar{\beta}p_{adt} + \xi_{adt} \) is common across consumers and \( \mu_{iadt} = (\alpha_{ij} - \bar{a}_j) + (\alpha_{ik} - \bar{a}_k) + (\alpha_{if} - \bar{a}_f) + (\alpha_{id} - \bar{a}_d) - (\beta_t - \bar{\beta})p_{adt} \) are consumer-specific deviations from the mean utility.
We assume $\epsilon_{i,\omega d t}$ follow extreme value distribution, which gives rise to the following probability of consumer $i$ choosing model $\omega$ from channel $d$ in year $t$:‡‡

$$s_{i,\omega d t} = \frac{\exp(\delta_{\omega d t} + \mu_{i,\omega d t})}{1 + \sum_{\omega' = 1}^{\Omega} \exp(\delta_{\omega' d t} + \mu_{i,\omega' d t})}$$  \hspace{1cm} (2)

The unconditional market share of PC model $\omega$ in channel $d$ and year $t$ is obtained by integrating over the joint distribution of consumer heterogeneity $\mu$:

$$s_{\omega d t} = \int \cdots \int_{-\infty}^{\infty} \frac{\exp(\delta_{\omega d t} + \mu_{i,\omega d t})}{1 + \sum_{\omega' = 1}^{\Omega} \exp(\delta_{\omega' d t} + \mu_{i,\omega' d t})} \phi(\mu) \, d\mu$$  \hspace{1cm} (3)

### 3.2 Product line pricing

We assume PC manufacturers play a Bertrand-Nash pricing game. Each manufacturer $v$ takes the other manufacturers’ prices as given and maximizes product line profits from PC sales across all distribution channels by jointly setting wholesale prices of its PC models in all channels. Manufacturer $v$’s profit function in year $t$ is:

$$\Pi_v = \sum_{d = 1}^{D_v} \sum_{\omega = 1}^{\Omega_v} (p_{\omega d t}^w - m_{\omega d t}^c) s_{\omega d t} M_t - FC_v$$  \hspace{1cm} (4)

Where,

- $\Omega_v$ is the set of products sold by manufacturer $v$ in year $t$
- $D_v$ is the set of distribution channels used by manufacturer $v$ in year $t$
- $p_{\omega d t}^w$ is the wholesale price for model $\omega$ in channel $d$ in year $t$
- $m_{\omega d t}^c$ is manufacturer $v$’s marginal cost for model $\omega$ in channel $d$ in year $t$.

‡‡ Since household consumers can shop only in a subset of channels, an alternative model might be $\lambda_h s_{h,\omega d t} + (1 - \lambda_h) s_{b,\omega d t}$, where $\lambda_h$ is the proportion of PCs sold to household consumers in year $t$, and $s_{h,\omega d t} = \int s_{h,\omega d t} \phi(i) \, di$, $s_{b,\omega d t} = \int s_{b,\omega d t} \phi(l) \, dl$ denote the shares in household and business segments respectively. At the aggregate level, we expect share predictions from this model to be similar to those from our proposed specification as both models yield a flexible aggregate substitution pattern – the main purpose of accounting for heterogeneity with aggregate data.
$M_t$ is the market size in year $t$.

$FC_{vt}$ is the fixed cost for manufacturer $v$ in year $t$.

The first-order conditions under the Bertrand-Nash assumption are:

$$s_{v dt} + \sum_{d=1}^{D_v} \sum_{\alpha'=1}^{\Omega_v} \left( p_{\alpha' dt}^w - mc_{\alpha' dt} \right) \frac{\partial s_{\alpha' dt}}{\partial p_{v dt}} = 0 \quad \text{(5)}$$

In matrix form,

$$S_t + \Delta_{wr}(P_t^w - MC_t) = 0 \quad \text{(6)}$$

The manufacturer’s pricing equations are:

$$P_t^w = MC_t - (\Delta_{wr})^{-1} S_t \quad \text{(7)}$$

Where $S_t$, $P_t^w$ and $MC_t$ are respectively vectors of shares, wholesale prices and manufacturer marginal costs. Define $\Delta_{wr}$, the manufacturer’s response matrix as:

$$\Delta_{wr} \equiv \begin{pmatrix}
\frac{\partial s_{11 t}}{\partial p_{11 t}^w} & \cdots & \frac{\partial s_{\Omega_v 1 t}}{\partial p_{\Omega_v 1 t}^w} & \cdots & \frac{\partial s_{1 D_v t}}{\partial p_{1 D_v t}^w} & \cdots & \frac{\partial s_{\Omega_v D_v t}}{\partial p_{\Omega_v D_v t}^w} \\
\vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\
\frac{\partial s_{11 t}}{\partial p_{11 w}^w} & \cdots & \frac{\partial s_{\Omega_v 1 t}}{\partial p_{\Omega_v 1 w}^w} & \cdots & \frac{\partial s_{1 D_v t}}{\partial p_{1 D_v w}^w} & \cdots & \frac{\partial s_{\Omega_v D_v t}}{\partial p_{\Omega_v D_v w}^w} \\
\vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\
\vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\
\frac{\partial s_{11 t}}{\partial p_{11 D_v t}^w} & \cdots & \frac{\partial s_{\Omega_v 1 t}}{\partial p_{\Omega_v 1 D_v t}^w} & \cdots & \frac{\partial s_{1 D_v t}}{\partial p_{1 D_v D_v t}^w} & \cdots & \frac{\partial s_{\Omega_v D_v t}}{\partial p_{\Omega_v D_v D_v t}^w} \\
\end{pmatrix}$$

$\Delta_{wr}$ is the matrix of first derivatives of shares with respect to wholesale prices.

Define retailer’s response matrix $\Delta_{rt}$ as:
\[
\Delta_{rt} \equiv \begin{pmatrix}
\frac{\partial s_{1r}}{\partial p_{1r}} & \ldots & \frac{\partial s_{\Omega_{w},lr}}{\partial p_{1r}} & \ldots & \frac{\partial s_{1D_{l},lr}}{\partial p_{1r}} & \ldots & \frac{\partial s_{\Omega_{w},D_{l},lr}}{\partial p_{1r}} \\
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{\partial s_{1r}}{\partial p_{\Omega_{w},lr}} & \ldots & \frac{\partial s_{\Omega_{w},lr}}{\partial p_{\Omega_{w},lr}} & \ldots & \frac{\partial s_{1D_{l},lr}}{\partial p_{\Omega_{w},lr}} & \ldots & \frac{\partial s_{\Omega_{w},D_{l},lr}}{\partial p_{\Omega_{w},lr}} \\
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{\partial s_{1r}}{\partial p_{1D_{l},lr}} & \ldots & \frac{\partial s_{\Omega_{w},lr}}{\partial p_{1D_{l},lr}} & \ldots & \frac{\partial s_{1D_{l},lr}}{\partial p_{1D_{l},lr}} & \ldots & \frac{\partial s_{\Omega_{w},D_{l},lr}}{\partial p_{1D_{l},lr}} \\
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{\partial s_{1r}}{\partial p_{\Omega_{w},D_{l},lr}} & \ldots & \frac{\partial s_{\Omega_{w},lr}}{\partial p_{\Omega_{w},D_{l},lr}} & \ldots & \frac{\partial s_{1D_{l},lr}}{\partial p_{\Omega_{w},D_{l},lr}} & \ldots & \frac{\partial s_{\Omega_{w},D_{l},D_{l},lr}}{\partial p_{\Omega_{w},D_{l},lr}} \\
\end{pmatrix}
\]

\(\Delta_{rt}\) is the matrix of first derivatives of shares with respect to retail prices.

Define \(\Delta_{r}\), the matrix of first derivatives of retail prices with respect to wholesale prices as:

\[
\Delta_{r} \equiv \begin{pmatrix}
\frac{\partial p_{1r}}{\partial p_{1r}} & \ldots & \frac{\partial p_{\Omega_{w},lr}}{\partial p_{1r}} & \ldots & \frac{\partial p_{1D_{l},lr}}{\partial p_{1r}} & \ldots & \frac{\partial p_{\Omega_{w},D_{l},lr}}{\partial p_{1r}} \\
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{\partial p_{1r}}{\partial p_{\Omega_{w},lr}} & \ldots & \frac{\partial p_{\Omega_{w},lr}}{\partial p_{\Omega_{w},lr}} & \ldots & \frac{\partial p_{1D_{l},lr}}{\partial p_{\Omega_{w},lr}} & \ldots & \frac{\partial p_{\Omega_{w},D_{l},lr}}{\partial p_{\Omega_{w},lr}} \\
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{\partial p_{1r}}{\partial p_{1D_{l},lr}} & \ldots & \frac{\partial p_{\Omega_{w},lr}}{\partial p_{1D_{l},lr}} & \ldots & \frac{\partial p_{1D_{l},lr}}{\partial p_{1D_{l},lr}} & \ldots & \frac{\partial p_{\Omega_{w},D_{l},lr}}{\partial p_{1D_{l},lr}} \\
\vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\
\frac{\partial s_{1r}}{\partial p_{\Omega_{w},D_{l},lr}} & \ldots & \frac{\partial p_{\Omega_{w},lr}}{\partial p_{\Omega_{w},D_{l},lr}} & \ldots & \frac{\partial p_{1D_{l},lr}}{\partial p_{\Omega_{w},D_{l},lr}} & \ldots & \frac{\partial p_{\Omega_{w},D_{l},D_{l},lr}}{\partial p_{\Omega_{w},D_{l},lr}} \\
\end{pmatrix}
\]

By the chain rule, we have \(\Delta_{rt} = \Delta_{r}\Delta_{r}\).

In equations (7), we note that we do not observe marginal costs, wholesale prices and the response matrix \(\Delta_{r}\), all of which need to be inferred from the pricing equations. To achieve this, we make the following two assumptions. First, we assume a simple downstream markup rule for products sold in the indirect channels as:
\[ p_{\text{adt}} = (1 + r_{\text{adt}}) p_{\text{adt}}^w \] and \( r_{\text{adt}} = 0 \) for products sold through direct channels. Thus matrix \( \Delta_r \) becomes a diagonal matrix \( \text{diag} \{1 + r_{\text{rt}}, \cdots, 1 + r_{\text{omr}}, \cdots, 1 + r_{\text{Drt}}, \cdots, 1 + r_{\text{omDrt}}\} \). Hence we have:

\[ \Delta_{\omega} = (1 + R_t) \bullet \Delta_{\omega} = \Delta_{\omega} \bullet (1 + R_t), \] where \( R_t \) is the vector of downstream markups with \( r_{\omega} \) in row \( \omega \) and “•” means multiplying every element in the \( \omega \)th row of matrix \( \Delta_{\omega} \) by the \( \omega \)th element of vector \( 1 + R_t \). \( 1 + r_{\text{rt}} \).

Second, we assume symmetric PC model-level marginal costs across direct and indirect channels. Specifically, PC model \( \omega \)'s marginal costs in the retail and dealer/VAR/SI channels are assumed to equal the mean marginal cost of model \( \omega \) that are sold in the direct channels in the same year. So we estimate a model-channel-year specific marginal cost for each of the direct channels with the MC for all the indirect channels for that model being the average of the MCs among all direct channels for that model in that year. If a model is sold only through indirect channels, which occurred only for four small brands with a total market share of 0.58%, we match its marginal costs to another brand with the same microprocessor, form factor and manufacturer in that year.

With these two assumptions, the manufacturer’s first order conditions become:

\[ S_t + (\Delta_r \bullet (1 + R_t))(P_t^w - MC_t) = 0 \] \( (8) \)

or

\[ S_t + \Delta_r (P_t - (1 + R_t) \bullet MC_t) = 0 \] \( (8') \)

The pricing equations are:

\[ P_t = (1 + R_t) \bullet MC_t - (\Delta_r)^{-1} S_t \] \( (9) \)

Let \( \psi_t \equiv (1 + R_t) \bullet MC_t \) be the vector of unknowns: marginal costs for products sold in the direct channels (the corresponding downstream markups are 0) and downstream markups (R) for products sold through indirect channels (the corresponding marginal costs are assumed to equal the mean marginal costs for the same models sold in the direct channels). We can compute these unknowns by solving the system of nonlinear equations (9). Note that we cannot first estimate marginal costs for products sold in the direct
channels and then match them to products sold in the indirect channels to get the corresponding markups because that would require us to assume that the manufacturers maximize profits from direct channels and from indirect channels separately. Since we assume manufacturers maximize profits from products sold through direct and indirect channels, we must estimate the marginal costs and downstream markups in equation (9) simultaneously\(^\ddagger\).

### 3.3 Measuring consumer welfare: compensating variation

One of our research objectives is to measure the change in consumer welfare associated with various policy simulations of firms’ channel and product line options. An attractive feature of the discrete choice model is the ability to compute consumer welfare explicitly. A popular welfare measure in such contexts is the Hicksian, or compensating variation, which captures the dollar amount by which consumers need to be compensated to maintain the same level of utility after a channel is eliminated or a product line is dropped from a distribution channel (Trajtenberg 1989, Petrin 2002, Chintagunta, Dubé and Singh 2003). Specifically, we denote individual \(i\)’s utility net of the extreme value taste shock as \(V_i\) (\(V_i = \delta_{a,i} + \mu_{a,i}\)) and their marginal utility of income as \(\beta_i\). Suppose channel \(d\) is eliminated that changes consumer valuations for each alternative from \(V^0\) to \(V^d\). As derived in Small and Rosen (1981), assuming individual marginal value of income is held constant so Hicksian demand can be approximated by Marshallian demand, individual \(i\)’s associated change in welfare can be computed as:

\[
CV_i = \frac{\log\left(\sum_{d'=1 \neq d} \sum_{a=1}^{D_d} \exp(V^1_{i adrenal})\right) - \log\left(\sum_{d'=1 \neq d} \sum_{a=1}^{D_d} \exp(V^0_{i adrenal})\right)}{\beta_i} \quad (10)
\]

The numerator in equation (10) captures the difference between the expected maximum utility under the two product line-channel structures. Dividing the utility difference by the marginal utility of income makes the change money-metric. The value \(CV_i\) thus measures the dollar amount by which consumer \(i\) must be compensated to be indifferent under the new scenario. We can compute the expected aggregate change in consumer utility by integrating over the distribution of consumer heterogeneity:

\[^\ddagger\text{Most studies (e.g. Petrin 2002) typically decompose the marginal cost } MC_i \text{ into a component that depends on factor prices and some cost residual. Since we need only the MC estimates for our policy simulations, we do not do that decomposition. Nevertheless, our formulation allows for MCs to change due to those factors.}\]
\[ CV_i = M_t \int \cdots \int CV \phi(\mu) d\mu \]  

(11)

IV. Estimation

The demand and supply models can be estimated either simultaneously or sequentially. Both approaches produce consistent estimates. The main advantage of a sequential approach is that it is computationally less of a burden, especially for the random coefficients specification. It also provides an elegant way to compute equilibrium prices and demand for our various policy experiments. Consequently, we follow the estimation method in recent empirical work (e.g. Nevo 2001, Petrin 2002, Chintagunta, Dubé and Singh 2003) and adopt a 2-step sequential approach. We first estimate the parameters of the demand equations. We use Monte Carlo draws to simulate the multi-dimensional integral in the demand equation. We experiment with different sets of draws until the estimates do not change much with a further increase of simulation draws. The results we report are based on 33 draws.

The unobserved product attributes that go into the error term \( \xi_{\text{prod}} \) include unobserved product characteristics, which, if correlated with price, would result in a price endogeneity problem. Instrumental variables techniques are used to account for price endogeneity. We used three sets of variables as instruments: (1) Product characteristics including dummies for brand, form factor, microprocessor and time. These instruments vary both with brand model and time. (2) Costs of goods sold (COGS) from the COMPSTAT database. We assume brands belonging to the same manufacturers have the same mean COGS. For those manufacturers whose COGS data are not available, we use industry averages as proxies. (3) Producer price index (PPI) for the computer industry (www.bls.gov). We interact PPI with brand dummies. Together, these instruments explain about 70% of price variation.

In the demand specification, we allowed consumers to have the option of not choosing any of the inside models, otherwise, a homothetic price change will not affect demand. Since our consumers consist of business and household segments, we can use either the number of office-based employees in each year (60 million, Bureau of Labor Statistics, Occupational Employment Statistics) or the number of households (100 million, U.S. Census Bureau), or a combination of the two as the market size. We
experimented with different market size definitions and find the estimation is very robust to the choice of market size. Our final specification uses the number of office-based employees as the market size.

We use the demand parameter estimates to estimate the marginal costs, downstream markup levels and wholesale prices in the following way: (1) Estimate the retail response matrix $\Delta_{rt}$. Note that we use a Monte Carlo method to simulate the retail response matrix with the same set of draws as in the demand estimation.

$$\Delta_{rt} = \frac{1}{nd} \sum_{r=1}^{nd} \begin{pmatrix} -\beta_1 s_{11r}(1-s_{11r}) & \beta_1 s_{11r} s_{112r} & \cdots & \beta_1 s_{11r} s_{1d,\Omega,t} \\ \beta_1 s_{12r} s_{11r} & -\beta_1 s_{12r}(1-s_{12r}) & \cdots & \beta_1 s_{12r} s_{1d,\Omega,t} \\ \vdots & \vdots & \ddots & \vdots \\ \beta s_{1d,\Omega,t} s_{11r} & \beta s_{1d,\Omega,t} s_{12r} & \cdots & -\beta s_{1d,\Omega,t}(1-s_{1d,\Omega,t}) \end{pmatrix}$$

(2) Compute marginal costs and downstream markups using equations (9).

(3) Estimate wholesale prices by dividing the vector of retail prices $p_t$ by the vector of downstream markup levels $1+R_t$. $P_t^w = P_t \cdot (1+R_t)$.

Next, we estimate equilibrium prices and shares for each policy experiment using the estimated marginal costs, downstream markups and demand parameters by simultaneously solving the system of demand equations (3) and pricing equations corresponding to that simulation scenario. When solving this system of equations, if a product line is switched from a direct channel to another direct channel, we set the intrinsic channel preference parameter for this product line sold in the origin channel to equal the intrinsic channel preference parameter of the destination channel. If a product line is switched or extended from an indirect channel to a direct channel, in addition to adjusting the intrinsic channel preference parameter, we also set the downstream markup levels to zero for that product line to be sold in the direct channel. If a product line is switched or extended from a direct channel to an indirect channel, in addition to adjusting the intrinsic channel preference parameter, we set the downstream markup levels for the product line to equal the markup levels of the same product line in another indirect channel. We first estimate equilibrium shares and retail prices and then obtain wholesale prices by dividing the equilibrium
retail prices by the adjusted markup levels. For the merger simulations, we carry out the computation of
equilibrium prices and shares by assuming Compaq and HP are maximizing their joint profits.

We compute the compensating variation for each individual and integrate it over the distribution to
obtain the welfare change for the population of consumers. When a product line is removed from one
channel, some consumers may buy other products in that channel, some may switch to other channels and
some may simply drop out of the market. The ultimate welfare implications are not clear. If dropping a
product line from a channel results in price increases, consumers will be worse off. A priori, we do not
know whether prices will increase or decrease. That will depend on the complex and subtle substitutions
across product, manufacturer and channel. It is possible that prices of some models or some
manufacturers will increase, while prices of some other models or manufacturers will decrease.

We compute manufacturers’ profit changes based on the wholesale prices and shares in the new
policy scenario. When channel $d$ is dropped from a manufacturer’s distribution system, its profit changes
consist of two parts:

(1) The forgone profits from the product lines in channel $d$, $\Delta \Pi_{vt}^1$,

$$\Delta \Pi_{vt}^1 = - \sum_{\omega \in d} (p_{\omega dt}^w - mc_{\omega dt}) s_{\omega dt} M_t - FC_{dt}$$  \hspace{1cm} (12)

(2) Change in profits from the product lines in the remaining channels, $\Delta \Pi_{vt}^2$,

$$\Delta \Pi_{vt}^2 = \sum_{d'=1, d' \neq d} \Omega_{d'}^w \sum_{\omega=1} (p_{\omega d't}^w - mc_{\omega d't}) s_{\omega d't}^1 M_t - \sum_{d'=1, d' \neq d} \sum_{\omega=1} (p_{\omega d't}^w - mc_{\omega d't}) s_{\omega d't}^1 M_t$$  \hspace{1cm} (13)

The net profit change is the sum of the two effects $\Delta \Pi_{vt} = \Delta \Pi_{vt}^1 + \Delta \Pi_{vt}^2$.

When a product line is switched from one channel to another, the change in profit is the difference
in profits under the two channel-product structures:

$$\Delta \Pi_{vt} = \sum_{d=1} \sum_{\omega=1} (p_{\omega dt}^w - mc_{\omega dt}) s_{\omega dt} M_t - \sum_{d=1} \sum_{\omega=1} (p_{\omega dt}^w - mc_{\omega dt}) s_{\omega dt} M_t$$  \hspace{1cm} (14)

\hspace{1cm} §§ Switching and / or dropping channels could result in changes in fixed costs as well. All our computations here are
up to any fixed cost changes as we do not have data on those costs.
Similarly, we can estimate changes in downstream profits in channel $d$ as:

$$
\Delta \Pi_{dt} = \sum_{\omega=1}^{\Omega_{d}} (p_{\text{exit}}^1 - p_{\text{exit}}^w) s_{\text{exit}}^1 M_t - \sum_{\omega=1}^{\Omega_{d}} (p_{\text{exit}}^1 - p_{\text{exit}}^w) s_{\text{exit}}^w M_t
$$

(15)

**V. Results**

We first report estimation results for the demand system, followed by the estimates of the marginal costs and markups. We then present the results of the policy simulations and draw implications for firms’ actions.

**5.1. Demand Estimates**

The demand parameters from OLS, 2SLS and random coefficients logit are reported in Table 3. For space reasons, we do not report the intrinsic brand preference estimates for each of the 74 brands but instead report the manufacturer means in the first 10 rows, which are followed by the preferences for microprocessor, form factor, channel and time trend. The last row is the mean price response and the last two columns report the estimates for the heterogeneity parameters and their standard errors.

A comparison of OLS and 2SLS estimates reveals the necessity in accounting for price endogeneity. The mean price response from OLS is -0.24 versus -1.04 from 2SLS, and the corresponding elasticities are -0.58 and -2.56 respectively. A Hausman test (Wooldridge 2002, p119) of the null hypothesis that price is not endogenous yields a t-statistic of 8.88. Thus we reject the null hypothesis, finding the instrumental variables estimate to be significantly larger in magnitude than the OLS estimate.*** The negative signs on the brand preferences are due to the large relative share of the outside good or no purchase option. We also find that several of the product attributes have statistically significant effects as do the channel dummy variables. The large negative preference for the Internet relative to the other channels is due to the small penetration of that channel in our data. With more time-series observations, we could potentially estimate a year-specific preference parameter for the Internet which would reflect the evolving nature of preferences for that channel. All but two heterogeneity

*** Consistent with this result, the elasticities obtained from 2SLS estimation are also more reasonable than those from the OLS estimates (manufacturers pricing in the elastic - as opposed to inelastic - part of the demand curve).
parameters are significant at 5% or 10% level. Consumers are heterogeneous in preferences for brand, Apple processor, distribution channel and form factor and in price sensitivity. More importantly, accounting for consumer heterogeneity makes the price coefficient more negative to -1.94, an 87% increase over the 2SLS estimate. This is consistent with the elasticity estimates that go from -2.56 for the 2SLS to -3.45 for the random coefficients model.

One of the key outputs of our demand analysis that will form the basis of our policy simulations is the substitution pattern across channels and manufacturers. In Table 4 we report the channel substitution patterns. We find considerable asymmetry in the nature of these patterns. Furthermore, the substitution patterns are intuitively appealing. The three direct channels compete primarily among themselves: when direct outbound drops prices, it attracts consumers from direct inbound and the Internet; when direct inbound drops prices, its shares primarily come from direct outbound and the Internet; and when the Internet changes prices, it affects direct inbound and direct outbound the most. When the retail channel changes prices, it affects the direct channels the least.

In Table 5, we report manufacturer substitution patterns. Own elasticities range from -2.74 to -4.35 with an average around -3.45. The three direct selling manufacturers Dell, Gateway and Micron primarily compete among themselves, Compaq, HP, NEC and IBM are primary competitors, and three foreign manufacturers NEC, Toshiba and Acer are competing more among themselves. Like the pattern of substitution between the channels of distribution, the pattern of substitution between firms is also asymmetric. IBM has the biggest impact on the sales of Apple and HP, Apple has the highest impact on Toshiba and NEC, and HP has the highest impact on Compaq.

5.2. Estimates for marginal costs and downstream markups

In Table 6, we report the imputed wholesale prices, channel margin, manufacturer margin and downstream firm markup levels. For the direct channels, wholesale prices are the same as retail prices. Wholesale prices for the dealer/VAR/SI and the retail channels are lower than those in the direct channels because manufacturers have to give up some profits to other channel members. Note that marginal cost estimates vary across channel due to differences in PC products sold in the different channels. The
Internet has the lowest marginal costs primarily because its major sellers were low cost manufacturers like Dell and Gateway and because by 1998 when Internet sales started, costs had already declined.

The direct and indirect channels on average have about the same percentage margins, 31.6% and 29.6% respectively. However, manufacturers enjoy only a 17.6% margin in the indirect channels, much lower than that in the direct channels. The Internet has the highest channel margin of 36%, followed by direct outbound of 32%, and the retail channel has the lowest channel margin of 27% and the lowest manufacturer margin of 15%. Downstream firms have a 17% markup (the $r$ in the model specification) over wholesale prices with 18% for the dealer/VAR/SI channel and 16% for the retail channel.

We report the imputed wholesale prices, marginal costs and margins for the manufacturers in Table 7. The total product channel margins range from 24.1% for NEC/Packard Bell to 38.6% for Dell and the total manufacturer margins range from 17.2% to 35.7%. Downstream firms have markups from 11.9% for Micron machines to 20.9% for IBM machines.

The rank ordering of the manufacturer margin estimates that we have obtained is consistent with views in the popular press that heavily touts the Dell business model and direct selling (e.g. DiCarlo 2004). Dell has the highest wholesale prices and enjoys the highest manufacturer margin because Dell machines are primarily sold through direct channels. Toshiba has the highest retail prices and second highest wholesale prices but its manufacturer margin is the second lowest because it has the highest marginal cost and its products are primarily sold through indirect channels. Gateway has the second highest manufacturer margin because it has the lowest marginal cost and it sells primarily via direct channels. NEC/Packard Bell has the lowest manufacturer margin due to its low price and indirect selling, which might foretell NEC/Packard Bell’s withdrawal from the U.S. market a few years later.

From a manufacturer’s perspective, selling direct is much more profitable than selling indirect because they retain all the channel margins by selling direct. Manufacturers have an average of 31.6% margin in the direct channels but only 17.6% in the indirect channels, 45% lower. NEC/Packard Bell and Toshiba’s margins from indirect channel are less than half of the direct channels. This might help explain
why the direct sellers like Dell have been so successful while the indirect sellers have experienced great difficulty in competing with their direct counterparts.

5.3. Policy simulations

Given our data and consequent model specification, there are several important caveats to our policy simulations below. 1) Dropping or switching products across distribution channels may involve changes in a firm’s fixed costs. As we do not observe these fixed costs, our estimated changes in total profits and the “true” changes in profits can differ by the amount of the fixed costs, or by the differences in fixed costs between the two alternatives. 2) As our data only cover one year of Internet sales, our model and results do not reflect the evolution of preferences for that channel. Hence our simulations with respect to the Internet are necessarily limited. 3) As channel markups are estimated parameters, and as these parameters are assumed to be invariant to the policy simulation, a key assumption in our analysis is that channel markups do not change with the simulation scenarios. Given that our simulation scenarios often involve a single product line of one manufacturer, this assumption may not pose serious problem. Nevertheless we acknowledge this as a caveat to our simulation.

(1) Economic value of distribution channels

To assess the economic value of a distribution channel to a manufacturer, we drop this channel from a particular manufacturer’s distribution system, compute equilibrium prices and shares under the new distribution system and then compute changes in the manufacturer’s profits. To assess the economic value of a distribution channel to consumers, we drop the channel from all manufacturers’ distribution systems, compute equilibrium prices and shares and then compute the compensating variation.

As noted previously, when a channel is dropped from the distribution system, manufacturer profit changes come from two sources: the forgone profits from the eliminated channel and the profit changes in the remaining channels. The former equal the historical profits and are functions of channel market share and markups. The latter depend on consumers’ channel substitution patterns. When a channel is eliminated from a manufacturer’s distribution system, if the majority of its previous customers switch to other more profitable channels for the manufacturer’s products, that channel will have low economic
value to the manufacturer because maintaining a channel involves large fixed costs. On the other hand, if the majority of the consumers simply stop buying the manufacturer’s products, this channel will have high economic value to the manufacturer. The calculated economic value of each channel of distribution for each PC manufacturer is shown in Table 8A.

Economically, the most valuable channel to Compaq and HP is retail even though both firms have more sales in the dealer/VAR/SI channel. The asymmetric switching across channels primarily causes this: when the dealer/VAR/SI channel is not available, the previous customers are more likely to switch to other channels for the firms’ products. However when the retail channel is not available, most customers seem to simply stop buying the firm’s products. The most valuable channel to IBM, Apple, Toshiba and Acer is the dealer/VAR/SI channel and these manufacturers also have the most sales from this channel. Direct outbound is the most valuable channel to Dell and direct inbound is the most valuable channel to Gateway and Micron.

A noteworthy observation from Table 8A is the negative economic value of the retail channel to Gateway, which implies that Gateway would be better off were this channel to be eliminated from its distribution system. This is consistent with Gateway’s actions a few years later when it exited the retail channel. We are able to obtain this implication even with data several years prior to the time when Gateway actually closed its retail outlets.

The most valuable channel to consumers is retail, even though its market share is second to the dealer/VAR/SI channel. For the period 1995-1998, consumers would need $148 billion in compensation if the retail channel were to be eliminated, as compared to $104 billion for the dealer/VAR/SI channel. The bigger consumer surplus loss associated with the removal of the retail channel is caused by the asymmetric substitution pattern across channels. As we mentioned before, dealer/VAR/SI primarily serves the business segment and business consumers also have access to all other channels. Therefore when the dealer/VAR/SI channel is not available, its customers can switch to other channels and thus have a lower surplus loss. On the other hand, household consumers have fewer channel choices and retail is their primary channel during the time period of the data (Forrester Research Technographics 99). If this
channel were not available, they may have to drop out of the market and thus have larger surplus loss. Recall that the total PC sales in these four years were $500 billion and the estimated consumer surplus losses seem reasonable when compared to that figure. Consumers would need respectively, $80 billion and $48 billion in compensation if the direct inbound and direct outbound channels were to be removed.

We next explore further the implications of dropping a channel by examining at the level of a given firm how that decision affects its rivals, the downstream firms and the welfare of customers. Table 8B reports those results for select combinations of firms and channels. We see that were NEC to drop its direct outbound channel, it loses variable profits of $106.3 million, while its rivals’ profits will increase by $35.6 and downstream firms gain by an amount $35.6 million (recall that removing a manufacturer’s direct outbound will benefit independent downstream firms). Likewise, eliminating Dell’s dealer / VAR / SI channel will hurt it and downstream firms, but benefit its rivals. Removing Gateway’s retail channel has relatively a small impact on other rival or downstream firms. In all cases however, consumers are worse-off when a channel is removed.

(2) Dropping a product line in its entirety or from a channel

Manufacturers usually incur losses when their product lines are dropped entirely or from some channels. The losses are smaller than historical profits because some customers will buy the firm’s other products in the channel, or the same products from other channels. In Table 9 we report such results for select combinations of manufacturers / product lines/ and channels. For example, IBM will incur $662 million losses with its entire ThinkPad line eliminated, $307 million losses with the ThinkPad line eliminated from the Dealer/VAR/SI channel, and $117 million losses with it removed from the direct inbound channel. The historical profits for the four years are $688 million, $460 million and $128 million respectively.

Other manufacturers always benefit from the removal of a manufacturer’s product line due to lesser competition. When IBM’s ThinkPad line is dropped, other manufacturers’ profits will go up by $417 million. When the ThinkPad line is eliminated only from the direct outbound channel, other manufacturers’ profits will increase by $18 million.
As was the case with dropping a direct channel, downstream firms benefit if a product line is dropped from a direct channel because some of the previous customers of the product line will switch to the indirect channels. But downstream firms get hurt when a product line is dropped from an indirect channel due to direct profit losses. For example, when the ThinkPad line is dropped from the direct outbound channel, downstream profits increase by $14 million and when it is dropped from the retail channel, downstream profits decrease by $41 million.

The removal of a product line always leads to welfare losses to consumers due to less variety and fewer alternatives available. For example, when the ThinkPad line is dropped from the retail channel, consumers will need $108 million in compensation so as not to be made worse-off. The biggest loss to customers occur when IBM removes the ThinkPad line from dealer / VAR/ SI channel, indicating the strength IBM has developed in this channel. From these policy experiments, manufacturers can evaluate the value of each product line and each product line-channel combination and thus decide the best product line and channel mix.

(3) Adding a channel to a distribution system

Distribution channels differ greatly in manufacturer margin and in consumer’s intrinsic channel preferences. Manufacturers enjoy higher margins from the direct channels but direct channels have much lower sales in the time period considered and thus enjoy lower consumer intrinsic preference than the indirect channels. When a channel is added into a manufacturer’s distribution system by switching or extending product lines from another channel, the manufacturer needs to balance these two opposing factors. We simulate various channel-adding strategies for Dell, Compaq and Gateway and the results are in Table 10.

Dell entered the retail channel in the early 1990s and exited in 1994 due to huge losses.††† Through policy simulation, we can check whether Dell’s retail decision was economically justified. We add the retail channel into Dell’s distribution system by switching the Dimension line from the direct outbound, the Optiplex line from the direct inbound, or extending the Inspiron line from the direct outbound and

††† This occurred prior to our data period.
direct inbound into the retail channel by assuming the retail channel has the same markups as the dealer/VAR/SI channel for Dell’s products. We find that it was the right decision for Dell to exit the retail channel. Its prices on average decrease with the proposed moves, but its share increases are not big enough to offset the losses from lowered unit margins. If Dell were to switch any of its current product lines from the direct channels to the retail channel, it will be worse off by several million dollars. For example, if Dell switches its Dimension line to the retail, its total profits will decrease by $1.44 billion in the four years examined. The switching of the Optiplex line will result in $907 million loss for Dell. Extending product lines from the direct channels to the retail channel slightly increases Dell’s profits. But if these profits cannot recover the fixed costs associated with entering the retail channel, Dell will be better off not to enter retailing.

One of the major channel strategy shifts for Compaq in the late 1990s was to move towards direct selling. We simulate changes in Compaq’s profits by switching or extending product lines from indirect channels to direct channels. Switching product lines from retail channel to Internet or extending product lines from the Dealer/VAR/SI channel to the direct inbound and direct outbound channels will increase Compaq’s profits substantially. If the Armada line is switched from the retail to Internet, Compaq’s profits will increase by $1.5 billion.‡‡‡ If the Armada line is extended from the dealer/VAR/SI channel to the direct outbound channel, its profits will increase by $137 million. When Compaq decided to sell direct, its dealers were deeply concerned by the move (Greenberg 2000). Our policy simulations demonstrate that dealers’ worries are well grounded because any proposed move toward direct channels will lead to huge losses for the downstream firms. For instance, if Armada were switched from Dealer/VAR/SI to direct inbound, downstream firms would have to incur a profit loss of $585 million. Note this provides an upper bound for the true profit loss since in reality only part of the sales would migrate to the new channel. From the policy experiments we can see that Compaq’s decision to sell direct was economically justified, but it needed to take measures to coordinate its relations with its channel

‡‡‡ We reiterate our earlier caveat regarding the Internet for our data.
partners. We are able to obtain these implications even with data prior to the time when Compaq actually migrated channels in a big way.

Gateway’s big channel strategy shift was to close all its retail outlets and use third party retailers to market its products. We have already shown that Gateway’s own retail outlets were a net loss to the firm, but are there better channel options than entering retailing through third party retailers? We demonstrate that Gateway would have higher profits by switching retail sales to the Internet. If Gateway directs all retail sales to the Internet, its total profits will increase by $77 million even with the low intrinsic preference for the Internet during that time period.

Consumers are better off when a product line is extended to another channel because of more choices. For example, when the Inspiron line is extended from the direct inbound channel to the retail, consumer welfare increases by $200 million. Consumers are also better off when product lines are switched from the retail channel to the Internet. The shifting of Gateway’s retail sales to the Internet will increase consumer welfare by $74 million. However, consumers are worse off with the proposed switching of product lines from direct outbound or direct inbound to retail.

(4) Merger of Compaq and Hewlett-Packard

Analyses of mergers have always been an important area both for researchers and antitrust authorities. The U.S. PC industry has experienced significant mergers and market restructuring in recent years. The $25 billion Hewlett-Packard / Compaq merger in 2001 is “not only the computer industry’s largest ever deal, it is also indicative of the changing nature of the market”. “It creates a powerhouse that is competitive with IBM”. “From a PC-sector perspective we now have the number one PC company in the world that is absolutely going to be competitive with Dell”. The merger will “allow the new company to effect ‘economies of scale’ and develop a more effective business structure along the lines of rival PC-manufacturer Dell” (CNN.com 2001).

Given that our data pre-dates the actual merger, and the PC industry changed considerably in that time period, our analysis of the merger needs to be interpreted with some caution. Nevertheless, given our previous caveats, we investigate what will be the impact of the Hewlett-Packard / Compaq merger on the
new company, on rival companies, and on consumers? We simulate the potential impact on all parties involved of this gigantic merger under various post-merger channel actions. The results are reported in Table 11. The merger results in significant market power for the new company in raising prices and thus increasing its profits. Compaq-HP product prices increase by 2% to 13% and the merger alone will increase its profits by $1.1 billion in the four years considered. One of the major drivers for the merger is for the company to emulate Dell’s business model. We test this by moving sales from the indirect channels to the direct channels after the merger. We can see that, all proposed “going direct” moves will lead to profit increases for the merged company. For example, if the new company switches all Compaq dealer/VAR/SI sales to direct outbound, the company’s total profits will increase by $3.5 billion.

We note that we only model the gains from merging the PC business and we have ignored the various costs involved in integrating the two firms and other institutional issues like compatibility of corporate cultures. Thus our results should be viewed as providing an upper bound to the gains from merging the PC business. The larger question whether the merger was the right thing for HP depends on the gains from acquiring the other parts of the Compaq business (services, servers, etc.) and the acquisition price paid by HP§§§.

The merger creates stronger competition for other PC makers. For example, the merger alone will lead to $2.3 billion total losses to other PC manufacturers. The losses are higher if the new company moves sales from indirect channels to direct channels. If the new company switches all HP dealer/VAR/SI sales to the direct inbound channel, other PC manufacturers will have a total loss of $2.9 billion. We note that our computations assume that rival PC manufacturers take no actions other than choosing the new equilibrium prices under the Bertrand-Nash assumptions. In reality, these rival firms are very likely to take other measures to counteract the adverse merger effect (e.g., introduce new products) and thus our results can be viewed as an upper bound for the possible merger impact.

§§§ Note that the market structure in the US PC industry in 1995-1998 was very different from that after the merger actually occurred. In that period, HP and Compaq together took up 30% market share, more than twice the share of its nearest competitor NEC/Packard Bell. Dell was the third largest player but not far ahead of IBM and Gateway. In 2001 when the merger occurred, Dell has become the No.1 player and a real threat to all other PC makers.
The merger will also result in huge consumer welfare losses due to increased prices. In the years 1995-1998, consumers will need $35 billion compensation to maintain the pre-merger welfare level. Thus, our results indicate that, subject to our caveats, while the merger will greatly benefit the two firms involved, the effect of it on rivals, and customers will be in the opposite direction.

VI. Summary and Discussion

In this paper, we have examined manufacturers’ distribution channel and product line options in the PC industry. We first estimate a demand system with a mixed logit demand specification that produces a flexible and intuitively appealing substitution pattern across channels and manufacturers. We then present an approach to inferring wholesale prices, marginal costs and downstream markups from the pricing equations by only observing retail prices without explicitly modeling the downstream firms’ profit maximization problems. We do this by assuming brand model level symmetric marginal costs across direct and indirect channels and a simple but unknown downstream markup rule. We used the estimated demand parameters, marginal costs and downstream markups to compute the economic values of the different distribution channels to firms and to consumers, and to conduct a series of policy experiments on manufacturers’ channel and product line options. We also simulated the impact on all parties involved of the merger between Compaq-HP by considering various post-merger channel actions.

Our analysis enables us to quantify the counterfactual impact of a manufacturer’s various channel actions on the manufacturer itself, other manufacturers, downstream firms in the indirect channels and individual consumers. We are able to provide an economic rationale for various channel actions observed in the marketplace. For example, our results show that Dell’s decision to withdraw from the retail channel and Compaq’s decision to sell direct were economically justified, but Compaq needed to handle carefully its relations with downstream firms. We find that Gateway would be better off by stopping retail sales and switching to the Internet; a course of action the company subsequently chose. Our research is not only of academic interest but also of managerial significance to firms that consider restructuring their channels. Further our results are also useful for rival firms interested in understanding the impact of a channel mix change by a competing manufacturer.
One limitation of our research is that we assume the firms play the same game under the counterfactual policy scenarios. This assumption is inherent in all policy simulation studies. To the extent we believe that one product line of one manufacturer does not fundamentally alter the nature of competition in the market, this assumption seems reasonable. A more serious limitation is our assumption that retail markups are unaffected by the simulation scenarios. Modeling downstream firms’ behavior could alleviate this concern. However, this is a non-trivial task given the complexities of the distribution channels in the market for PCs. One other issue is that our policy simulations lack information on fixed costs and integration costs in the case of HP-Compaq merger. Access to data on those costs will provide a more complete picture of our simulations.

A potential direction for future research is to examine the importance of the Internet as a sales channel in the PC industry. Our data only cover the beginning of Internet sales and the conclusions on the Internet channel are only tentative. Research is needed with data that cover a longer period of online sales. With such data, we could measure time varying preferences for channels and potentially forecast these preferences to examine the long-term impact of the Internet on the PC channels of distribution. Our research methodology in conjunction with time series methods can be easily applied to such an analysis.

To conclude, we believe that this research attempts to fill a void that Franses (2005) and Bronnenberg et al. (2005) note exists in the research literature on using models for marketing policy analyses at the firm level. We have focused on a single industry (PCs) and provided some insights into how marketing channels and product lines can be combined to enhance the performance of firms and determine the effect those options can have on customer welfare. We hope it spurs other researchers to explore such policy analyses in other markets with different institutional arrangements.
References


### Table 1  Market Shares (by Units) of the Top 10 Manufacturers in the U.S. Market

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<th>Manufacturer</th>
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<th>1996</th>
<th>1997</th>
<th>1998</th>
<th>Total</th>
<th>Market share trend</th>
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### Table 2  Sales Distribution (by Units) by Channel (%)

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<tr>
<th>Manufacturer</th>
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<th>Direct Inbound</th>
<th>Dealer /VAR/SI</th>
<th>Retail</th>
<th>Internet</th>
<th>Others</th>
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*We estimate intercepts for all the 74 brands carried by the 10 manufacturers. For space reasons, we only report the means of the brand intercepts for each of the manufacturers.

** CPU4 and CPU5 are exclusively used in Apple computers.

### Table 4  Channel Substitution Pattern*

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<tr>
<th>Channel</th>
<th>Direct outbound</th>
<th>Direct inbound</th>
<th>Dealer/VAR/SI</th>
<th>Retail</th>
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<td>Others</td>
<td>0.11</td>
<td>0.12</td>
<td>0.47</td>
<td>0.16</td>
<td>0.01</td>
<td>-3.74</td>
</tr>
</tbody>
</table>

*Effect of 1% price change in column channel on row channel’s shares.
Table 5  Manufacturer Substitution Pattern*

<table>
<thead>
<tr>
<th></th>
<th>Compaq</th>
<th>NEC</th>
<th>IBM</th>
<th>Dell</th>
<th>HP</th>
<th>Apple</th>
<th>Toshiba</th>
<th>Acer</th>
<th>Gateway</th>
<th>Micron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaq</td>
<td>-3.33</td>
<td>0.23</td>
<td>0.12</td>
<td>0.10</td>
<td>0.15</td>
<td>0.12</td>
<td>0.13</td>
<td>0.09</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>NEC</td>
<td>0.39</td>
<td>-2.74</td>
<td>0.15</td>
<td>0.04</td>
<td>0.12</td>
<td>0.15</td>
<td>0.13</td>
<td>0.11</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>IBM</td>
<td>0.20</td>
<td>0.16</td>
<td>-3.84</td>
<td>0.07</td>
<td>0.10</td>
<td>0.12</td>
<td>0.06</td>
<td>0.06</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Dell</td>
<td>0.15</td>
<td>0.03</td>
<td>0.07</td>
<td>-2.89</td>
<td>0.06</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>HP</td>
<td>0.39</td>
<td>0.19</td>
<td>0.16</td>
<td>0.09</td>
<td>-3.45</td>
<td>0.08</td>
<td>0.12</td>
<td>0.09</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Apple</td>
<td>0.30</td>
<td>0.20</td>
<td>0.18</td>
<td>0.06</td>
<td>0.08</td>
<td>-3.49</td>
<td>0.13</td>
<td>0.08</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Toshiba</td>
<td>0.38</td>
<td>0.23</td>
<td>0.11</td>
<td>0.05</td>
<td>0.13</td>
<td>0.15</td>
<td>-4.35</td>
<td>0.10</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Acer</td>
<td>0.34</td>
<td>0.24</td>
<td>0.13</td>
<td>0.06</td>
<td>0.13</td>
<td>0.13</td>
<td>-3.71</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Gateway</td>
<td>0.09</td>
<td>0.02</td>
<td>0.05</td>
<td>0.04</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>-3.22</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Micron</td>
<td>0.17</td>
<td>0.05</td>
<td>0.06</td>
<td>0.39</td>
<td>0.04</td>
<td>0.05</td>
<td>0.05</td>
<td>0.03</td>
<td>0.15</td>
<td>-4.11</td>
</tr>
</tbody>
</table>

* The impact on row manufacturer’s share of column manufacturer’s 1% price change

Table 6  Mean prices, Marginal Costs and Margins by Channel

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mean retail price</th>
<th>Mean wholesale price</th>
<th>Mean MC</th>
<th>Channel margin (%)</th>
<th>Mean manufacturer margin (%)</th>
<th>Downstream markup (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct outbound</td>
<td>2,496</td>
<td>2,496</td>
<td>1,716</td>
<td>32.49</td>
<td>32.49</td>
<td>18.10</td>
</tr>
<tr>
<td>Direct inbound</td>
<td>2,419</td>
<td>2,419</td>
<td>1,675</td>
<td>32.01</td>
<td>32.01</td>
<td>18.10</td>
</tr>
<tr>
<td>Dealer/VAR/SI</td>
<td>2,566</td>
<td>2,141</td>
<td>1,756</td>
<td>31.14</td>
<td>19.06</td>
<td>18.10</td>
</tr>
<tr>
<td>Retail</td>
<td>2,436</td>
<td>2,072</td>
<td>1,767</td>
<td>26.83</td>
<td>14.94</td>
<td>16.28</td>
</tr>
<tr>
<td>Internet</td>
<td>2,234</td>
<td>2,234</td>
<td>1,492</td>
<td>35.67</td>
<td>35.67</td>
<td>35.67</td>
</tr>
<tr>
<td>Others</td>
<td>2,389</td>
<td>2,389</td>
<td>1,696</td>
<td>30.49</td>
<td>30.49</td>
<td>30.49</td>
</tr>
<tr>
<td>Total</td>
<td>2,458</td>
<td>2,291</td>
<td>1,717</td>
<td>30.75</td>
<td>25.77</td>
<td>17.44</td>
</tr>
</tbody>
</table>

Channel margin = (retail price-MC)/retail price
Manufacturer margin = (wholesale price-MC)/wholesale price
Downstream markup (r) = (retail price-wholesale price)/wholesale price

Table 7  Mean prices, Marginal Costs and Margins by Manufacturer

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Mean retail price</th>
<th>Mean wholesale price</th>
<th>Mean marginal cost</th>
<th>Channel margin (%)</th>
<th>Mean manufacturer margin (%)</th>
<th>Mean downstream markup (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2,458</td>
<td>2,291</td>
<td>1,717</td>
<td>30.75</td>
<td>25.77</td>
<td>17.44</td>
</tr>
</tbody>
</table>

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### Table 8A  Economic Value of Distribution Channels to Firms & Consumers (1995-1998 total: US$ Million)*

<table>
<thead>
<tr>
<th>Channel</th>
<th>Direct outbound</th>
<th>Direct inbound</th>
<th>Dealer/VAR/SI</th>
<th>Retail</th>
<th>Internet</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaq</td>
<td>130.7</td>
<td>750.3</td>
<td>3026.8</td>
<td>3422.5</td>
<td>6.3</td>
<td>914.3</td>
</tr>
<tr>
<td>NEC</td>
<td>106.3</td>
<td>25.0</td>
<td>629.4</td>
<td>6171.6</td>
<td>222.7</td>
<td>265.2</td>
</tr>
<tr>
<td>IBM</td>
<td>274.6</td>
<td>367.0</td>
<td>1809.8</td>
<td>846.5</td>
<td>12.2</td>
<td>578.8</td>
</tr>
<tr>
<td>DELL</td>
<td>4743.3</td>
<td>1961.9</td>
<td>1373.9</td>
<td>958.7</td>
<td>12.2</td>
<td>56.8</td>
</tr>
<tr>
<td>HP</td>
<td>397.2</td>
<td>118.2</td>
<td>1168.9</td>
<td>248.3</td>
<td>3.6</td>
<td>35.6</td>
</tr>
<tr>
<td>Apple</td>
<td>25.0</td>
<td>49.3</td>
<td>680.1</td>
<td>543.0</td>
<td>13.4</td>
<td>28.9</td>
</tr>
<tr>
<td>Toshiba</td>
<td>32.9</td>
<td>828.2</td>
<td>1312.8</td>
<td>-1.3</td>
<td>63.3</td>
<td>14.3</td>
</tr>
<tr>
<td>Acer</td>
<td>35.6</td>
<td>32.4</td>
<td>344.4</td>
<td>233.2</td>
<td>6525.8</td>
<td>46,548.0</td>
</tr>
<tr>
<td>Gateway</td>
<td>148,782.3</td>
<td>1278.7</td>
<td>103,699.1</td>
<td>148,782.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micron</td>
<td>35,6</td>
<td>32,4</td>
<td>344.4</td>
<td>233.2</td>
<td>6525.8</td>
<td>46,548.0</td>
</tr>
<tr>
<td>Consumers</td>
<td>48,046.3</td>
<td>80,086.2</td>
<td>130,699.1</td>
<td>148,782.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Standard errors are computed via bootstrapping method (Wooldridge 2001, p379) and are available from the authors.

### Table 8B  Policy Simulation: Dropping a Channel (1995-1998 total: US$ Million)

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mfr’s profit change</th>
<th>Other mfrs’ Profit change</th>
<th>Downstream profit change</th>
<th>Net profit change</th>
<th>CV</th>
<th>Total welfare effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gateway’s dealer/VAR/SI</td>
<td>-31.2</td>
<td>18.2</td>
<td>-18.4</td>
<td>-31.4</td>
<td>157.6</td>
<td>-189.0</td>
</tr>
<tr>
<td>Gateway’s retail</td>
<td>1.3</td>
<td>7.3</td>
<td>-4.2</td>
<td>4.4</td>
<td>22.4</td>
<td>-18.0</td>
</tr>
<tr>
<td>Dell’s dealer/VAR/SI</td>
<td>-171.5</td>
<td>100.1</td>
<td>-74.4</td>
<td>-145.9</td>
<td>565.2</td>
<td>-711.0</td>
</tr>
<tr>
<td>NEC’s direct outbound</td>
<td>-106.3</td>
<td>35.6</td>
<td>16.6</td>
<td>-54.1</td>
<td>728.4</td>
<td>-782.6</td>
</tr>
</tbody>
</table>

### Table 9  Policy Simulation: Dropping a Product Line (1995-1998 total: US$ Million)

<table>
<thead>
<tr>
<th>Product Line</th>
<th>Mfr’s profit change</th>
<th>Other mfrs’ Profit change</th>
<th>Downstream profit change</th>
<th>Net profit change</th>
<th>CV</th>
<th>Total welfare effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dropping entire product line</td>
<td>-662.0</td>
<td>417.3</td>
<td>-758.2</td>
<td>-1,003.0</td>
<td>6,148.9</td>
<td>-7,151.9</td>
</tr>
<tr>
<td>IBM ThinkPad line</td>
<td>-299.6</td>
<td>66.8</td>
<td>18.1</td>
<td>-214.7</td>
<td>627.1</td>
<td>-841.7</td>
</tr>
<tr>
<td>Apple iMac line</td>
<td>-1,124.1</td>
<td>1,100.3</td>
<td>-360.5</td>
<td>-384.4</td>
<td>5,368.8</td>
<td>-5,753.2</td>
</tr>
<tr>
<td>Toshiba Satellite line</td>
<td>-538.2</td>
<td>810.3</td>
<td>11.2</td>
<td>283.3</td>
<td>1,953.5</td>
<td>-1,652.0</td>
</tr>
</tbody>
</table>

### Table 10  Policy Simulation: Adding a Channel (1995-1998 total: US$ million)

<table>
<thead>
<tr>
<th>Channel</th>
<th>Mfr’s profit change</th>
<th>Other mfrs’ Profit change</th>
<th>Downstream profit change</th>
<th>Net profit change</th>
<th>CV</th>
<th>Total welfare effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch entire channel sales</td>
<td>Gateway: retail to Internet</td>
<td>77.0</td>
<td>-80.2</td>
<td>-31.3</td>
<td>-34.5</td>
<td>-74.3</td>
</tr>
<tr>
<td>Switch a product line</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dell Dimension: direct outbound to retail</td>
<td>-1,439.1</td>
<td>231.4</td>
<td>75.4</td>
<td>-1132.3</td>
<td>4,119.9</td>
<td>-5,252.2</td>
</tr>
<tr>
<td>Dell Optiplex: direct inbound to retail</td>
<td>-907.5</td>
<td>109.5</td>
<td>35.4</td>
<td>-762.6</td>
<td>2,502.5</td>
<td>-3,265.1</td>
</tr>
<tr>
<td>Compaq Armada: retail to Internet</td>
<td>1,459.5</td>
<td>-702.8</td>
<td>-516.4</td>
<td>240.2</td>
<td>-1,803.9</td>
<td>2,044.2</td>
</tr>
<tr>
<td>Extend a product line to another channel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dell Inspiron: direct outbound &amp; retail</td>
<td>33.5</td>
<td>-40.8</td>
<td>3.3</td>
<td>-4.0</td>
<td>-118.6</td>
<td>114.6</td>
</tr>
<tr>
<td>Dell Inspiron: direct inbound &amp; retail</td>
<td>32.7</td>
<td>-35.0</td>
<td>1.3</td>
<td>-1.0</td>
<td>-200.2</td>
<td>199.2</td>
</tr>
<tr>
<td>Compaq Armada: dealer/VAR/SI &amp; D.O.</td>
<td>136.8</td>
<td>-709.7</td>
<td>-137.5</td>
<td>-710.4</td>
<td>-1,913.5</td>
<td>1,203.1</td>
</tr>
<tr>
<td>Compaq Armada: dealer/VAR/SI &amp; D.I.</td>
<td>137.6</td>
<td>-585.0</td>
<td>-113.4</td>
<td>-560.9</td>
<td>-1,744.9</td>
<td>1,184.0</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Channel</th>
<th>Mfr’s profit change</th>
<th>Other mfrs’ Profit change</th>
<th>Downstream profit change</th>
<th>Net Profit change</th>
<th>CV</th>
<th>Total Welfare effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merger only</td>
<td>1,123</td>
<td>-2,289</td>
<td>-1,069</td>
<td>-2,236</td>
<td>34,999</td>
<td>-37,235</td>
</tr>
<tr>
<td>HP sales: from dealer/VAR/SI to D.I.</td>
<td>2,293</td>
<td>-2,933</td>
<td>-2,490</td>
<td>-3,130</td>
<td>32,648</td>
<td>-35,778</td>
</tr>
<tr>
<td>HP sales: from retail to Internet</td>
<td>1,324</td>
<td>-3,365</td>
<td>-1,697</td>
<td>-3,738</td>
<td>24,040</td>
<td>-27,778</td>
</tr>
<tr>
<td>Compaq sales: from dealer/VAR/SI to D.O.</td>
<td>3,518</td>
<td>-5,783</td>
<td>-3,489</td>
<td>-5,754</td>
<td>35,003</td>
<td>-40,756</td>
</tr>
<tr>
<td>Compaq sales: from dealer/VAR/SI to D.I.</td>
<td>5,002</td>
<td>-6,135</td>
<td>-3,691</td>
<td>-4,823</td>
<td>34,796</td>
<td>-39,619</td>
</tr>
<tr>
<td>Armada sales: from retail to Internet</td>
<td>1,518</td>
<td>-6,160</td>
<td>-1,568</td>
<td>-6,210</td>
<td>30,958</td>
<td>-37,168</td>
</tr>
</tbody>
</table>