A Decomposition of the Sources of Incomplete Cross-Border Transmission: The Case of Beer*

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Abstract

Despite its importance, we have a limited understanding of the microeconomics of the international transmission of shocks. The conventional wisdom is that price changes are the primary mechanism by which shocks are transmitted across borders. Yet traded-goods prices exhibit large and persistent differences across countries. This paper quantifies the sources of this incomplete transmission, that is, this price inertia using the example of the beer market. The paper seeks to synthesize two disparate literatures on the sources of price inertia in the face of shocks. The empirical trade literature on this topic which includes Goldberg and Verboven (2001) attributes this price inertia to a local cost component and to markup adjustments by manufacturers and retailers, but without modeling the role of each of these factors at each stage along a distribution chain. Burstein, Neves, and Rebelo (2003) and Corsetti and Dedola (2002) attribute local-currency price stability entirely to the share of local non-traded costs in final-goods prices, but do not allow for a role for markup adjustment by manufacturers and retailers. This paper is the first to quantify the relative importance of these two factors in the incomplete transmission of shocks to prices. The paper documents two basic facts about the transmission of shocks across borders. First, there is a nonlinear relationship between integration at the microeconomic level (proxied for by market share) and the transmission of shocks to prices; Second, a local component in manufacturers' costs explains a large part of the incomplete transmission though markup adjustment by manufacturers and retailers plays a nontrivial role. These facts are analyzed within the framework of an oligopoly model.

Keywords: cross-border transmission; international price discrimination.

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1 Introduction

Despite its importance, we have a limited understanding of the microeconomics of the cross-border transmission of shocks. The conventional wisdom is that price changes are the primary mechanism by which shocks are transmitted across borders. Yet traded-goods prices exhibit large and persistent differences across countries. This paper quantifies the sources of this incomplete transmission, that is, this price inertia using the example of the beer market.

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The paper documents two basic facts about the transmission of shocks across borders. First, there is a nonlinear relationship between integration at the microeconomic level (proxied for by market share) and the transmission of shocks to prices; Second, a local component in manufacturers' costs explains a large part of the incomplete transmission though markup adjustment by manufacturers and retailers plays a nontrivial role.

These facts are analyzed within the framework of an oligopoly model. The paper has two goals: first, to document at the product level when shocks are transmitted across borders; and second, to identify the sources of their incomplete transmission within the framework of an oligopoly model.

The paper differs from previous work in three ways. First, I model the vertical relationships between manufacturers and retailers, which enables a richer analysis of the causes of incomplete transmission than was possible with previous models. Second, I use a product-level analysis to investigate the causes of incomplete transmission along a distribution chain. Though several recent papers have investigated the role of the distribution chain, and in particular, of a local cost component in the incomplete transmission of foreign cost shocks to final-goods prices, their work has relied on aggregate data with their well-known limitations. Third, I use an oligopoly framework that allows me to address questions about the sources of transmission at a microeconomic level.

I begin my analysis by documenting in reduced-form regressions whether prices are systematically related to factors such as exchange-rate fluctuations and the share of local nontraded costs in final-goods prices. I then turn to a more systematic analysis of the sources of incomplete transmission. I estimate a structural econometric model that links firms' pass-through behavior to strategic interactions with other firms (supply conditions) and to interactions with consumers (demand conditions). Using the estimated demand system, I conduct counterfactual experiments to quantify how a foreign cost shock affects domestic and foreign firms' profits and consumer surplus. My general strategy is to estimate brand-level demand and then to use those estimates jointly with assumptions about firms' pricing behavior to recover both retail and manufacturer marginal costs without observing actual costs. I then use the estimated demand system, assumptions about firms' pricing behavior, and the derived marginal costs to compute the new equilibrium following a shock to foreign brands' marginal costs. I compute the change in firms' profits and in consumer surplus using the new equilibrium prices and quantities.

Theoretical work has shown that the response of prices to cost shocks depends on the curvature of demand. This implies that pass-through results may depend on particular functional-form assumptions. I address this issue by estimating a very flexible demand system and by examining if my parameter estimates are consistent with industry lore and with price responses to exchange-rate and local-cost fluctuations in reduced-form regressions. In addition, I empirically test for the best-fit vertical market structure in the beer market in another paper, Hellerstein (2004), by comparing accounting price-cost margins to the derived price-cost margins each vertical model produces and by using non-nested tests developed by Villas-Boas (2004). This paper's empirical analysis focuses on the best-fit vertical market structure for this industry, that is, double marginalization with manufacturers acting as multi-product firms.[1]

I choose to study the beer market for several reasons. First, beer is a good that is fairly concentrated at the manufacturer level, consistent with my assumption of oligopoly. Because manufactured goods' prices tend to exhibit dampened responses to foreign shocks in aggregate data, beer is an appropriate choice to investigate the puzzling phenomenon of incomplete transmission. Second, trade barriers such as voluntary export restraints or antidumping sanctions that likely distort price-setting behavior in other industries, such as autos or textiles, are rarely threatened or imposed in this industry. For example, no anti-dumping cases have been brought in the U.S. beer industry in the past fifteen years. This simplifies the analysis of price inertia as it does not need to control for the effect of trade barriers, whether threatened or imposed, on firms' price-setting behavior. Third, I have a rich panel data set with monthly retail and wholesale prices for 34 products from a number of manufacturers over 40 months (July 1991-December 1994). It is unusual to observe both retail- and wholesale-price data for a single product. These data allow

[1] In the double-marginalization model, manufacturers set their prices first and the retailer then sets its prices taking the wholesale prices it observes as given. Thus, a double margin is added to manufacturers' marginal cost. See Tirole (1988).

me to assess how well the model captures wholesale-price movements.

The rest of the paper proceeds as follows. In the next section, I discuss the market and data along with some preliminary descriptive results. Section 3 sets out the theoretical model, and section 4 the estimation methodology. Results from the random-coefficients demand model are reported in section 5, and the results of the counterfactual experiments in section 6. The last section concludes.

2 A First Look at the Market and the Data

In this section I describe the beer market my data cover. I then present summary statistics for the data and some preliminary descriptive results.

2.1 Market

As recently as 1970, imported beers made up less than one percent of total U.S. beer consumption. Consumption of imported brands grew slowly in the 1980s and by double digits for each year in the 1990s resulting in a market share of over seven percent by the end of the decade. Despite these changes, the U.S. beer industry remains quite concentrated at the manufacturer level. The three largest domestic brewers *Anheuser-Busch* (45%), *Adolph Coors* (10%), and *Miller Brewing* (23%) together account for roughly 80 percent of U.S. beer sales.

Beer exemplifies one type of imported good: packaged goods imported for consumption. Such imports do not require any further production process before reaching consumers. Beer shipments to supermarkets in Illinois are handled by independent wholesale distributors for most brands. The model abstracts from this additional step in the vertical chain, as the brewers set their distributors' prices through a practice known as *resale price maintenance* and cover a significant portion of their distributors' marginal costs. This practice makes the analysis of pricing behavior along the distribution chain relatively straight-forward.

During the 1990s supermarkets increased the selection of beers they offered as well as the total shelf space devoted to beer. A study from this period found that beer was the tenth most frequently purchased item and the seventh most profitable item for the average U.S. supermarket.[2] Supermarkets sell approximately 20 percent of all beer consumed in the U.S. As my data focus on one metropolitan statistical area, I do not need to control for variation in retail alcohol sales regulations. Such regulations can differ considerably across states.

2.2 Data

My data come from *Dominick's Finer Foods*, the second-largest supermarket chain in the Chicago metropolitan area in the mid 1990s with a market share of roughly 20 percent. I have a rich scanner data set that records retail prices for each product sold by *Dominick's* over a period of four years. The data come from the *Kilts Center for Marketing* at the University of Chicago and include aggregate retail volume market shares and retail prices for 34 brands produced by 18 manufacturers. Summary statistics for prices, servings sold, and volume market shares are provided in Table 1. Of the chain's 88 stores, I include only those that report prices for the full sample period. My data contain roughly two-thirds (56) of the chain's stores.

I aggregate data from each *Dominick's* store into one of three price zones. These zones are defined by *Dominick's* mainly on the basis of customer demographics. Although they do not report these zones, I was able to identify them through zip-code level demographics (with a few exceptions, each *Dominick's* store in my sample is the only store located in its zip code) and by

[2] Canadian Trade Commissioner (2000).

comparing the average prices charged for the same product across stores. I classify each store according to its pricing behavior as a low-, medium-, or high-price store. I then aggregate sales across the stores in each pricing zone. This aggregation procedure retains some cross-sectional variation in the data which is helpful for the demand estimation. Residents' income covaries positively with retail prices across the three zones.

I define a product as one twelve-ounce serving of a brand of beer. Quantity is the total number of servings sold per month. I define a market as one of *Dominick's* price zones in one month. The potential market is defined as the total beer purchased in supermarkets by the residents of the zip codes in which each *Dominick's* store is located. During this period, the annual per-capita consumption of beer in the U.S. was 22.6 gallons. This implies the potential market for total beer consumption to be 20 servings per capita per month in each pricing zone, that is: 1 gallon=128 ounces, so $\frac{(22.6*128)}{12*12} = 20.1$ servings per month. The potential market for beer sold in supermarkets is 20 percent of the total potential market for beer sales. Each adult consumes on average 4 servings per month that were purchased at a supermarket. So the potential market of beer servings sold in supermarkets is 4 multiplied by the resident adult population in each pricing zone.

I define the outside good to be all beer sold by other supermarkets to residents of the same zip codes as well as all beer sales in the sample's *Dominick's* stores not already included in my sample. These *Dominick's* sales mainly consist of microbrewery or other specialty brands, each with a relatively small market share. The share of *Dominick's* total revenue from beer sales included in my sample is high, with a mean of 65.04 percent. The combined volume market share of products covered in the sample is on average 18.46 percent, though it is much higher in the medium and high pricing zones, at 24.11 percent and 20.10 percent, respectively, than in the low pricing zone, where it is only 11.17 percent. Promotions occur infrequently in the *Dominick's* data. Bonus-buy sales appear to be the most common promotion used for beer which appear in the data as price reductions.

I supplement the *Dominick's* data with information on manufacturer costs, product characteristics, advertising, and the distribution of consumer demographics. Product characteristics come from the ratings of a *Consumer Reports* study conducted in 1996. Table 2 reports summary statistics for the following characteristics: percent alcohol, calories, bitterness, maltiness, hops, sulfury, fruity, and floral.

Manufacturer cost data for use as instruments come from the U.S. Department of Labor's Foreign Labor Statistics Program. The joint distribution of each pricing zone's residents with respect to age and income comes from the 1990 *U.S. Census*. To construct appropriate demographics for each pricing zone, I collected a sample of the joint distribution of residents' age and income for each zip code in which a *Dominick's* store was located. I then aggregate the data across each pricing zone to get one set of demographics for each zone.

2.3 Preliminary Descriptive Results

I begin my analysis by documenting in reduced-form regressions whether prices are systematically related to factors such as exchange-rate fluctuations and the share of local nontraded costs in final-goods prices. I estimate the following basic price equation:

$$\ln(p_{jt}) = \ln(w_{jt}) + \ln(e_{jt}) + \ln(s_{jt}) \tag{1}$$

where the subscripts j and t refer to product j in market t where a market is defined as a month and price-zone pair, p is the product's price, w is a measure of local wages, e is the nominal exchange rate, and s is the quantity sold. Table 3 gives the results of a regression of the log of the retail price on the log of a measure of local costs: hourly wages paid in the grocery sector in Illinois from 1991-1994. The share of variation in the retail price attributed to movements in local costs is 62 percent. This leads us to calibrate the model so that roughly 60 percent of the retail price's movement will be attributable to nontraded local costs.

3 Model

This section describes the supply model and derives simple expressions to compute pass-through coefficients. It then sets out the random-coefficients model used to estimate demand.

3.1 Supply

Consider a double-marginalization supply model in which manufacturers act as Bertrand oligopolists with differentiated products. Strategic interactions between manufacturers and the single retailer with respect to prices follow a sequential Nash model. Manufacturers set their prices first and the retailer then sets its prices taking the wholesale prices it observes as given. Thus, a double margin is added to the marginal cost to produce the product. To solve the model, one uses backwards induction and solves the retailer's problem first. The variety of potential interactions between manufacturers, retailers, and consumers makes any theoretical prediction about welfare effects contingent on fairly precise assumptions about consumer or firm behavior. The model considers only one retailer as the data used for the empirical analysis have prices for only a single retail firm.

3.1.1 Retailer

Consider a single retail firm that sells all of the market's J differentiated products. Let all firms use linear pricing and face constant marginal costs. The profits of the retail firm in market t are given by:

$$\Pi_{jt}^{r} = \left(p_{jt}^{r} - p_{jt}^{w} - ntc_{jt}^{r}\right) s_{jt}(p_{t}^{r}) \tag{2}$$

where p_{jt}^{r} is the price the retailer sets for product j, p_{jt}^{w} is the wholesale price paid by the retailer for product j, ntc_{jt}^{r} are destination-market nontraded costs paid by the retailer to sell product j, and $s_{jt}(p^{r})$ is the quantity demanded of product j which is a function of the prices of all J products. Assuming a Bertrand-Nash equilibrium in prices, and that the retailer acts as a profit maximizer, the retail price p_{jt}^{r} must satisfy the first-order profit-maximizing conditions:

$$s_{jt} + \sum_{k} \left(p_{kt}^{r} - p_{kt}^{w} - ntc_{kt}^{r}\right) \frac{\partial s_{kt}}{\partial p_{jt}^{r}} = 0, \text{ for } j = 1, 2, ..., J_{t}. \tag{3}$$

This gives us a set of J equations, one for each product. One can solve for the markups by defining $S_{jk} = -\frac{\partial s_{kt}(p_{t}^{r})}{\partial p_{jt}^{r}}$ $j, k = 1, ..., J.$, and a $J \times J$ matrix Ω_{rt} called the retailer reaction matrix with the jth, kth element equal to S_{jk} , the marginal change in the kth product's market share given a change in the jth product's retail price. The stacked first-order conditions can be rewritten in vector notation:

$$s_{t} + \Omega_{rt}(p_{t}^{r} - p_{t}^{w} - ntc_{t}^{r}) = 0 \tag{4}$$

and inverted together in each market to get the retailer's pricing equation, in vector notation:

$$p_t^r = p_t^w + ntc_t^r + (\Omega_{rt})^{-1} s_t \tag{5}$$

where for product j in market t:

$$p_{jt}^r = \begin{cases} p_{jt}^w + ntc_{jt}^r - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p_{jt}^r}}, \text{ for } j = 1, 2, ..., J_t. \\ \\ \text{wholesale price +non-traded costs+markup function} \end{cases} \tag{6}$$

3.1.2 Manufacturers

Let there be M manufacturers that each produce some subset Γ_{mt} of the market's J_t differentiated products. Each manufacturer chooses its wholesale price p_{jt}^w while assuming the retailer behaves according to its first-order condition (3). The manufacturer's profit function is:

$$\Pi_{jt}^w = \sum_{j \in \Gamma_{mt}} \left(p_{jt}^w - mc_{jt}^w\right) s_{jt}(p_t^r\left(p_t^w\right)) \tag{7}$$

where mc_{jt}^w has two components: tc_{jt}^w are traded costs and ntc_{jt}^w are destination-market nontraded costs incurred by the manufacturer to produce and sell product j.[3] Assuming a Bertrand-Nash equilibrium in prices and that all manufacturers act as profit maximizers, the wholesale price p_{jt}^w must satisfy the first-order profit-maximizing conditions:

$$s_{jt} + \sum_{k \in \Gamma_{mt}} (p_{kt}^w - mc_{kt}^w) \frac{\partial s_{kt}}{\partial p_{jt}^w} = 0 \text{ for } j = 1, 2, ..., J_t. \tag{8}$$

[3]Nontraded costs incurred by the manufacturer in its home country are treated as part of its traded costs. As such nontraded costs will be denominated in the home country's currency, they will be subject to shocks caused by variation in the nominal exchange rate which nontraded costs incurred in the destination market will not.

This gives us another set of J equations, one for each product. Note, however, that equation 6 derives a value for $p^w_{jt} + ntc^r_{jt}$, not for p^w_{jt} alone. We can rewrite the manufacturers' first-order conditions to reflect this fact:

$$s_{jt} + \left(p^w_{jt} + ntc^r_{jt} - mc^w_{jt} + ntc^r_{jt}\right) \frac{\partial s_{jt}}{\partial p^w_{jt}} = 0, \text{ for } j = 1, 2, ..., J_t. \tag{9}$$

Let Ω_{wt} be the manufacturer's reaction matrix with elements $\frac{\partial s_{kt}(p^r(p^w))}{\partial mc^r_{jt}}$, the change in each product's share with respect to a change in each product's marginal cost to the retailer. Multiproduct firms are represented by a manufacturer ownership matrix, T_w, with elements $T_w\,(j,k) = 1$ if both products j and k are produced by the same manufacturer, and zero otherwise. T_w post-multiplies the manufacturer reaction matrix Ω_{wt} element by element. The manufacturer's reaction matrix is a transformation of the retailer's reaction matrix: $\Omega_{wt} = \Omega'_{pt}\Omega_{rt}$ where Ω_{pt} is a J-by-J matrix of the partial derivative of each retail price with respect to each product's marginal cost to the retailer. Each column of Ω_{pt} contains the entries of a response matrix computed without observing the retailer's marginal costs. This manufacturer response matrix is derived in Villas-Boas (2002). The (jth, kth) entry in Ω_{pt} is the partial derivative of the kth product's retail price with respect to the jth product's retail marginal cost for that market. The (jth, kth) element of Ω_{wt} is the sum of the effect of the jth product's retail marginal cost on each of the J products' retail prices which in turn each affect the kth product's retail market share, that is: $\sum_m \frac{\partial s^r_{kt}}{\partial p^r_{mt}} \frac{\partial p^r_{mt}}{\partial p^w_{jt}}$ for $m = 1, 2, ...J$. The manufacturers' marginal costs are recovered by inverting the multiproduct manufacturer reaction matrix $\Omega_{wt}. * T_w$ for each market t:

$$p^w_t + ntc^r_t = mc^w_t + ntc^r_t + \left(\Omega_{wt}\left(p^r\left(p^w\right)\right). * T_w\right)^{-1} s_t(p^r_t\left(p^w_t\right)) \tag{10}$$

where for product j in market t:

$$(11) \qquad p_{jt}^{w} + ntc_{jt}^{r} = \begin{cases} mc_{jt}^{w} + ntc_{jt}^{r} - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}, \text{ for } j = 1, 2, ..., J_t. \\ tc_{jt}^{w} + ntc_{jt}^{w} + ntc_{jt}^{r} - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}, \text{ for } j = 1, 2, ..., J_t. \\ \text{manufacturer traded costs + manufacturer nontraded costs+} \\ \text{retailer nontraded costs+manufacturer markup function} \end{cases}$$

The manufacturer of product j can use its estimate of the retailer's nontraded costs and reaction function to compute how a change in the manufacturer price will affect the retailer price for its product. Manufacturers can assess the impact on the vertical profit, the size of the pie, as well as its share of the pie by considering the retailer reaction function before choosing a price. Manufacturers may also act strategically with respect to one another. The retailer mediates these interactions by its pass-through of a given manufacturer's price change to the product's retail price. Manufacturers set prices after considering the nontraded costs the retailer must incur, the retailer's pass-through of any manufacturer price changes to the retail price, and other manufacturers' and consumers' reactions to any retail-price changes.

3.1.3 Counterfactual Experiments: Pass-Through Coefficients

To recover pass-through coefficients I estimate the effect of a shock to foreign firms' marginal costs on all firms' wholesale and retail prices by computing a new Bertrand-Nash equilibrium. Suppose a shock hits the traded component of the jth product's marginal cost. To compute the manufacturer pass-through, one substitutes the new vector of traded marginal costs, tc_t^{w*}, into the system of J nonlinear equations that characterize manufacturer pricing behavior, and then searches for the wholesale price vector p_t^{w*} that will solve the system in each market t:

(12)
$$p_{jt}^{w*} = \begin{cases} tc_{jt}^{w*} + ntc_{jt}^{w} - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}, \text{ for } j = 1, 2, ..., J_t. \\ \\ \text{traded +nontraded costs +markup function} \end{cases}$$

One can gauge the pass-through effect by taking the partial derivative of p_{jt}^{w} with respect to tc_{jt}^{w} :

(13)
$$\frac{\partial p_{jt}^{w}}{\partial tc_{jt}^{w}} = 1 + \frac{s_{jt}\frac{d^2 s}{\partial p_{jt}^{w2}}\frac{\partial p_{jt}^{w}}{\partial tc_{jt}^{w}}}{\left(\frac{\partial s_{jt}}{\partial p_{jt}^{w}}\right)^2} - \frac{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}\frac{\partial p_{jt}^{w}}{\partial tc_{jt}^{w}}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}$$

And rearranging terms:

(14)
$$\frac{\partial p_{jt}^{w}}{\partial tc_{jt}^{w}} = \frac{1}{2 - s_{jt}\frac{\frac{d^2 s}{\partial p_{jt}^{w2}}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}\frac{1}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}} = \frac{1}{2 - \frac{\text{market share}\cdot\text{curvature coefficient}}{\text{slope of derived demand}}}$$

(15)
$$\frac{\partial p_{jt}^{w}}{\partial tc_{jt}^{w}}\frac{tc_{jt}^{w}}{p_{jt}^{w}} = \frac{1}{\left(2 - s_{jt}\frac{\frac{d^2 s}{\partial p_{jt}^{w2}}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}\frac{1}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}\right)\cdot\frac{p_{jt}^{w}}{mc_{jt}^{w}}\frac{mc_{jt}^{w}}{tc_{jt}^{w}}} = \frac{1}{2 - \frac{\text{market share}\cdot\text{curvature coefficient}}{\text{slope of derived demand}}\cdot\frac{p_{jt}^{w}}{mc_{jt}^{w}}\frac{mc_{jt}^{w}}{tc_{jt}^{w}}}$$

The wholesale pass-through rate is given by: $PT^w = \frac{\left(p_{jt}^{w*} - p_{jt}^{w}\right)}{p_{jt}^{w*} + p_{jt}^{w}} \cdot \frac{tc_{jt}^{w*} + tc_{jt}^{w}}{tc_{jt}^{w*} - tc_{jt}^{w}}$. Equation 15 shows that it is determined by the jth good's market share s_{jt}, the curvature of the derived demand curve with respect to the wholesale price, summarized by the curvature coefficient, $\frac{\frac{d^2 s}{\partial p_{jt}^{w2}}}{\frac{\partial s_{jt}}{\partial p_{jt}^{w}}}$, the slope of the derived demand curve with respect to the wholesale price, $\frac{\partial s_{jt}}{\partial p_{jt}^{w}}$, the manufacturer's margin, $\frac{p_{jt}^{w}}{mc_{jt}^{w}}$, and the ratio of the manufacturer's total marginal cost to the traded component of its marginal cost, $\frac{mc_{jt}^{w}}{tc_{jt}^{w}}$. When derived demand is linear, so $\frac{d^2 s}{\partial p_{jt}^{w2}} = 0$, then $\frac{\partial p_{jt}^{w}}{\partial tc_{jt}^{w}} = \frac{1}{2}$. As the derived demand curve gets flatter and becomes more elastic, that is, as $\left|\frac{\partial s_{jt}}{\partial p^w_{jt}}\right|$ rises, pass-through falls if the second derivative is positive, and rises if the second derivative is negative. When the derived demand curve is less concave than the linear case so $\frac{d^2 s}{\partial p^{w2}_{jt}} > 0$, $\frac{\partial p^w_{jt}}{\partial tc^w_{jt}} > \frac{1}{2}$, manufacturer pass-through rises. When the derived demand curve is more concave than the linear case so $\frac{d^2 s}{\partial p^{w2}_{jt}} < 0$, $\frac{\partial p^w_{jt}}{\partial tc^w_{jt}} < \frac{1}{2}$, manufacturer pass-through falls. As the curvature coefficient rises, manufacturer pass-through falls if the second derivative is negative, and rises if the second derivative is positive. A firm's market power and cost structure also determine its pass-through rate: as a product's market share s_{jt}, manufacturer margin $\frac{p^w_{jt}}{mc^w_{jt}}$, or ratio of total marginal cost to traded marginal costs rises, its pass-through falls if the second derivative is negative, and rises if the second derivative is positive. The sign of the second derivative, thus, determines the signs of the marginal effects of the other variables in the manufacturer's pass-through equation.

3.2 Retail Pass-Through

To compute pass-through at the retail level, one substitutes the derived values of the vector p^{w*}_t into the system of J nonlinear equations for the retail firm, and then searches for the retail price vector p^{r*}_t that will solve it:

$$(16) \qquad p^{r*}_{jt} = p^{w*}_{jt} + ntc^r_{jt} - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p_{jt}}} = \text{marginal cost } + \text{markup function, for } j = 1, 2, ..., J_t.$$

Assuming the retailer's nontraded marginal costs ntc^r_{jt} vary independently of the wholesale price, the partial change in the retail price for a given change in the wholesale price is given by:

$$(17) \qquad \frac{\partial p^r_{jt}}{\partial p^w_{jt}} = 1 + \frac{s_t \frac{d^2 s_t}{\partial p_{jt}} \frac{\partial p^r_{jt}}{\partial p^w_{jt}}}{\left(\frac{\partial s_{jt}}{\partial p_{jt}}\right)^2} - \frac{\partial p^r_{jt}}{\partial p^w_{jt}}$$

Rearranging terms, one gets:

$$\text{(18)} \qquad \frac{\partial p^r_{jt}}{\partial p^w_{jt}} = \frac{1}{2 - s_t \frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}} \frac{1}{\frac{\partial s_{jt}}{\partial p_{jt}}}} = \frac{1}{2 - \frac{\text{market share}\cdot\text{curvature coefficient}}{\text{slope of demand}}}$$

$$\text{(19)} \qquad \frac{\partial p^r_{jt}}{\partial p^w_{jt}} \frac{p^w_{jt}}{p^r_{jt}} = \frac{1}{\left(2 - s_t \frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}} \frac{1}{\frac{\partial s_{jt}}{\partial p_{jt}}}\right) \cdot \frac{p^r_{jt}}{mc^r_{jt}} \frac{mc^r_{jt}}{p^w_{jt}}} = \frac{1}{\left(2 - \frac{\text{market share}\cdot\text{curvature coefficient}}{\text{slope of demand}}\right) \cdot \frac{p^r_{jt}}{mc^r_{jt}} \frac{mc^r_{jt}}{p^w_{jt}}}$$

Retail pass-through, defined as pass-through by the retailer of just those costs passed on by the manufacturer is given by $PT^R = \frac{p^{r*}_{jt} - p^r_{jt}}{p^{r*}_{jt} + p^r_{jt}} \frac{p^{w*}_{jt} + p^w_{jt}}{p^{w*}_{jt} - p^w_{jt}}$. Equation 19 shows that it is determined by the jth good's market share s_{jt}, the curvature of the demand curve with respect to the retail price, summarized by the curvature coefficient, $\frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}}$, the slope of the demand curve with respect to the retail price, $\frac{\partial s_{jt}}{\partial p^r_{jt}}$, the retailer's margin, $\frac{p^r_{jt}}{mc^w_{jt}}$, and the ratio of the retailer's total marginal cost to the manufacturer's price, $\frac{mc^r_{jt}}{p^w_{jt}}$ .When demand is linear, so $\frac{d^2 s_t}{\partial p_{jt}} = 0$, then $\frac{\partial p^w_{jt}}{\partial p^w_{jt}} = \frac{1}{2}$. As the demand curve gets flatter and becomes more elastic, that is, as $\left|\frac{\partial s_{jt}}{\partial p^r_{jt}}\right|$ rises, pass-through falls if the second derivative is positive, and rises if the second derivative is negative. When the demand curve is less concave than the linear case so $\frac{d^2 s}{\partial p^{r2}_{jt}} > 0$, then $\frac{p^r_{jt}}{p^w_{jt}} > \frac{1}{2}$, retail pass-through rises. When the demand curve is more concave than the linear case so $\frac{d^2 s}{\partial p^{r2}_{jt}} < 0$, then $\frac{p^r_{jt}}{p^w_{jt}} < \frac{1}{2}$, retail pass-through falls. As the curvature coefficient rises, pass-through falls if the second derivative is negative, and rises if the second derivative is positive. A retailer's market power and cost structure also determines its pass-through rate: as a product's market share s_{jt}, retail margin $\frac{p^r_{jt}}{mc^r_{jt}}$, or ratio of total marginal cost to the manufacturer price $\frac{mc^r_{jt}}{p^w_{jt}}$ rises, its pass-through falls if the second derivative is negative, and rises if the second derivative is positive. The sign of demand's second derivative, thus, determines the signs of the marginal effects of the other variables in the retail pass-through equation.

Finally, vertical pass-through, defined as pass-through of the original marginal-cost shock to the retail price is $PT^V = \frac{p^{r*}_{jt} - p^r_{jt}}{p^{r*}_{jt} + p^r_{jt}} \cdot \frac{tc^{w*}_{jt} + tc^w_{jt}}{tc^{w*}_{jt} - tc^w_{jt}}$. It is given by:

(20)

$$\frac{\partial p^r_{jt}}{\partial tc^w_{jt}} \frac{tc^w_{jt}}{p^r_{jt}} = \frac{\frac{\partial p^w_{jt}}{\partial tc^w_{jt}}}{\left(2 - s_{jt} \frac{\frac{d^2 s}{\partial p^{r2}_{jt}}}{\frac{\partial s_{jt}}{\partial p^r_{jt}}} \frac{1}{\frac{\partial s_{jt}}{\partial p^r_{jt}}}\right) \cdot \frac{p^r_{jt}}{mc^r_{jt}} \frac{mc^r_{jt}}{p^w_{jt}} \frac{p^w_{jt}}{mc^w_{jt}} \frac{mc^w_{jt}}{tc^w_{jt}}} = \frac{\frac{\partial p^w_{jt}}{\partial tc^w_{jt}}}{\left(2 - \frac{\text{market share}\cdot\text{curvature coefficient}}{\text{slope of demand}}\right) \cdot \frac{p^r_{jt}}{mc^r_{jt}} \frac{mc^r_{jt}}{p^w_{jt}} \frac{p^w_{jt}}{mc^w_{jt}} \frac{mc^w_{jt}}{tc^w_{jt}}}$$

The vertical pass-through equation is identical to the retail pass-through equation except that the vertical margin replaces the retail margin and the equation is multiplied by the change in the wholesale price given the change in the traded component of the manufacturer's marginal cost.

3.3 Demand

The pass-through computations done with the Bertrand-Nash supply model require consistent estimates of demand.[4] Market demand is derived from a standard discrete-choice model of consumer behavior that follows the work of Berry (1994), Berry, Levinsohn, and Pakes (1995), and Nevo (2001) among others. I use a random-coefficients logit model to estimate the demand system, as it is a very flexible and general model. The pass-through coefficients' accuracy depends in particular on consistent estimation of the curvature of the demand curve, that is, of the second derivative

[4] The pass-through coefficients' accuracy depends in particular on consistent estimation of the curvature of the demand curve, that is, of the first and second derivatives of the demand equation. The only demand curves where a constant fraction of a marginal-cost shock will always be passed on are constant elasticity curves, that is, where the curvature coefficient is constant: $\left(\frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}}\right) = \kappa$. Demand curves exist in which pass-through rates can take on any values, however. Feenstra (1989) discusses some of the extreme cases. In general, with constant marginal costs, as the demand curve becomes more concave than the constant elasticity of substitution demand curve, pass-through will be incomplete.

of the demand equation. The random-coefficients model imposes very few restrictions on the demand system's own- and cross-price elasticities. This flexibility makes it the most appropriate model to study pass-through in this market.[5]

Suppose consumer i chooses to purchase one unit of good j if and only if the utility from consuming that good is as great as the utility from consuming any other good. Consumer utility depends on product characteristics and individual taste parameters: product-level market shares are derived as the aggregate outcome of individual consumer decisions. All the parameters of the demand system can be estimated from product-level data, that is, from product prices, quantities, and characteristics.

Suppose we observe t=*1*, ..., T markets. I define a market in the next section. Let the indirect utility for consumer i in consuming product j in market t take a quasi-linear form:

$$(21) \qquad u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} + \varepsilon_{ijt} = V_{ijt} + \varepsilon_{ijt}, \quad i = 1, ..., I., \quad j = 1, ..., J., \quad t = 1, ..., T.$$

where ε_{ijt} is a mean-zero stochastic term. A consumer's utility from consuming a given product is a function of a vector of individual characteristics ζ and a vector of product characteristics (x, ξ, p) where p are product prices, x are product characteristics observed by the econometrician, the consumer, and the producer, and ξ are product characteristics observed by the producer and consumer but not by the econometrician. Let the taste for certain product characteristics vary

[5] Other possible demand models such as the multistage budgeting model or the nested logit model do not fit this market particularly well. It is difficult to define clear nests or stages in beer consumption because of the high cross-price elasticities between domestic light beers and foreign light and regular beers. When a consumer chooses to drink a light beer that also is an import, it is not clear if he categorized beers primarily as domestic or imported and secondarily as light or regular, or vice versa.

with individual consumer characteristics:

$$\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \Pi D_i + \Sigma v_i \tag{22}$$

where D_i is a vector of demographics for consumer i, Π is a matrix of coefficients that characterize how consumer tastes vary with demographics, v_i is a vector of unobserved characteristics for consumer i, and Σ is a matrix of coefficients that characterizes how consumer tastes vary with their unobserved characteristics. I assume that, conditional on demographics, the distribution of consumers' unobserved characteristics is multivariate normal. The demographic draws give an empirical distribution for the observed consumer characteristics D_i. Indirect utility can be redefined in terms of mean utility $\delta_{jt}= \beta x_{jt} - \alpha p_{jt} + \xi_{jt}$ and deviations (in vector notation) from that mean $\mu_{ijt}= [\Pi D_i \;\; \Sigma v_i] * [p_{jt} \;\; x_{jt}]$:

$$u_{ijt} = \delta_{jt} + \mu_{ijt} + \varepsilon_{ijt} \tag{23}$$

Finally, consumers have the option of an outside good. Consumer i can choose not to purchase one of the products in the sample. The price of the outside good is assumed to be set independently of the prices observed in the sample.[6] The mean utility of the outside good is normalized to be zero and constant over markets. The indirect utility from choosing to consume the outside good

[6] As the manufacturers I observe supply their products to the outside market, this assumption may be problematic given my data. Recent empirical work shows that consumers rarely search over several local supermarkets to locate the lowest price for a single good. This implies that beer in other supermarkets (the outside good in my model) is unlikely to be priced to respond in the short run (over the course of a month) to the prices set by *Dominick's*. Any distortions introduced by this assumption are likely to be second order. The inclusion of an outside good means my use of a single retailer does not require an assumption of monopoly in the retail market. It makes the estimates of pass-through more credible given that the retail firm in my sample is constrained by the availability of goods other than those it sells. Even if the price of the outside good does not respond to price changes in the sample, it remains a potential choice for consumers when faced with a price increase for products in the sample.

is:

$$u_{i0t} = \xi_{0t} + \pi_0 D_i + \sigma_0 v_{i0} + \varepsilon_{i0t} \tag{24}$$

Let A_j be the set of consumer traits that induce purchase of good j. The market share of good j in market t is given by the probability that product j is chosen:

$$s_{jt} = \int_{\zeta \in A_j} P^*(d\zeta) \tag{25}$$

where $P^*(d\zeta)$ is the density of consumer characteristics $\zeta = [D \quad \nu]$ in the population. To compute this integral, one must make assumptions about the distribution of consumer characteristics. I report estimates from two models. For diagnostic purposes, I initially restrict heterogeneity in consumer tastes to enter only through the random shock ε_{ijt} which is independently and identically distributed with a Type I extreme-value distribution. For this model, the probability of individual i purchasing product j in market t is given by the multinomial logit expression:

$$s_{ijt} = \frac{e^{\delta_{jt}}}{1 + \sum_{k=1}^{J_t} e^{\delta_{kt}}} \tag{26}$$

where δ_{jt} is the mean utility common to all consumers and J_t remains the total number of products in the market at time t.

In the full random-coefficients model, I assume ε_{ijt} is i.i.d with a Type I extreme-value distribution but now allow heterogeneity in consumer preferences to enter through an additional term μ_{it}. This allows more general substitution patterns among products than is permitted under the restrictions of the multinomial logit model. The probability of individual i purchasing product

j in market t must now be computed by simulation. This probability is given by computing the integral over the taste terms μ_{it} of the multinomial logit expression:

$$s_{jt} = \int_{\mu_{it}} \frac{e^{\delta_{jt}+\mu_{ijt}}}{1+\sum_k e^{\delta_{kt}+\mu_{ikt}}} f(\mu_{it})\, d\mu_{it} \tag{27}$$

The integral is approximated by the smooth simulator which, given a set of N draws from the density of consumer characteristics $P^*(d\zeta)$, can be written:

$$s_{jt} = \frac{1}{N}\sum_{i=1}^{N} \frac{e^{\delta_{jt}+\mu_{ijt}}}{1+\sum_k e^{\delta_{kt}+\mu_{ikt}}} \tag{28}$$

Given these predicted market shares, I search for demand parameters that implicitly minimize the distance between these predicted market shares and the observed market shares using a generalized method-of-moments (GMM) procedure, as I discuss in further detail in the estimation section.

4 Estimation

This section describes the econometric procedures used to estimate the model's demand parameters.

4.1 Demand

The results depend on consistent estimates of the model's demand parameters. Two issues arise in estimating a complete demand system in an oligopolistic market with differentiated products: the high dimensionality of elasticities to estimate and the potential endogeneity of price.[7] Following

[7] In an oligopolistic market with differentiated products, the number of parameters to be estimated is proportional to the square of the number of products, which creates a dimensionality problem given a large number of products.

McFadden (1973), Berry, Levinsohn, and Pakes (1995), and Nevo (2001) I draw on the discrete-choice literature to address the first issue: I project the products onto a characteristics space with a much smaller dimension than the number of products. The second issue is that a product's price may be correlated with changes in its unobserved characteristics. I deal with this second issue by instrumenting for the potential endogeneity of price. Following Villas-Boas (2002), I use input prices interacted with product fixed effects as instruments. Input prices should be correlated with those aspects of price that affect consumer demand but are not themselves affected by consumer demand, that is, with supply shocks.

I estimate the demand parameters by following the algorithm proposed by Berry (1994). This algorithm uses a nonlinear generalized-method-of-moments (GMM) procedure. The main step in the estimation is to construct a moment condition that interacts instrumental variables and a structural error term to form a nonlinear GMM estimator. Let θ signify the demand-side parameters to be estimated with θ_1 denoting the model's linear parameters and θ_2 its non-linear parameters. I compute the structural error term as a function of the data and demand parameters by solving for the mean utility levels (across the individuals sampled) that solve the implicit system of equations:

$$s_t\left(x_t, p_{t,}\delta_t|\theta_2\right) = S_t \tag{29}$$

where S_t are the observed market shares and $s_t\left(x_t, p_{t.}\delta_t|\theta_2\right)$ is the market-share function defined in equation (*28*). For the logit model, this is given by the difference between the log of a product's observed market share and the log of the outside good's observed market share: $\delta_{jt} = \log(S_{jt}) - \log\left(S_{0t}\right)$. For the full random-coefficients model, it is computed by simulation.[8]

[8] See Nevo (2000) for details.

Following this inversion, one relates the recovered mean utility from consuming product j in market t to its price, p_{jt}, its constant observed and unobserved product characteristics, d_j, and the error term $\Delta\xi_{jt}$ which now contains changes in unobserved product characteristics:

$$\Delta\xi_{jt} = \delta_{jt} - \beta_j d_j - \alpha p_{jt} \tag{30}$$

I use brand fixed effects as product characteristics following Nevo (2001). The product fixed effects d_j proxy for the observed characteristics term x_j in equation (*21*) and mean unobserved characteristics. The mean utility term here denotes the part of the indirect utility expression in equation (*23*) that does not vary across consumers.

4.2 Instruments

The moment condition discussed above requires an instrument that is correlated with product-level prices p_{jt} but not with changes in unobserved product characteristics $\Delta\xi_{jt}$ to achieve identification of the model. While I observe national promotional activity by brand, I do not observe local promotional activity. It follows that the residual $\Delta\xi_{jt}$ likely contains changes in products' perceived characteristics that are stimulated by local promotional activity. For example, an increase in the mean utility from consuming product j caused by a rise in product j's unobserved promotional activity should cause a rightward shift in product j's demand curve and, thus, a rise in its retail price. Therefore, the residual will be correlated with the price and (nonlinear) least squares will yield inconsistent estimates. The solution to this endogeneity problem is to introduce a set of j instrumental variables z_{jt} that are orthogonal to the error term $\Delta\xi_{jt}$ of interest. The population moment condition requires that the variables z_{jt} be orthogonal to those unobserved changes in product characteristics stimulated by local advertising.

I use the prices of inputs to the brewing process as instruments. Input prices should be correlated with the retail price, which affects consumer demand, but are not themselves correlated with changes in unobserved characteristics that enter the consumer demand. Input prices like wages are unlikely to have any relationship to the types of promotional activity that will stimulate perceived changes in the characteristics of the sample's products. My instruments are hourly compensation in local currency terms for production workers in Food, Beverage and Tobacco Manufacturing Industries. These annual figures come from the Foreign Labor Statistics Program of the U.S. Department of Labor's Bureau of Labor Statistics. Bilateral nominal exchange rates account for some of the variation in these data. The model's identification of monthly variation in nominal exchange-rates should not be affected, however, given the time mismatch between my instrument data (which are annual) and my price data (which are monthly). I interact the hourly compensation variables, which vary by country and year, with indicator variables for each brand following Villas-Boas (2002). This allows each product's price to respond independently to a given supply shock.

One might expect foreign wages to be weakly correlated with domestic retail prices, thus generating a weak instrumental-variables problem.[9] Given the well-known border effect on prices we should expect a somewhat weaker relationship between wages and prices for foreign products than for domestic products.[10] The model's first-stage results, reported in the appendix, indicate that foreign products' input prices appear to be effective as instruments. I discuss these results further in the next section.

[9] Staiger and Stock (1997) examine the properties of the IV estimator in the presence of weak instruments.
[10] Engel and Rogers (1996) examine the persistent deviations from the law of one price across national borders.

5 Results

This section presents results from the estimation of the model. It first discusses results from the estimation of the demand system. It then examines how well the derived markups and marginal costs reflect stylized facts for the beer market.

5.1 Demand Estimation: Logit Demand

Table 4 reports results from estimation of demand using the multinomial logit model. Due to its restrictive functional form, this model will not produce credible estimates of pass-through. However, it is helpful to see how well the instruments for price perform in the logit demand estimation before turning to the full random-coefficients model. Table 13 in Appendix C reports the first-stage results for demand. Most of the coefficients have the expected sign: as hourly compensation increases, the retail price of each product should increase. T-statistics calculated using Huber-White robust standard errors indicate that most of the coefficients are significant at the 5-percent level. The negative coefficients on some variables likely result from collinearity between some of the regressors.

Table 4 suggests the instruments may have some power. The first-stage F-test of the instruments, at 17.42, is significant at the 1-percent level. The consumer's sensitivity to price should increase after I instrument for unobserved changes in characteristics. That is, consumers should appear more sensitive to price once I instrument for the impact of unobserved (by the econometrician, not by firms or consumers) changes in product characteristics on their consumption choices. It is promising that the price coefficient falls from -5.62 in the OLS estimation to -8.34 in the IV estimation. The second and fourth columns of Table 4 include brand-level national advertising expenditure in the estimation. Although signed as expected, at .17 in the OLS estimation and

.16 in the IV estimation, the advertising coefficient is highly insignificant. The brand-level fixed effects likely capture those aspects of consumer taste that are stimulated by national advertising. The Hausman exogeneity test for the price variable, at 10.28, is significant at the 1-percent level. A Hausman test of overidentifying restrictions fails to reject this specification. It returns a value of 11.56, far below the critical value of 45 that must be surpassed to fail the test.

5.2 Demand: Random-Coefficients Model

Table 5 reports results from estimation of the demand equation (*30*). I allow consumers' age and income to interact with their taste coefficients for price and percent alcohol. As I estimate the demand equation using product fixed effects, I recover the consumer taste coefficients in a generalized-least-squares regression of the estimated product fixed effects on product characteristics. This GLS regression assumes changes in brands' unobserved characteristics $\Delta\xi$ are independent of changes in brands' observed characteristics x: $E(\Delta\xi|x) = 0$.

The coefficients on the characteristics appear reasonable. As consumers' age and income rise, they become less price sensitive. The coefficients on age, at 3.16, and on income, at .28, are significant at the 5-percent level. The mean preference in the population is in favor of a bitter and hoppy taste in beer. Both characteristics have positive and highly significant coefficients. The mean preference in the population is quite averse to sweet, fruity, or malty flavors in beer. All three have negative coefficients, with the first two highly significant. As the percent alcohol rises, the mean utility in the population falls. This result appears reasonable once one considers that identification here comes from the variation in the percent alcohol between light and regular beers. As light beers sell at a premium, there clearly is some gain in utility from less alcohol within a given range. I do not consider nonalcoholic beers in this sample, so the choice of no alcohol is not reflected in this coefficient. Calories have a negative sign, as one would expect, though the coefficient is not significant. Finally, an indicator variable for poor quality, the "Sulfury/Skunky" characteristic, has a large, negative, and highly significant coefficient as one would expect. The minimum-distance weighted R^2 is .46 indicating these characteristics explain the variation in the estimated product fixed effects fairly well.

Table 5 reports median own-price elasticities by pricing zone for the sample's 34 brands. Residents from the low-price zone have much higher demand elasticities in absolute value than do residents from the medium- and high-price zones, whose elasticities are virtually indistinguishable. The variation in the demand elasticities across the pricing zones is striking.

The marginal utility of income, the coefficient on the price variable, appears quite high in the low-price zone. There is also considerable heterogeneity in the taste for foreign brands across the zones. Demand elasticities are much higher in absolute value for imported beers than for domestic beers in the low-price zone. This pattern is reversed in the medium- and high-price zones, where affluent consumers are willing to pay more for imported brands. The demand elasticities for foreign brands in the low-price zone are more than twice as large (in absolute value) as the demand elasticities for the same products in the medium- and high-price zones. The demand elasticity for *Amstel* is -4.73 in the medium-price zone, -5.26 in the high-price zone, and -11.65 in the low-price zone. A domestic sub-premium beer like *Keystone* exhibits less variation in its demand elasticities across the price zones: the median demand elasticities for this brand are -6.51, -5.72, and –5.42 in the low-, medium- and high-price zones, respectively.

Table 6 reports a sample of the median own- and cross-price elasticities for selected brands. The cross-price elasticities are generally intuitive. The cross-price elasticities are higher between imported brands than between imported and domestic brands. A change in the price of *Amstel*, from Holland, has a greater impact on the market share of other imported brands such as *Heineken* at .0168 or *Beck's* at .0162 than on such domestic brands as *Miller High Life* at .0054. The cross-price elasticities between a domestic premium light beer such as *Bud Light* and an import such as *Beck's* at .1005 or *Corona* at .0986 are somewhat higher than those between *Bud Light* and the domestic brands *Bud* at .0853 or *Miller High Life* at .0827.

Table 7 reports the retail price, the derived wholesale price, and the derived manufacturer marginal cost for each brand. Again, the results appear intuitive. Manufacturer marginal costs are about 15 cents higher for imported brands at 33 cents than for domestic brands at 19 cents, which likely reflects the cost of transporting the products from the foreign production site to the U.S. market. The median wholesale price of 57 cents for foreign brands is about twice that of domestic brands, at 28 cents, which is consistent with industry lore.[11] The median retail price is one dollar for imported brands and 49 cents for domestic brands. Table 8 reports markups by brand.

The median retail markup for domestic brands is 12 cents while for imported brands it is over twice that at 29 cents. Markups at the manufacturer level are somewhat lower: the median domestic markup is 9 cents and the median foreign markup is 20 cents. Markups are generally higher for light beers than for regular beers, also consistent with the market's stylized facts. Finally, the model's derived wholesale prices appear to follow observed wholesale-price movements fairly closely: the correlation between the two series is over 86 percent across all brands, zones, and months.

[11] Ghemawat (1992) reports that "imported brands... wholesaled at twice the average price of domestic brands" p. 5.

6 Counterfactual Experiments

Using the full random-coefficients model and the derived marginal costs I conduct counterfactual experiments to analyze how firms react to foreign shocks. This section presents and discusses the results from these experiments.

6.1 Foreign Brands' Pass-Through

The first counterfactual experiments consider how foreign manufacturers and the retailer adjust their prices following a five-percent increase in foreign firms marginal costs due to an exchange-rate depreciation. The first column of table 9 reports manufacturers' pass-through of the exchange-rate depreciation to the wholesale price. The second column reports the pass-through coefficient after accounting for the local component of the retailer's costs. The last column reports the retailer's pass-through of the original shock to its price.

I find some variation in firms' pass-through across brands. The median vertical pass-through of the 5-percent cost increase ranges from -1 percent for *Sapporo* to 39 percent for *Corona*. The results are generally consistent with the predictions of the theoretical model discussed in section 2. The model predicts that as a brand's market share rises, its pass-through of a cost increase should also rise given a demand curve with a positive second derivative, as is the standard case. The foreign brands with the highest market shares, *Becks*, *Corona*, *Heineken* and *Peroni*, are those with the four highest retail traded pass-through rates at 36, 39, 37, and 27 percent, respectively.

The pass-through elasticities generally resemble those of previous studies. Goldberg and Knetter (1997) report the literature's median estimate of pass-through elasticities to import prices to be 50 percent over the course of one year, though they acknowledge that the distribution of these estimates has thick tails.[12] Knetter (1993) estimates a 56-percent pass-through to export prices for German firms exporting beer to the U.S. market. My model produces median wholesale pass-through coefficients of about 40 and 34 percent, respectively, following the cost shock, for the two German brands in the sample: *Beck's* and *St. Pauli Girl*. The pass-through elasticities following a cost decrease roughly match those following a cost increase.

Table 10 decomposes the sources of this incomplete transmission of the foreign cost shock to final-goods prices. The first column reports the share of the incomplete transmission that can be attributed to a local cost component in manufacturers' marginal costs. The second column reports the share that can be attributed to markup adjustment by manufacturers following the shock. Column three reports the share attributable to a local cost component in retailers' marginal costs, and column four the share to the retailer's markup adjustment.

The local cost component at the manufacturer level plays the most significant role in the incomplete transmission: It is responsible for over half the observed price inertia in the face of the cost shock. The manufacturer's markup adjustment accounts for just over a quarter of the remaining adjustment, while the retailer's local cost component and markup adjustment are each 10 percent on average. Most of the adjustment is done by the manufacturer.

Table 11 reports the equilibrium effects of 5-percent increase in foreign firms' marginal costs on all firms' profits, price-cost markups, and quantities sold. The first two columns give the percent change by brand in manufacturer and retailer profits following the depreciation. The third column gives the median percent change in the quantity sold by brand, and the last two columns the median percent change in the manufacturer and retailer markups by brand.

Comparing the first two columns of Table 11 to the last three columns gives some indication

[12] As Menon (1995) notes in his survey of the literature, researchers have found very different pass-through coefficients even when working with data that cover the same industries and time periods.

of the underlying causes of variation in a brand's total profits: changes in the quantity sold or changes in the markup. The results indicate that declines in foreign brands' profits result more from declines in quantities sold than from declines in markups. Those foreign manufacturers who shrink their markups by more than the average lose less total profits than the foreign brands' median loss of 7 percent. The four brands with the smallest percent declines in manufacturer profits, *Sapporo, St. Pauli Girl,* and *Tecate*, 0, 3, and 2-percent losses, respectively, are also brands with large percent declines in their manufacturer markups at -3, -2, and -3, respectively, and small percent declines in their quantities sold: 1, -5, and -4 percent, respectively.

6.2 Domestic Versus Foreign Manufacturers

The results suggest some strategic interaction between import-competing domestic manufacturers and foreign manufacturers following a depreciation: these domestic manufacturers increase their profits by lowering prices to take market share from foreign manufacturers. Domestic manufacturers' profits increase overall following a 5-percent cost increase, mainly from increases in market share rather than from increases in markups. The domestic brands with increased profits are the light or superpremium brands that compete most directly with imported beers.[13] As Column 1 of Table 11 shows, only superpremium or light beers' profits rise significantly: *Bud Light* by 3 percent, *Michelob Light* by 6 percent, *Rolling Rock* by 11 percent, and *Special Export* by 6 percent. The profits of such sub-premium beers as *Busch* or *Old Milwaukee* change very little or decline slightly. Those brands in the sub-premium segment of the market are considered poor substitutes for foreign brands and so have little to gain from shrinking markups to try to capture market share following a depreciation.

[13] Table 12 classifies the domestic brands in the *Dominick's* data according to their market segment: subpremium, premium, or superpremium.

These strategic interactions between domestic and foreign manufacturers provide one possible explanation for the puzzle of incomplete cross-border transmission. It may not be profit maximizing for foreign manufacturers to fully pass-through a cost shock in a market where some domestic manufacturers exploit each increase in a foreign brand's price to increase their market share.

7 Conclusion

This paper makes three contributions. The first is an explanation of an approach I find useful to quantify the effect of a foreign shock on domestic consumers and on domestic and foreign firms. The approach enables me to ask more and deeper questions about the microeconomics of international transmission than was possible with previous empirical models. I estimate a structural econometric model that makes it possible to compute manufacturers' and retailers' pass-through of a foreign cost shock without observing wholesale prices or firms' marginal costs. Using the estimated demand system, I conduct counterfactual experiments to determine whether domestic manufacturers, foreign manufacturers, a domestic retailer, or domestic consumers bear the cost of the shock. Second, I use an unusual dataset with retail and wholesale prices that allows me to check the validity of my technique. Third, I quantify the importance of various sources for the incomplete process of international transmission. My results suggest that the overall effects of a foreign cost shock are large and unevenly distributed across domestic and foreign firms and domestic consumers. Finally, the paper demonstrates that a local cost component in manufacturers' costs explains a large part of the incomplete transmission though local costs and markup adjustment by manufacturers and retailers plays a nontrivial role.

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Description	Mean	Median	Standard Deviation	Min	Max
Retail prices (cents per serving)	71	61	27	27	132
Market share of each product	.54	.15	1.16	.00005	9.17
Servings sold	16589	4655	34800	1.83	279,918
Share of Dominick's beer sales	65.04	65.89	13.96	31.58	98.20
Market share of 34 products	18.46	17.34	7.38	7.01	36.12
Market share of outside good	81.54	82.66	7.38	63.89	93.21

Table 1: *Summary statistics for prices, servings sold, and market shares for the 34 products in the sample.* The share of *Dominick's* total beer sales refers to the share of revenue of the 34 products I consider in the total beer sales by the *Dominick's* stores in my sample. The market share refers to the volume share of the product in the potential market which I define as all beer servings sold at supermarkets in the zip codes in which one of the *Dominick's* stores in my sample is located. Source: *Dominick's*.

Description	Mean	Median	Std	Minimum	Maximum
Percent Alcohol	4.52	4.60	.68	2.41	6.04
Calories	132.18	142.50	23.00	72.00	164.00
Bitterness	2.50	2.10	1.08	1.70	5.80
Maltiness	1.67	1.20	1.52	.60	7.10
Hops (=1 if yes)	.12	–	–	–	–
Sulfury/Skunky (=1 if yes)	.29	–	–	–	–
Fruity (=1 if yes)	.21	–	–	–	–
Floral (=1 if yes)	.12	–	–	–	–

Table 2: *Product characteristics.* Source: "Beer Ratings." *Consumer Reports*, June (1996), pp. 10-19.

Price	Coefficient
Local Wages	.62
	(4.54)*
Observations	1800

Table 3: *Some preliminary descriptive results.* Hourly compensation in local currency terms for the grocery sector in Illinois. T-statistics are based on robust standard errors. The dependent variable is the retail price for each brand in each month and each price zone. The regression also includes brand, month, and zone dummy variables. 1800 observations. Sources: My calculations;

Variable	OLS		IV		
Price	-5.62	-5.62	-8.34	-8.32	.
	(.27)	(.27)	(.99)	(.99)	
Advertising		.17		.16	
		(.22)		(.22)	
Measures of Fit					
Adjusted R^2	.86	.86			
Price Exogeneity Test			10.28	10.13	
95% Critical Value			(3.84)	(3.84)	
Overidentification Test			11.56	11.60	
95% Critical Value			(45)	(45)	
First-Stage Results					
F-Statistic			17.42	17.40	
Partial R^2			.98	.97	
Instruments			wages	wages	

Table 4: *Diagnostic results from the logit model of demand.* Dependent variable is $ln(S_{jt}) - ln(S_{ot})$. All four regressions include brand fixed effects. Based on 4080 observations. Huber-White robust standard errors are reported in parentheses. Wages denote a measure of hourly compensation from the U.S. Bureau of Labor Statistics which is described in the text. Advertising is the annual amount spent on advertising for each brand across all potential media outlets. Sources: Competitive Media Reporting, 1991-1994; My calculations.

Product	Elasticities	By Zone: Low	Medium	High
Domestic Brands				
Coors	-6.34	-7.65	-5.92	-5.92
Keystone	-5.85	-6.51	-5.72	-5.42
Michelob Light	-6.05	-8.15	-5.36	-5.61
All Domestic Brands	-6.1	-7.3	-5.7	-5.8
Foreign Brands				
Amstel	-6.06	-11.65	-4.73	-5.26
Molson Light	-5.21	-9.15	-4.32	-4.65
Sapporo	-6.22	-12.04	-4.88	-5.44
All Foreign Brands	-6.3	-11.0	-5.0	-5.8

Table 5: *Median own-price demand elasticities.* Median across all 120 markets. 4080 observations. Source: My calculations.

Brand	Amstel	Beck's	Bud	Bud L	Corona	Heineken	Miller HL
Amstel	-6.06	.0162	.0058	.0075	.0163	.0168	.0054
Beck's	.1437	-5.71	.0528	.0684	.1320	.1356	.0506
Bud	.1299	.1359	-6.37	.1560	.1413	.1345	.1511
Bud Light	.0977	.1005	.0853	-5.88	.0986	.0992	.0827
Corona	.0717	.0673	.0263	.0334	-6.04	.0693	.0261
Heineken	.1309	.1236	.0464	.0601	.1276	-6.12	.0453
Miller HL	.0843	.0910	.1015	.1041	.0915	.0895	-6.49

Table 6: *A sample of median own- and cross-price demand elasticities.* Cell entries i, j, where i indexes row and j column, give the percent change in the market share of brand j given a 1-percent change in the price of brand i. Each entry reports the median of the elasticities from the 120 markets. Source: My calculations.

Product	Retail Price	Wholesale Price	Manufacturer Marginal Cost
Domestic Brands	49	28	19
Foreign Brands	100	57	33

Table 7: *Prices and marginal costs for the 33 brands in the sample.* Median in cents per 12-ounce serving across the 120 markets. 4080 observations. Source: My calculations.

Product	Markup		
	Brewer cents	Retailer cents	Vertical cents
Domestic Brands			
Coors	8	13	22
Keystone	6	9	16
Michelob Light	11	18	28
All Domestic Brands	9	12	21
European Brands			
Amstel	22	30	52
Molson Light	18	28	46
Sapporo	24	31	55
All Foreign Brands	20	29	50

Table 8: *Median derived price-cost markups by brand.* Median across 120 markets. The markup is price less marginal cost with units in cents per 12-ounce serving. Source: My calculations.

	Manufacturer Traded	Retail Nontraded	Retail Traded
Amstel	43	34	19
Bass	36	28	16
Beck's	40	31	36
Corona	52	40	39
Foster's	28	21	10
Grolsch	14	10	3
Guinness	53	40	23
Harp	19	14	0
Heineken	51	40	37
Molson L	30	24	7
Peroni	53	41	37
Sapporo	17	14	-1
St. Pauli	34	26	11
Tecate	25	19	9
All Foreign	34	26	17

Table 9: *Counterfactual experiments: median pass-through of a 5-percent increase in foreign brands' marginal costs.* Median over 120 markets. Retail traded pass-through: the retail price's percent change for a given percent change in foreign brands' marginal costs. Manufacturer traded pass-through: the wholesale price's percent change for a given percent change foreign brands' marginal costs. Retail nontraded pass-through: the retail price's percent change for a given percent change in the wholesale price due to the presence of a local component in costs. Source: My calculations.

	Manufacturer		Retail	
	Nontraded	Traded	Nontraded	Traded
Amstel	52	18	12	18
Bass	50	25	10	14
Beck's	66	28	14	-7
Corona	69	9	21	0
Foster's	47	33	8	13
Grolsch	43	46	3	7
Guinness	54	6	17	22
Harp	42	39	4	14
Heineken	66	10	18	6
Molson L	45	29	7	18
Peroni	67	7	20	6
Sapporo	42	40	3	15
St. Pauli	47	26	9	17
Tecate	46	36	7	11
All Foreign	52	27	10	10

Table 10: *Counterfactual experiments: Decomposition of the incomplete transmission of a 5-percent increase in foreign brands' marginal costs to final-goods prices.* Median over 120 markets. Manufacturer nontraded: the share of the incomplete transmission explained by the presence of a local component in manufacturer's marginal costs. Retail traded: the share of the incomplete transmission explained by the retailer's markup adjustment. Manufacturer traded: the share of the incomplete transmission explained by manufacturers' markup adjustment. Retail nontraded: the share of the incomplete transmission explained by the presence of a local component in the retailer's costs. Source: My calculations.

Product	Profit		Quantity	Markup	
	Manufacturer	Retail		Manufacturer	Retail
Domestic Brands					
Budweiser	0	-2	-2	2	0
Bud Light	3	5	6	-1	-1
Busch	-2	-7	-8	5	0
Busch Light	-2	-6	-7	5	0
Coors	-1	-4	-4	3	0
Coors Light	-1	0	0	1	0
Keystone	-5	-13	-16	13	2
Michelob Light	6	10	13	-6	-3
Miller Genuine Draft	0	-1	-1	1	0
Miller High Life	3	4	5	-2	-1
Miller Lite	1	1	2	1	-1
Milwaukee's Best	-7	-14	-17	11	3
Milwaukee's Best Lite	2	4	5	-2	-1
Old Milwaukee	-4	-10	-11	8	1
Old Style	4	7	10	-3	-2
Old Style Classic	-3	-7	-8	6	1
Rolling Rock	11	17	24	-7	-6
Special Export	6	12	15	-5	-3
Stroh's	-4	-10	-11	9	2
Foreign Brands					
Amstel	-5	-9	-7	0	-4
Bass	-7	-10	-6	-1	-4
Becks	-12	-16	-16	0	-2
Corona	-13	-17	-19	1	-1
Fosters	-6	-5	-5	-2	-4
Grolsch	-5	-4	-2	-4	-3
Guinness	-8	-15	-12	2	-3
Harp	-4	-5	2	-4	-5
Heineken	-14	-15	-17	2	-1
Molson Light	-5	-4	0	-1	-5
Peroni	-13	-16	-18	2	-1
Sapporo	0	-4	1	-3	-4
St. Pauli Girl	-3	-9	-5	-2	-4
Tecate	-2	-5	-4	-3	-4

Table 11: *Median percent changes in profits, quantities, and markups after a 5-percent foreign-cost shock.* Median percent change in profits, quantity sold and in the retail and manufacturer product markup over all markets. 4080 observations.

Superpremium	Premium	Sub-Premium
Michelob Light	Budweiser	Busch
Rolling Rock	Bud Light	Busch Light
	Coors	Keystone
	Coors Light	Milwaukee's Best
	Miller Lite	Milwaukee's Best Light
	Miller Genuine Draft	Old Milwaukee
	Miller High Life	Stroh's
	Old Style	
	Old Style Light	
	Special Export	

Table 12: *Market-segment classification for domestic brands.* The three segments are differentiated mainly by price with superpremium being the most expensive and subpremium the least expensive.

	Hourly Wages	T-Statistic
Amstel	.0596	1.46
Bass	.5714	3.75
Beck's	-.0063	-.46
Budweiser	.1218	3.44
Bud Light	.1710	4.10
Busch	.1464	1.66
Busch Light	.0793	1.04
Coors	.1598	3.86
Coors Light	.0039	.09
Corona	-.0001	-2.44
Foster's	-.3095	-6.11
Grolsch	.1087	2.67
Guinness	.0027	.01
Harp	.3371	2.36
Heineken	.0607	1.42
Keystone Light	-.0143	-.50
Michelob Light	.6118	7.63
Miller Genuine Draft	.1827	6.31
Miller High Life	.0702	2.05
Miller Lite	.1925	6.71
Milwaukee's Best	.5678	8.92
Milwaukee's Best Light	.3147	4.37
Molson Golden	.1216	.85
Molson Light	.1869	1.22
Old Milwaukee	-.3186	-7.72
Old Style	.2595	3.99
Old Style Classic	-.1666	-3.32
Peroni	.0001	1.81
Rolling Rock	.7274	7.69
Sapporo	-.0014	-1.00
Special Export	.2750	2.96
St. Pauli	-.1472	-3.18
Stroh's	-.0753	-1.11
Tecate	.0002	7.21

Table 13: *First-stage results for demand.* Hourly compensation in local currency terms for the food, beverage, and tobacco manufacturing industries. T-statistics are based on Huber-White robust standard errors. The dependent variable is the retail price for each brand in each month and each price zone. The regression also includes brand dummy variables. 4080 observations. Sources: My calculations; *Foreign Labor Statistics Program*, Bureau of Labor Statistics, U.S. Department of Labor.