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Abstract

Despite its importance, the microeconomics of the international transmission of shocks is not well understood. The conventional wisdom is that relative price changes are the primary mechanism by which shocks are transmitted across borders. Yet traded-goods prices exhibit significant inertia in the face of shocks such as exchange rate changes. This paper uses a structural model to quantify the relative importance of manufacturers' and retailers' local-cost components and markup adjustments as sources of this incomplete transmission. The model is applied to a panel dataset of one industry with retail and wholesale prices for UPC (Universal Product Code)-level products. Markup adjustments by manufacturers and the retailer explain two-thirds of the incomplete transmission, and local-cost components account for the remaining one-third. Foreign manufacturers generally bear more of the cost (or reap more of the benefit) of an exchange-rate-induced marginal cost shock than do domestic consumers, domestic manufacturers, or the domestic retailer.

Key words: cross-border transmission, exchange rates, pass-through, distribution margins

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1 Introduction

The microeconomics of the cross-border transmission of shocks continues, despite its importance, to be short of solid quantitative evidence. The conventional wisdom is that relative-price changes are the primary mechanism by which shocks are transmitted across borders. Yet the prices of traded goods exhibit significant inertia in the face of shocks like exchange-rate changes. This study presents a new analysis of the sources of this incomplete cross-border transmission and then uses this analysis to re-examine its implications for social welfare. I develop and estimate a structural model that decomposes the sources of local-currency price stability for a particular industry. The model enables counterfactual experiments that quantify the relative importance of firms' local-cost components and markup adjustments in the incomplete transmission of shocks to prices.

Understanding the sources of incomplete cross-border transmission has important implications for industry and for the economy generally. Assumptions about these sources, and their welfare implications, shape economists' policy recommendations on basic issues in international goods and financial markets. In keeping with the importance of the subject, there is a large theoretical literature on the welfare implications of alternative sources of this incomplete transmission.[1] A nascent empirical literature has documented the sources of incomplete transmission in different settings, but often has been hampered by a lack of data.[2] This study is the first to examine empirically the relative importance of four factors – nontraded costs and markup adjustments of manufacturers and retailers, respectively – in the process of incomplete cross-border transmission. It has two goals: to document at the product level when shocks are transmitted across borders; and to identify the sources and welfare effects of any incomplete transmission within the framework of a structural model.

The model is estimated using an unusual dataset from the beer industry. It finds that markup adjustment by manufacturers and retailers accounts for most of the incomplete transmission, though local nontraded costs play a nontrivial role. On average, firms pass through 13 percent of a foreign-cost shock to their retail prices; this leaves 87 percent of the shock to be accounted for.

[1] See, for example, Betts and Devereux (2000), Corsetti and Dedola (2005), Devereux, Engel, and Tille (2003), Dixit (1989), Dornbusch (1987), Engel and Rogers (2001), Feenstra, Gagnon, and Knetter (1996), Froot and Klemperer (1989), Krugman (1987), Obstfeld and Rogoff (2001), Tille (2001), Yi (2003).

[2] See, for example, Goldberg and Verboven (2001), Betts and Kehoe (2005), Burstein, Neves, and Rebelo (2003), Campa and Goldberg (2004), and Evans (2003). There is little disaggregated evidence on the sources of incomplete transmission. Prices along the distribution chain, particularly import and wholesale prices, are typically unavailable. It is also difficult to obtain cost data amenable to comparison from foreign manufacturers. Though several theoretical papers examine how exchange-rate fluctuations may affect welfare, no published empirical study has formally estimated these costs.

The model finds that firms' markup adjustments explain 68 percent and local-cost components 32 percent of this remainder. As for welfare, foreign manufacturers generally bear more of the cost (or reap more of the benefit) of a foreign cost shock than do domestic consumers, domestic manufacturers, or the domestic retailer.

Several features of this study distinguish it from previous work. First, its structural model of the vertical relationships between manufacturers and retailers enables a richer analysis of the causes of incomplete transmission than was possible with previous models. Second, I model the role of nontraded costs in the process of incomplete transmission. Third, I use the most disaggregated data available – *UPC*-level transaction prices and quantities – which allow for an empirical method based on a model of individual firms' price-setting behavior rather than on aggregate price indexes.

I begin my analysis by documenting in reduced-form regressions how prices are systematically related to such factors 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. The structural model enables me to decompose the equilibrium retail price of each product into six components: the traded marginal costs, nontraded marginal costs, and markups of manufacturers and retailers, respectively.

Theoretical work has shown that the response of prices to cost shocks depends on the curvature of a market's demand and cost schedules. This finding implies that any pass-through results may depend on a model's functional-form assumptions. I address this issue by estimating a very flexible demand system – a random-coefficients demand system – and by examining whether my parameter estimates are consistent with industry lore and with price responses to exchange-rate and local-cost fluctuations in reduced-form regressions. On the cost side, elsewhere I empirically test for the best-fit vertical market structure in the beer market (Hellerstein 2004) by comparing accounting price-cost margins to the derived price-cost margins that different vertical models produce and by using non-nested tests developed by Villas-Boas (2004). This study's empirical analysis focuses on the best-fit vertical market structure for this industry: a standard linear-pricing model with Bertrand competition in which manufacturers set wholesale prices and retailers follow setting retail prices.

I study the beer market for several reasons. First, because manufactured goods' prices tend to exhibit dampened responses to foreign cost shocks in aggregate data, beer is an appropriate choice to investigate the puzzling phenomenon of incomplete transmission.[3] Second, trade barriers such as voluntary export restraints and antidumping sanctions, which distort price-setting behavior in industries like autos or textiles, are rarely threatened or imposed in this industry.[4] This pattern simplifies the analysis of price inertia. Third, I have a rich panel data set consisting of monthly retail and wholesale prices for 34 products from 18 manufacturers over 40 months (July 1991-December 1994). It is unusual to have both retail- and wholesale-price data for a single product over time. These data enable me to separate out the role of local nontraded costs in the incomplete transmission.

The framework outlined here can be used to analyze the incomplete transmission of various types of foreign-cost shock, including a productivity shock, the imposition of a tariff or other trade barrier, a factor-price increase, or a change in the nominal exchange rate. For this study, I interpret foreign firms' marginal-cost shocks as caused by changes in the bilateral nominal exchange rate. The model assumes that foreign manufacturers incur marginal costs in their own currencies to brew, bottle, and ship their beer. They observe the realized value of the nominal exchange rate before setting prices in the domestic currency, and they assume that any exchange-rate change is exogenous and permanent over the sample period of one month.[5] A key identification assumption is that, in the short run, nominal exchange-rate fluctuations dwarf other sources of variation in manufacturers' marginal costs, such as factor-price changes. This assumption, though strong, has clear support in the data[6]: Figure 1 illustrates that the exchange rate is much more volatile in monthly data than are brewers' other typical marginal costs for the case of Germany.[7] The paper presents figures of the derived exchange rate that suggest that the model captures observed nominal exchange-rate movements fairly well for the sample's foreign brands.

The counterfactual experiments produce four major findings about the transmission of shocks across borders. First, markup adjustments by manufacturers and by the retailer account for

[3] Does the dollar matter for beer imports? According to the industry press, yes. *Beer Marketer's Insights*, the leading industry newsletter, writes in late 2003, "Hits keep comin' for *Heineken*. Most of them are currency-related. *Heineken* warned again about effect of weak dollar on its 2004 earnings. Heineken said the currency could clobber its earnings" *Beer Marketer's Insights*, Vol. 5, No. 68, December 19, 2003.

[4] Blonigen and Haynes (2002) document the effect of anti-dumping investigations on firms' exchange-rate pass-through.

[5] This assumption is consistent with the stylized fact identified by Meese and Rogoff (1983) that the best short-term forecast of the nominal exchange rate is a random walk.

[6] The breakdown of the Bretton-Woods fixed exchange-rate system in 1973 led to a permanent threefold to ninefold increase in nominal exchange-rate volatility. Meanwhile such fundamentals as real output, interest rates, or consumer prices showed no corresponding rise in volatility. While nominal exchange rates are now remarkably volatile, they ordinarily appear unconnected to the fundamentals of the economies whose currencies they price.

[7] This assumption is particularly valid for the beer industry which integrated backward starting in the late 1970s. By the early 1990s most brewers were purchasing their agricultural inputs under long-term contracts with farmers, which insulated them from short-run price fluctuations. Most brewers also manufactured their own packaging including labels, bottles, and cans. Some even integrated backward with respect to energy: in the late 1970s, *Adolph Coors* purchased and developed a coalfield to supply its plants, as described in Ghemawat (1992).

roughly two-thirds of the incomplete transmission, with local-cost components accounting for the other third. Second, foreign manufacturers generally bear more of the social-welfare costs (or reap more of the social-welfare benefits) of a change in the nominal exchange rate than do consumers or domestic manufacturers and retailers. For example, following a 10-percent depreciation of the dollar against the Mexican peso, domestic manufacturer profits rise by 0.1 percent, consumer surplus falls by 4.5 percent, and retailer profits fall by 1.8 percent, while Mexican manufacturer profits fall by 7.8 percent. Third, previous work on cross-border transmission did not model the retailer's pricing decision, and thus implicitly assumed that manufacturers' interactions with downstream firms did not matter. My findings suggest that the retailer plays an important role by absorbing part of an exchange-rate-induced marginal-cost shock (on the order of 10 percent) before it reaches consumers. The assumption that retailers act as neutral pass-through intermediaries, which is common in the literature, may produce estimates of the role of nontraded costs in the incomplete transmission that are upwardly biased. Finally, the results suggest some strategic interaction following a depreciation between foreign manufacturers not affected by the exchange-rate change, import-competing domestic manufacturers, and affected foreign manufacturers that may contribute to the incomplete cross-border transmission. Following a dollar depreciation, manufacturers with brands that are close substitutes for affected foreign brands increase their profits by lowering markups to take market share from foreign manufacturers. It may not be profit-maximizing for foreign manufacturers to fully pass through a cost shock in a market in with competing manufacturers that shrink their markups to put pressure on foreign manufacturers just as they face upward cost pressures from a domestic currency depreciation.

This study addresses two literatures on the sources of local-currency price stability with very different modeling approaches. The empirical trade literature, most notably Goldberg and Verboven (2001), attributes local-currency price inertia to a local-cost component and to firms' markup adjustments, but without modeling their roles for both manufacturers and retailers. Papers in the international-finance literature, such as Burstein, Neves, and Rebelo (2003), Campa and Goldberg (2004), and Corsetti and Dedola (2005), attribute local-currency price stability to the share of local nontraded costs in final-goods prices but do not model markup adjustments by the firms that incur these costs, whether manufacturers or retailers. This study improves on this earlier work by modeling markup adjustments for firms at each stage of the distribution chain.

The next section uses a simple numerical exercise to illustrate the basic features of the process of cross-border transmission. Section 3 sets out the theoretical model. Section 4 discusses the market and the data, along with some preliminary descriptive results, and Section 5 presents the estimation methodology. Results from the random-coefficients demand model are reported in Section 6, and those of the counterfactual experiments in Section 7.

2 A Simple Example of a Decomposition

To build intuition for the theoretical model, this section uses a simple numerical exercise to illustrate the roles of nontraded costs and markup adjustments of retailers and manufacturers, respectively, in the process of cross-border transmission. Figure 2 illustrates the stages of cross-border transmission in the theoretical model, what happens to a good's price as it moves from a factory gate, to an export port, to an import port, to a retailer, and finally, is purchased by a consumer. The exercise follows the price of a bottle of Japanese beer as it travels from the factory gate to the consumer before and after a dollar depreciation. Suppose the brewer's cost to produce the beer and transport it to a U.S. port is 50 yen. At the U.S. border, the product's price begins to be denominated in dollars. The prevailing exchange rate is assumed to be 1.5 cents per yen, so the brewer's marginal cost in dollars is 75 cents. The brewer incurs an additional 25 cents in local nontraded costs to get the product to the retailer and has a 25-cent markup. (A markup is defined as a firm's price less its marginal cost, and a margin as a firm's price less its marginal cost, divided by its price.) The retailer incurs 25 cents in nontraded costs in the form of rent, wages, and the like, and has a 50-cent markup. The first line of prices under the figure summarizes this sequence.

The second line of prices shows what happens to the beer's price following a 100-percent dollar depreciation against the yen. The exchange rate is now 3 cents per yen. While the cost in yen to produce the beer has not changed, its cost in dollars has doubled. For simplicity, I assume that the exchange-rate change is fully passed through at the dock, so the new import price is \$1.50. Manufacturer-nontraded pass-through is defined as incomplete pass-through caused by the presence in a good's price of local nontraded costs incurred by a manufacturer. The addition of the brewer's nontraded cost of 25 cents produces a manufacturer nontraded pass-through elasticity of 75 percent. Manufacturer-traded pass-through is defined as the incomplete pass-through of the original shock to the wholesale price following a markup adjustment by the manufacturer. If, following the depreciation, the brewer's markup remained constant at 25 cents, its price would be \$2.00, which implies 60-percent pass-through. If the brewer's margin remained constant at 25 percent, its price would be \$2.19, and the brewer's traded pass-through would equal its nontraded pass-through of 75 percent. Its \$1.90 price reflects a 52-percent pass-through of the original shock. Retail-nontraded pass-through is defined as the incomplete pass-through of the original shock to the retail price due to the presence of a local nontraded component in retail costs. The retailer's nontraded costs lower the pass-through rate further, from 52 percent to 43 percent. Retail-traded pass-through is defined as the incomplete pass-through of the original shock to the retail price following the retailer's markup adjustment. The retailer's original margin was 33 percent, and its original markup, 50 cents. If the retailer maintained a constant margin after the depreciation, its price would be \$2.86, rather than the \$2.50 we observe. The retailer's traded pass-through is 25 percent, and would have been 43 percent with no margin adjustment.

The pass-through of the original exchange-rate shock to the retail price is, thus, 25 percent. This leaves 75 percent of the original shock to account for in the decomposition. Roughly 33 percent of this 75-percent incomplete transmission can be attributed to the presence of local nontraded costs in the brewer's price. This component brings pass-through down to 75 percent, from 100 percent at the dock. The decline in pass-through from 75 to 52 percent following the brewer's margin adjustment accounts for another 31 percent of the incomplete transmission. The decline in pass-through from 52 to 43 percent from the retailer's nontraded costs eats up another 12 percent of the 75 percent. And the decline in pass-through from 43 to 25 percent following the retailer's margin adjustment accounts for the final 24 percent of the incomplete transmission.

Figure 3 illustrates how this paper's analysis differs from the standard pass-through analysis. Most pass-through studies focus on the prices of goods at the dock. To understand more deeply how and why shocks are transmitted across national borders, we should also measure the penetration of foreign cost shocks further downstream. This study's pass-through elasticities are estimated further along the distribution chain, to wholesale and retail prices. The figure illustrates the difference between this study's wholesale-price pass-through elasticity, which will be partly a function of the presence of local nontraded costs, and the conventional import-price pass-through elasticity, which is calculated before such costs are incurred.

This section's simple exercise has illustrated the basic features of the sources of cross-border transmission. The next section sets out a model that formalizes the role of each of these sources in the incomplete transmission.

3 Model

This section describes the supply model and derives simple expressions to compute pass-through coefficients and to decompose the sources of local-currency price rigidity between the nontraded costs and markup adjustments of manufacturers and retailers, respectively. It then sets out the random-coefficients model used to estimate demand.

3.1 Supply

Consider a standard linear-pricing model in which manufacturers, acting as Bertrand oligopolists with differentiated products, set their prices followed by retailers who set their prices taking the wholesale prices they observe as given. Thus, a double margin is added to the marginal cost to produce the product. Strategic interactions between manufacturers and retailers with respect to prices follow a sequential Nash model. To solve the model, one uses backwards induction and solves the retailer's problem first.

3.1.1 Retailer

Consider a 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:

$$\Pi^r_{jt} = \sum_j \left(p^r_{jt} - p^w_{jt} - ntc^r_{jt}\right) s_{jt}(p^r_t) \tag{1}$$

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

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

This gives us a set of J equations, one for each product. One can solve for the markups by defining $S_{jk} = \frac{\partial s_{kt}(p^r_t)}{\partial p^r_{jt}}$ $j, k = 1, ..., J.$, and a $J \times J$ matrix $\mathit{\Omega}_{rt}$ 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:

$$s_t + \Omega_{rt}(p^r_t - p^w_t - ntc^r_t) = 0 \tag{3}$$

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

$$p^r_t = p^w_t + ntc^r_t - \Omega^{-1}_{rt} s_t \tag{4}$$

where the retail price for product j in market t will be the sum of its wholesale price, nontraded costs, and markup.

3.1.2 Manufacturers

Let there be M manufacturers that each produce some subset $\mathit{\Gamma}_{mt}$ of the market's J_t differentiated products. Each manufacturer chooses its wholesale price p^w_{jt} while assuming the retailer behaves according to its first-order condition (2). Manufacturer w's profit function is:

$$\Pi_t^w = \sum_{j\in\Gamma_{mt}} \left(p_{jt}^w - tc_{jt}^w - ntc_{jt}^w\right) s_{jt}(p_t^r\left(p_t^w\right)) \tag{5}$$

where 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.[8] Multiproduct firms are represented by a manufacturer ownership matrix, T_w, with elements $T_w\left(j,k\right)= 1$ if both products j and k are produced by the same manufacturer, and zero otherwise. 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:

$$s_{jt} + \sum_{k\in\Gamma_{mt}} T_w\left(k,j\right)\left(p_{kt}^w - tc_{kt}^w - ntc_{kt}^w\right)\frac{\partial s_{kt}}{\partial p_{jt}^w} = 0 \text{ for } j = 1, 2, ..., J_t. \tag{6}$$

This gives us another set of J equations, one for each product. Let Ω_{wt} be the manufacturer's reaction matrix with elements $\frac{\partial s_{kt}(p_t^r(p_t^w))}{\partial tc_{jt}^r}$, the change in each product's share with respect to a change in each product's traded marginal cost to the manufacturer. 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 wholesale price. Each column of Ω_{pt} contains the entries of a response matrix computed without observing the retailer's marginal costs. The properties of this manufacturer response matrix are described in greater detail in Villas-Boas (2004) and Villas-Boas and Hellerstein (2004). To obtain expressions for this matrix, one uses the implicit-function theorem to totally differentiate the retailer's first-order condition for product j with respect to all retail prices ($dp_k^r,\ k = 1, .., N$) and with respect to the manufacturer's price p_f^w with variation dp_f^w :

(7)

$$\sum_{k=1}^{N} \underbrace{\left(\frac{\partial s_j}{\partial p_k^r} + \sum_{i=1}^{N}\left(T_r\left(i,j\right)\frac{\partial^2 s_i}{\partial p_j^r \partial p_k^r}\left(p_i^r - p_i^w - c_i^r - ntc_i^w - tc_i^w\right)\right) + T_r\left(k,j\right)\frac{\partial s_k}{\partial p_j^r}\right)}_{v(j,k)} dp_k^r - \underbrace{T_r\left(f,j\right)\frac{\partial s_f}{\partial p_j^r}}_{w(j,f)} dp_f^w$$

Let V be a matrix with general element $v(j,k)$ and W be an N-dimensional vector with general element $w(j,f)$. Then $Vdp^r - W_f dp_f^w = 0$. One can solve for the derivatives of all retail prices with respect to the manufacturer's price f for the fth column of Λ_w :

[8] 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.

$$\frac{dp^r}{dp_f^w} = V^{-1}W_f.$$

Stacking the N columns together gives $\Lambda_w = V^{-1}W_f$ which gives the derivatives of all retail prices with respect to all manufacturer prices, with general element: $\Lambda_w(i,j) = \frac{dp_j^r}{dp_i^w}$. The ($j$th, kth) entry in Ω_{pt} is then the partial derivative of the kth product's retail price with respect to the jth product's wholesale price for that market. The (jth, kth) element of Ω_{wt} is the sum of the effect of the jth product's retail marginal costs on each of the J products' retail prices which in turn each affect the kth product's retail market share, that is: $\sum_m \frac{\partial s_{kt}}{\partial p_{mt}^r}\frac{\partial p_{mt}^r}{\partial p_{jt}^w}$ for $m = 1, 2, ...J$.

The manufacturers' marginal costs are then recovered by inverting the multiproduct manufacturer reaction matrix $\Omega_{wt}. * T_w$ for each market t, in vector notation:

$$p_t^w = tc_t^w + ntc_t^w - (\Omega_{wt} * T_w)^{-1} s_t \tag{8}$$

where for product j in market t the wholesale price is the sum of the manufacturer traded costs, nontraded costs, and markup function. 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:

$$p_{jt}^{w*} = tc_{jt}^{w*} + ntc_{jt}^w - \sum_{k\in\Gamma_{mt}} (\Omega_{wt} * T_w)^{-1} s_{kt} \text{ for } j = 1, 2, ..., J_t. \tag{9}$$

To get an expression for the matrix Λ_{tcw} with general element $\Lambda_{tcw}(i,j) = \frac{\partial p_j^w}{\partial tc_i^w}$ I totally differentiate the manufacturer's first-order condition for product j with respect to all manufacturer prices $(dp_k^w,\ k = 1,..,N)$ and with respect to the traded marginal cost tc_f^w with variation dtc_f^w :

(10)

$$\sum_{k=1}^{N} \underbrace{\left(\frac{\partial s_j}{\partial p_k^w} + \sum_{i=1}^{N} \left(T_w(i,j) \frac{\partial^2 s_i}{\partial p_j^w \partial p_k^w} \left(p_i^w - ntc_i^w - tc_i^w \right) \right) + T_w(k,j) \frac{\partial s_k}{\partial p_j^w} \right)}_{y(j,k)} dp_k^w - \underbrace{T_w(f,j) \frac{\partial s_f}{\partial p_j^w}}_{z(j,f)} dtc_f^w$$

Let Y be a matrix with general element $y(j,k)$ and Z be an N-dimensional vector with general element $z(j,f)$. Then $Y dp^w - Z_f dtc_f^w = 0$. One can solve for the derivatives of all wholesale prices with respect to the traded marginal cost f for the fth column of Λ_{tcw} :

$$\frac{dp^w}{dtc_f^w} = Y^{-1} Z_{f.}$$

Stacking the N columns together gives the matrix $\Lambda_{tcw} = Y^{-1}Z$ which computes the derivatives of all manufacturer prices with respect to all manufacturer traded marginal costs, with general element: $\Lambda_{tcw}(i,j) = \frac{dp_j^w}{dtc_i^w}$.

3.2 Retail Pass-Through

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

$$p_{jt}^{r*} = p_{jt}^{w*} + ntc_{jt}^r - \sum_k (\Omega_{wt} * T_w)^{-1} s_{kt} \text{ for } j,k = 1,2,...,J_t. \tag{11}$$

To get an expression for the matrix Λ_{tcr} with general element $\Lambda_{tcr}(i,j) = \frac{\partial p_j^r}{\partial tc_i^w}$ one must first calculate $\frac{\partial p_j^r}{\partial p_i^w}$, as described in the previous section. Retail-traded pass-through, defined as pass-through of the original marginal-cost shock to the retail price, is given by $\left(\frac{dp^r}{dp_f^w}\right)' \frac{dp^w}{dtc_f^w}$. To build intuition, the next section derives expressions for $\frac{dp^w}{dtc_f^w}$, $\frac{dp^r}{dp_f^w}$, and $\left(\frac{dp^r}{dp_f^w}\right)' \frac{dp^w}{dtc_f^w}$ for a simple model with single-product firms.

3.2.1 Simple Model: Single-Product Manufacturers

Consider a simple model of single-product manufacturers each selling to single-product retailers. One can compute the product j's wholesale pass-through elasticity by using the implicit-function theorem to take the total derivative of p^w_{jt} with respect to tc^w_{jt} and rearranging terms:

$$\frac{dp^w_{jt}}{dtc^w_{jt}} = \frac{1}{2 - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p^w_{jt}}} \frac{\frac{d^2 s}{\partial p^{w2}_{jt}}}{\frac{\partial s_{jt}}{\partial p^w_{jt}}}} = \frac{1}{2 + \text{markup} \cdot \text{curvature coefficient}} \tag{12}$$

$$\frac{dp^w_{jt}}{dtc^w_{jt}} \frac{tc^w_{jt}}{p^w_{jt}} = \frac{1}{\left(2 - \frac{s_{jt}}{\frac{\partial s_{jt}}{\partial p^w_{jt}}} \frac{\frac{d^2 s}{\partial p^{w2}_{jt}}}{\frac{\partial s_{jt}}{\partial p^w_{jt}}}\right) \frac{p^w_{jt}}{tc^w_{jt}}} = \frac{1}{(2 + \text{markup} \cdot \text{curvature coefficient }) \frac{p^w_{jt}}{tc^w_{jt}}} \tag{13}$$

The wholesale pass-through rate is given by: $PT^w = \frac{\left(p^{w*}_{jt} - p^w_{jt}\right)}{p^{w*}_{jt} + p^w_{jt}} \cdot \frac{tc^{w*}_{jt} + tc^w_{jt}}{tc^{w*}_{jt} - tc^w_{jt}}$. Equation (13) shows that it is determined by the jth good's markup, that is, its market share s_{jt} divided by the positive value of the slope of the derived demand curve with respect to the wholesale price, $-\frac{\partial s_{jt}}{\partial p^w_{jt}}$, the curvature of the derived demand curve with respect to the wholesale price, summarized by the curvature coefficient, $\frac{\frac{d^2 s}{\partial p^{w2}_{jt}}}{\frac{\partial s_{jt}}{\partial p^w_{jt}}}$, and the ratio of the manufacturer's wholesale price to the traded component of its marginal cost, $\frac{p^w_{jt}}{tc^w_{jt}}$. When derived demand is linear, so $\frac{d^2 s}{\partial p^{w2}_{jt}} = 0$, then $\frac{\partial p^w_{jt}}{\partial tc^w_{jt}} = \frac{1}{2}$ and pass-through is: $\frac{\frac{\partial p^w_{jt}}{p^w_{jt}}}{\frac{\partial tc^w_{jt}}{tc^w_{jt}}} = \frac{1}{2\frac{p^w_{jt}}{tc^w_{jt}}}$. 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: $\frac{\frac{\partial p^w_{jt}}{p^w_{jt}}}{\frac{\partial tc^w_{jt}}{tc^w_{jt}}} > \frac{1}{2\frac{p^w_{jt}}{tc^w_{jt}}}$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: $\frac{\frac{\partial p^w_{jt}}{p^w_{jt}}}{\frac{\partial tc^w_{jt}}{tc^w_{jt}}} < \frac{1}{2\frac{p^w_{jt}}{tc^w_{jt}}}$. As the ratio of the product's wholesale price to its traded marginal costs rises, manufacturer pass-through also falls. As a product's curvature coefficient or its markup rises, manufacturer pass-through falls if the second derivative is negative, as is the standard case. As a product's market share rises, the manufacturer's traded pass-through elasticity rises.

3.2.2 Simple Model: Single-Product Retailer

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

$$(14) \qquad \frac{dp^r_{jt}}{dp^w_{jt}} = \frac{1}{2 - \frac{s_t}{\frac{\partial s_{jt}}{\partial p_{jt}}} \frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}}} = \frac{1}{2 + \text{markup} \cdot \text{curvature coefficient}}$$

$$(15) \qquad \frac{dp^r_{jt}}{dp^w_{jt}} \frac{p^w_{jt}}{p^r_{jt}} = \frac{1}{\left(2 - \frac{s_t}{\frac{\partial s_{jt}}{\partial p_{jt}}} \frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}}\right) \frac{p^r_{jt}}{p^w_{jt}}} = \frac{1}{(2 + \text{markup} \cdot \text{curvature coefficient}) \frac{p^r_{jt}}{p^w_{jt}}}$$

Retail pass-through, defined as pass-through by the retailer of just those costs passed on by the manufacturer is: $PT^R = \frac{p^{r*}_{jt} - p^r_{jt}}{p^{r*}_{jt} + p^r_{jt}} \frac{p^{w*}_{jt} + p^w_{jt}}{p^{w*}_{jt} - p^w_{jt}}$. Equation (15) shows that it is determined by the jth good's markup, that is, its market share s_{jt} divided by the positive value of the slope of the demand curve with respect to the retail price, $-\frac{\partial s_{jt}}{\partial p^r_{jt}}$, the curvature of the demand curve with respect to the retail price, summarized by the curvature coefficient, $\frac{\frac{d^2 s_t}{\partial p_{jt}}}{\frac{\partial s_{jt}}{\partial p_{jt}}}$, and the ratio of the retailer's price to the manufacturer's price, $\frac{p^r_{jt}}{p^w_{jt}}$ .When demand is linear, so $\frac{d^2 s_t}{\partial p_{jt}} = 0$, then $\frac{\partial p^w_{jt}}{\partial p^w_{jt}} = \frac{1}{2}$; $\frac{dp^r_{jt}}{dp^w_{jt}} \frac{p^w_{jt}}{p^r_{jt}} = \frac{1}{2\frac{p^r_{jt}}{p^w_{jt}}}$ 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: $\frac{dp^r_{jt}}{dp^w_{jt}} \frac{p^w_{jt}}{p^r_{jt}} < \frac{1}{2\frac{p^r_{jt}}{p^w_{jt}}}$. As the markup or the curvature coefficient rises, pass-through falls if the second derivative is negative. As the ratio of the retail price to the manufacturer price $\frac{p^r_{jt}}{p^w_{jt}}$ rises, pass-through falls. Finally, retail traded-goods 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 $\left(\frac{dp^r}{dp^w_f}\right)' \frac{dp^w}{dtc^w_f}$.

Several implications of this section's theoretical model can be tested to see if they are supported by the data. If the second derivative of demand is negative, as should be the case with utility-maximizing consumers, then across products: first, as manufacturer markups rise, manufacturer-traded pass-through should fall; second, as retail markups rise, retail-traded pass-through should fall; and finally, as a product's market share rises, manufacturer- and retail-traded pass-through elasticities also should rise. An extension of this simple model to include multiproduct firms produces expressions for the determinants of pass-through that differ only in multiproduct firms' considerations, when making pricing decisions, of the cross-price elasticities between the products in their respective portfolios.

3.3 Demand

The pass-through computations done with the Bertrand-Nash supply model require consistent estimates of demand. 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 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.[9]

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. Let the indirect utility for consumer i in consuming product j in market t take a quasi-linear form:

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} + \varepsilon_{ijt} = V_{ijt} + \varepsilon_{ijt}, \quad i = 1, ..., I., \quad j = 1, ..., J., \quad t = 1, ..., T. \tag{16}$$

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 with individual consumer characteristics:

$$\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \Pi D_i + \Sigma v_i \tag{17}$$

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

[9] 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.

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 $\mu_{ijt}= [\Pi D_i \;\; \Sigma v_i] * [p_{jt} \;\; x_{jt}]$:

(18) $$u_{ijt} = \delta_{jt} + \mu_{ijt} + \varepsilon_{ijt}$$

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.[10] 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 is:

(19) $$u_{i0t} = \xi_{0t} + \pi_0 D_i + \sigma_0 v_{i0} + \varepsilon_{i0t}$$

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:

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

where $P^*(d\zeta)$ is the density of consumer characteristics $\zeta = [D \;\; \nu]$ 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

[10] 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, and so enables the me to estimate the aggregate demand curve for this market.

i purchasing product j in market t is given by the multinomial logit expression:

$$s_{ijt} = \frac{e^{\delta_{jt}}}{1 + \sum_{k=1}^{J_t} e^{\delta_{kt}}} \tag{21}$$

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:

$$s_{jt} = \int_{\mu_{it}} \frac{e^{\delta_{jt}+\mu_{ijt}}}{1 + \sum_k e^{\delta_{kt}+\mu_{ikt}}} f(\mu_{it})\, d\mu_{it} \tag{22}$$

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:

$$s_{jt} = \frac{1}{N} \sum_{i=1}^{N} \frac{e^{\delta_{jt}+\mu_{ijt}}}{1 + \sum_k e^{\delta_{kt}+\mu_{ikt}}} \tag{23}$$

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 The Market and the Data

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

4.1 Market

The imported beer market developed in the U.S. in the nineteenth century. The Dutch brand *Heineken,* for instance, was first imported to the U.S. in 1894. Following the Prohibition years from 1920 to 1933, the invention of the metal beverage can in 1935 enabled domestic brewers to build national brands without bearing the high fixed costs of maintaining local centers to collect deposit-return glass bottles. Such brands dominated U.S. consumption from that point until quite recently. As late as 1970, imported beers made up less than one percent of the total U.S. consumption of beer. Consumption of imported brands grew slowly in the 1980s and by double digits for each year in the 1990s – on average by 11 percent per year from 1993 to 2001 – resulting in a market share of over seven percent by the end of the decade. In 2002, after the trade-weighted dollar began to depreciate for the first time in a decade, imports saw their smallest percentage gains in market share in a decade: 6 percent in 2002 and 2 percent in 2003. Despite this recent growth in imports, 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 is an example of one type of imported good: packaged goods imported for consumption. Such imports do not require any further manufacture before reaching consumers and make up roughly half of the non-oil imports to the U.S. over the sample period. Beer shipments in my data are handled by independent wholesale distributors. The model abstracts from this additional step in the vertical chain, and assumes distributors are vertically integrated with brewers, in the sense that brewers bear their distributors' costs and control their pricing decisions. It is common knowledge in the industry that brewers set their distributors' prices through a practice known as *resale price maintenance* and cover a significant portion of their distributors' marginal costs.[11] This practice makes the analysis of pricing behavior along the distribution chain relatively straightforward.

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.[12] 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.

4.2 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 and wholesale prices for each product sold by *Dominick's* over a period of four years. They were gathered by the *Kilts Center for Marketing* at the University of Chicago's Graduate School of Business and include aggregate retail volume market shares and prices for 34

[11] Features of the *Dominick's* wholesale-price data confirm that brewers control distributor prices to the supermarket. One cannot distinguish between different distributors, each with an exclusive territory, by observing the wholesale prices they charge to individual *Dominick's* stores.

[12] Canadian Trade Commissioner (2000).

brands produced by 18 manufacturers.[13] 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 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. Products' market shares are calculated with respect to the potential market which 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.

The effect of local conditions is accounted for by the presence of an outside good. When computing the price elasticities for each brand, I take into account that consumers have the option of going to other retail outlets to purchase beer. In equilibrium, the retailer and manufacturer decide how much to raise the price of a brand following a foreign-cost shock after taking these elasticities into account. If consumers switch to domestic brands not included in my sample (such as micro-brews) or purchase beers in another supermarket following a rise in *Dominick's* price for a foreign brand, my model will produce consistent estimates of pass-through elasticities. The one limitation of this method of deriving the market's aggregate demand curve is that one must assume that the price of the outside good remains constant, which does not allow for strategic interactions between the retailer in my data and other retailers in the same market. I define the outside good to be all beer sold by other supermarkets to residents of the same zip codes as well

[13] The data can be found at http://gsbwww.uchicago.edu/kilts/research/db/dominicks/.

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 percent.

The combined volume market share of products covered in the sample with respect to the potential market is, on average, 18.5 percent, close to *Dominick's* median market share of 20 percent across all products. 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.

4.3 Preliminary Descriptive Results

Before turning to the estimation procedures for the structural model, it may be useful to explain how it can be used to identify the sources of traded-goods price inertia as well as its limitations. This section presents results from a simple regression of foreign beers' prices on their respective exchange rates, and explains how these results can serve as a benchmark for the results from the structural model. It then describes how the share of local nontraded costs is calculated for use in the structural model. Finally, it discusses the possible effects of the model's main limitation, an absence of dynamics, on the results.

Benchmark I begin the analysis by documenting in a simple regression whether *Dominick's* foreign beer prices are systematically related to movements in bilateral nominal exchange-rates. The results provide a benchmark against which to measure the performance of the structural model. If the structural model correctly identifies the sources of the incomplete transmission, its median retail pass-through elasticity across foreign brands should match this regression's retail pass-through elasticity. I estimate the following basic price equation:

$$\ln p^r_{jt} = \alpha \ln e_{jt} + \beta \ln w^d_{jt} + \gamma \ln w^f_{jt} + \delta \ln I_{jt} + \varepsilon_{jt} \tag{24}$$

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^r is the product's retail price, w^d is a measure of local costs, e is the bilateral nominal exchange rate (domestic-currency units per unit of foreign currency), w^f is a measure of foreign costs, I is a dummy for brand-specific promotions, and ε is a random error term. Local-and foreign-cost variables are included in the pricing equation to control for supply shocks other than exchange-rate changes that may affect a brand's retail price. The promotion variable controls for demand shocks that may affect a brand's retail price.

Table 3 reports results from estimation of the pricing equation. The first column reports coefficients from a regression of the retail price on the exchange rate alone. In this simple case, the average exchange-rate pass-through elasticity (α) is estimated to be 0.11 with a standard error of 0.01. This implies that a foreign beer's retail price increases by 0.11 percent following a one-percent dollar depreciation. The second column of Table 3 reports the coefficients from an *OLS* estimation of equation (24), which controls for the effects of other supply and demand shocks. The average pass-through elasticity (α) does not change from the previous regression, though its standard error rises to 0.03. The cost and promotion variables each have the expected signs and are significant at the one-percent level. The domestic and foreign cost variables are positive and the feature variable is negative as one would expect: prices generally fall during promotions. Overall, this regression suggests that local-currency price stability is an important feature of this market. It sets a benchmark of 11 percent for the retailer's traded pass-through elasticity, to be compared in section 7.1 with the results from the structural model.

Local nontraded costs To estimate the supply side of the structural model, we need first to estimate the share of local nontraded costs in each product's retail price in a separate regression. Ideally, one would directly observe the share of local costs in prices, but such data are typically unavailable. Following Goldberg and Verboven (2001), I estimate the following basic price equation:

$$\ln p^r_{jt} e_{jt} = \beta \ln w^d_{jt} e_{jt} + \gamma \ln w^f_{jt} + \varepsilon_{jt} \tag{25}$$

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^r is the product's retail price, w^d is local wages, e is the bilateral nominal exchange rate, w^f is foreign wages, and ε is a random error term. Local wages are hourly compensation in local currency terms for the grocery sector in Illinois multiplied by an exchange rate defined as foreign currency units per unit of domestic currency. The dependent variable is the retail price for each brand multiplied by the same exchange rate. The regression also includes brand dummy variables. The coefficient on the local-wage variable (β) gives us an estimate of the effect of a change in local wages, denominated in the manufacturer's currency, on the retail price, also denominated in the manufacturer's currency, controlling for the effects of changes in foreign wages. By removing any variation in the retail price correlated with exchange-rate fluctuations (that is, domestic-currency units per unit of foreign currency), we can identify the effect of a change in a product's local costs on this price, treating any costs originally denominated in the producer currency as constant. A simple numerical example may build intuition for this interpretation of the regression. Suppose the original retail price of a Japanese beer is $1, the exchange rate e_{jt} is ¥100 per dollar, the local wage w^d_{jt} is $0.70 and the foreign wage w^f_{jt} is ¥30. This beer's local costs make up 70 percent of its total marginal cost. Converted into its producer's currency, the beer's retail price is ¥100 and the local wage is ¥70. Now suppose the yen appreciates by ten percent against the dollar so ¥90 now equals one dollar. The local wage, unchanged in dollar terms, is now ¥63 in the producer currency, which, when added to the foreign wage of ¥30 produces a new retail price of ¥93. The percent-change in the retail price, denominated in producer currency, is 7 percent following this 10-percent exchange-rate change, a pass-through rate of 70 percent. The variable in this regression with no variation associated with the exchange-rate change, the foreign wage, comprises 30 percent of the beer's total marginal cost. The β coefficient is the share of local costs in a product's total marginal costs, in this case, 70 percent.

I estimate this share of local nontraded costs in brands' retail prices by region, in three regressions: one for Canadian brands, one for Mexican brands, and one for European brands. The results, reported in Table 4, indicate that the share of variation in the retail price attributed to movements in local costs is about 55 percent across all foreign brands.[14] The coefficient varies significantly according to products' region of origin. For Canadian brands, the share is 76 percent, and for Mexican brands, 85 percent, while for European brands it is much lower, at 46 percent. Note that these percentages give the nontraded costs at the manufacturer and the retailer level, combined, as a share of the retail price.

How plausible are these estimates when compared to industry sources? Industry studies indicate that local costs comprise up to 85 percent of the retail price of a bottle of beer.[15] Given the differences in factor costs across these three regions, the variation in these coefficients appears reasonable. The region with the highest costs, Europe, has the lowest share of local costs in its retail price: the region with the lowest costs, Mexico, has the highest share of local costs in its retail price. These results also match estimates of the share of local-cost components for other consumer goods. For example, Feenstra (1998) reports that a Barbie doll's retail price of ten dollars can be decomposed into three parts: a one-dollar markup for its manufacturer, *Mattel*; a one-dollar cost to manufacture the doll in China; and an eight-dollar cost for transportation, marketing, wholesaling, and retailing services for the product in the U.S. The share of local nontraded costs in the doll's retail price is 80 percent, close to the 85-percent local-cost share I find

[14] This average share is remarkably close to the 60 percent share of local nontraded costs in U.S. consumer prices found by Burstein, Neves, and Rebelo (2003).

[15] See, for example, *Standard and Poor's DRI*. "The Tax Burden on America's Beer Drinkers," January 17, 2001.

for Mexican beers.

This preliminary analysis has revealed two features of the data. The first set of regressions suggests that local-currency price stability is an important feature of this market. It finds that 11 percent of an exchange-rate change is transmitted to a beer's retail price. Where does the other 89 percent go? This incomplete transmission could be caused by the presence of local costs in brands' retail prices or by markup adjustments by foreign manufacturers and domestic retailers. The second set of regressions indicate a substantial share of local nontraded costs in foreign brands' retail prices, with considerable heterogeneity in their magnitude depending on a brand's provenance.

Dynamics The main limitation of the structural model is its lack of dynamics. Unfortunately, while the structural pass-through model yields a very rich set of results from the data's cross-sectional variation, it cannot simultaneously model dynamics over time. How might the absence of dynamics affect the model's results? On the demand side, dynamics may operate in two ways: first, consumption may be habit-based: consumers' former purchases may affect their current purchases. These demand-side dynamics may in turn affect firms' pricing behavior. Froot and Klemperer (1989) argue that firms' pass-through of an exchange-rate change depends on their beliefs about whether it is temporary or permanent. Temporary movements should have little effect on producers in a market with demand-side dynamics: It will not be optimal for a firm to raise its price and possibly lose customers in the future as well as in the present. The empirical literature has produced little evidence supporting Froot and Klemperer's emphasis on the difference between temporary and permanent shocks. Without incorporating dynamics, however, I cannot tie the structural model's estimated pass-through elasticities to firms' or consumers' expectations about future currency movements. Second, consumers may stockpile during sales which could affect my estimated demand elasticities. Unlike commodities like detergent or wine, however, beer cannot be stored for long periods. Brewers generally assume that it becomes stale or, to use industry parlance, "skunky" within 90 days of leaving the factory gate.[16] Industry reports note that most beer purchased in a supermarket is consumed within several hours of its purchase, so consumer stockpiling is not very common. Finally, beer is not a durable good – it is not an automobile or a household appliance – so the use of a static model to estimate pass-through is less problematic than it would be for a good where consumers would have more incentive to time their purchases to coincide with favorable macroeconomic conditions. For these reasons, it seems plausible to argue that the elasticities obtained with the structural model should not differ greatly from the true elasticities one would obtain with a dynamic model.

[16] Source: Interview with former *Anheuser-Busch* executive.

5 Estimation

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

5.1 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.[17] Following 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 (2004), 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:

$$s_t\left(x_t, p_{t,}\delta_t|\theta_2\right) = S_t \tag{26}$$

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 (*23*). 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.[18]

Following this inversion, one relates the recovered mean utility from consuming product j in

[17] 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.

[18] See Nevo (2000) for details.

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:

$$\Delta\xi_{jt} = \delta_{jt} - \beta_j d_j - \alpha p_{jt} \qquad (27)$$

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 (*16*) and mean unobserved characteristics. The mean utility term here denotes the part of the indirect utility expression in equation (*18*) that does not vary across consumers.

5.2 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.

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.[19] 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.[20] The model's first-stage results, reported in the appendix, indicate that foreign products' input prices appear to be effective as instruments.

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.

6 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.

6.1 Demand Estimation: Logit Demand

Table 5 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 2 in the appendix 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 5 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 econometri-

[19] Staiger and Stock (1997) examine the properties of the IV estimator in the presence of weak instruments.

[20] Engel and Rogers (1996) examine the persistent deviations from the law of one price across national borders.

cian, 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 5 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.

6.2 Demand: Random-Coefficients Model

Table 6 reports results from estimation of the demand equation (*27*). 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 7 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 8 reports retail prices and derived markups for selected brands. Foreign brands' median retail price of one dollar for foreign brands is about twice that of domestic brands, at 49 cents, which is consistent with industry lore.[21] 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.

Figure 4 compares the observed and derived exchange rates over the sample period for selected foreign brands. The derived exchange rates are 12-month moving averages to remove seasonal fluctuations. The observable comovement between the two variables suggests the structural model identifies nominal exchange-rate movements fairly well for the countries of origin of the sample's foreign brands.

7 Results from the Counterfactual Experiments and the Welfare Analysis

Using the full random-coefficients model and the derived marginal costs I conduct counterfactual experiments to analyze how firms and consumers react to foreign cost shocks. This section presents and discusses the results from these experiments. First, I consider the effect of various exchange-rate changes on foreign brands' prices. Second, I decompose the relative importance of nontraded costs and markup adjustments for foreign firms' incomplete pass-through. Third, I examine the effect of a 10-percent dollar depreciation on domestic and foreign firms' markups, quantities sold, and total variable profits. Finally, I quantify the depreciation's net impact on consumer and producer welfare in this market.

7.1 Foreign Brands' Pass-Through

The first set of counterfactual experiments considers the effect of a 10-percent dollar depreciation or appreciation on prices. Tables 9 and 10 report results for European, Canadian, and Mexican brands from six such exercises. The first columns of Tables 9 and 10 report manufacturers' traded pass-through elasticities: the incomplete pass-through of the original shock to the wholesale price

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

due to manufacturer markup adjustment. The second columns report retailers' nontraded pass-through elasticities: the incomplete pass-through of the original shock to the retail price due to the presence of a local component in retail costs. The last columns report the retailers' traded pass-through elasticities: the incomplete pass-through of the original shock to the retail price due to the retailer's markup adjustment.

The first counterfactual experiment examines how European manufacturers and the retailer adjust their prices following a ten-percent increase in European brands' traded marginal costs following a dollar depreciation against all European currencies. Its results are reported in the top panel of Table 9. The median manufacturer nontraded pass-through is 97 percent: The average local nontraded cost incurred by a foreign manufacturer is 3 cents. Very little nontraded value is added at this stage of the distribution chain. Manufacturer markup adjustments are large and vary quite a bit across brands: The median manufacturer-traded pass-through ranges from 17 percent for *Grolsch* to 61 percent for *Heineken*: It is 30 percent across all European brands. The average nontraded cost of the retailer is 21 cents per serving, which is consistent with information from industry sources that supermarkets' nontraded costs are roughly 40 to 50 percent of their total gross markup over the wholesale price. The median retailer nontraded pass-through is 20 percent and ranges from 11 percent for *Grolsch* to 42 percent for *Heineken.* Finally, the retailer appears to adjust its markup significantly for some brands and only marginally for others: Its median traded pass-through elasticity across all brands is 12 percent, ranging from 2 percent for *Grolsch* to 38 percent for *Beck's*.

The second counterfactual experiment considers how Canadian manufacturers and the retailer adjust their prices following a 10-percent increase in Canadian brands' traded marginal costs following a dollar depreciation. Its results are reported in the middle panel of Table 9. The median manufacturer nontraded pass-through is 79 percent. Manufacturer-traded pass-through coefficients are quite similar to those for European brands. Their median ranges from 48 percent for *Guinness* to 19 percent for *Molson Light*: It is 33 percent across all Canadian brands. The retailer's median nontraded pass-through elasticity is 15 percent and its traded pass-through elasticity is 6 percent, only half the European traded pass-through elasticity of 12 percent. Canadian brands have lower markups than do European brands which may reflect less market power, and hence, less ability to pass-through a given cost increase to consumers.

The third counterfactual experiment considers how Mexican manufacturers and the retailer adjust their prices following a ten-percent increase in Mexican brands' traded marginal costs following a dollar depreciation. Its results are reported in the bottom panel of Table 9. Manufacturer nontraded pass-through is 63 percent, and the median manufacturer-traded pass-through ranges from 55 percent for *Corona* to 13 percent for *Tecate*: It is 27 percent across both brands.

The retailer's median nontraded pass-through elasticity is 11 percent and its traded pass-through elasticity is 9 percent.

The final line of Table 9 reports the median pass-through elasticities across all three experiments. The median manufacturer-nontraded, manufacturer-traded, retail-nontraded, and retail-traded pass-through elasticities following a dollar depreciation are 97, 36, 21, and 13 percent, respectively. Pass-through elasticities for the same three counterfactual experiments except following a 10-percent dollar appreciation are reported in Table 10 and generally resemble those following a depreciation. The median manufacturer-nontraded, manufacturer-traded, retail-nontraded, and retail-traded pass-through elasticities across all foreign brands are 88, 33, 22, and 13 percent, respectively. The median retail-traded pass-through elasticities of 13 percent following a 10-percent dollar depreciation or appreciation is quite close to the 11-percent retail pass-through elasticity produced by the simple regression in section 4.3, which indicates that the structural model may correctly identify the sources of the incomplete transmission in this market.

Do brands' pass-through elasticities vary with their mark-ups and market shares in a manner that is consistent with the predictions of the theoretical model discussed in section 3.1? The results from the counterfactual experiments generally appear consistent with the predictions that brand-level pass-through will rise with market share and fall with markups. Figures 5 and 6 illustrate the positive relationship between integration at the microeconomic level, proxied for by market share, and the transmission of shocks to prices. Figure 5 displays a scatterplot with selected countries' median share in foreign brands' total sales on the X-axis and manufacturer and retailer traded pass-through elasticities on the Y-axis. It shows that following a 10-percent depreciation, pass-through elasticities rise as a country's total market share goes from 5 to 25 percent. Figure 6 displays a scatterplot with each brand's median share of foreign brands' total sales on the X-axis and manufacturer and retailer traded pass-through elasticities on the Y-axis. It shows that following a 10-percent depreciation, pass-through elasticities rise rapidly as brands' market share goes from 1 to 5 percent, peaking for those brands with a roughly 20-percent market share.

Figures 7 and 8 illustrate the negative relationship between brand markups and the transmission of shocks to prices, consistent with the predictions of the theoretical model. Figure 7 displays a scatterplot with each brand's median manufacturer markup on the X-axis and median manufacturer traded pass-through elasticity on the Y-axis. It shows that following a 10-percent change in the nominal exchange rate, as brands' manufacturer markups go from 20 cents to 25 cents, manufacturer traded pass-through falls. Figure 8 displays a scatterplot with each brand's median retail markup on the X-axis, and on the Y-axis, the median value of the retailer's pass-through, that is, of the retail traded pass-through divided by the manufacturer traded pass-through. It illustrates that following a 10-percent change in the nominal exchange rate, as brands' retail markups go from 27 cents to 32 cents, the retailer's pass-through falls.

The pass-through elasticities from the counterfactual experiments generally resemble those of previous studies and of the reduced-form regression discussed in Section 4. 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.[22] Knetter (1993) estimates a 56-percent annual pass-through elasticity to export prices for German firms exporting beer to the U.S. My model produces median manufacturer-traded pass-through elasticities (the pass-through measure from this study that is most directly comparable to Knetter's export-price measure) of 49 and 41 percent, respectively, following a depreciation, for the two German brands in the sample: *Beck's* and *St Pauli Girl*. The elasticities are even closer to Knetter's estimate following an appreciation at 40 and 53 percent, respectively.

7.2 Decomposition of the Incomplete Transmission

Tables 11 and 12 decompose the sources of the incomplete transmission of the exchange-rate shock to retail prices that is documented in Tables 9 and 10. The first column of each table 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. The third column reports the share attributable to a local-cost component in retailers' marginal costs, and the fourth column the share attributable to the retailer's markup adjustment.

Manufacturers' markup adjustment plays the most significant role in the incomplete transmission of the original shock to retail prices. Following a 10-percent dollar depreciation, it is responsible for just over half, or 60 percent, of the observed retail-price inertia. Manufacturers' local-cost components account for 14 percent of the remaining adjustment, while the retailer's local-cost component and markup adjustment account for 14 and 10 percent, respectively. Following a 10-percent exchange-rate appreciation, manufacturers' local-cost components account for 23 percent of the price adjustment, its markup adjustment for 60 percent, the retailer's local-cost component for 11 percent, and its markup adjustment for 6 percent. Overall, local-cost components account for 31 percent of the observed price inertia following a depreciation and 34 percent following an appreciation. Firms' markup adjustments account for 70 percent of the observed price inertia following a depreciation and 66 percent following an appreciation. Figure 9 illus-

[22] As Menon (1995) notes in his survey of the literature, the distribution across studies of these estimates has thick tails: Researchers have found very different pass-through coefficients even when working with data that cover the same industries and time periods.

trates the relationship between the pass-through of the original shock to the retail price and the share of the original shock accounted for by the decomposition.

These findings are strikingly similar to recent work by Betts and Kehoe (2005) who show that fluctuations in nontraded goods prices account for roughly 30 percent of the variation in real exchange rates, which implies that firms' markup adjustments on traded goods may account for the remaining 70 percent.

7.3 The Role of Strategic Interactions with Other Manufacturers

I define strategic interaction to be markup adjustment by competing manufacturers (import-competing domestic manufacturers and unaffected foreign manufacturers) following a change in the nominal exchange rate. Table 13 considers the possible role in foreign manufacturers' markup adjustments of this type of strategic interaction with domestic manufacturers and with foreign firms not affected by the exchange-rate change. It reports the equilibrium effects of a 10-percent increase in European firms' marginal costs on selected brands' profits, price-cost markups, and quantities sold. The first two columns of Table 13 give the percent change in manufacturer and retailer profits by brand 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 13 to the last three columns gives some indication of the underlying sources of variation in a brand's total profits following the depreciation: changes in the quantity sold or changes in the markup.

The results suggest some strategic interaction between import-competing domestic manufacturers and foreign manufacturers following a depreciation. Import-competing domestic manufacturers increase their profits by lowering prices to take market share from foreign manufacturers. The domestic brands with increased profits are the light or superpremium brands that compete most directly with imported beers. As Column 1 of Table 13 shows, only superpremium or light beers' profits rise following the depreciation: Manufacturer and retailer profits rise for *Bud Light* by 3 and 6 percent, *Michelob Light* by 7 and 11 percent, and *Miller High Life* by 2 and 4 percent. The profits of non-import-competing brands such as *Bud, Coors, Old Milwaukee, or Stroh's* change very little or decline. Premium brands that are not light beers such as *Bud* and *Coors* and sub-premium brands such as *Old Milwaukee* or *Stroh's* are considered poor substitutes for imported brands and so have little to gain by shrinking markups to try to capture market share following a depreciation. Imported brands that are not affected by the cost shock act like import-competing domestic brands, though manufacturers are somewhat less likely to cut their markups. Manufacturer profits rise by 3 percent for *Molson Light,* by 5 percent for *Tecate*, and by 3 percent for all competing import brands.

These strategic interactions between manufacturers provides an explanation for the puzzle of incomplete cross-border transmission that differs in emphasis from those of Goldberg and Verboven (2001), Burstein, Neves, and Rebelo (2003), or Corsetti and Dedola (2005). It may not be profit maximizing for foreign manufacturers to fully pass through a cost shock in a market where competing manufacturers exploit each increase in a foreign brand's price to increase market share by shrinking markups. Goldberg and Verboven (2001) and other pass-through studies note that foreign manufacturers adjust their markups following an exchange-rate shock, but do not report that competing domestic manufacturers lower their markups to amplify the competitive pressures on foreign manufacturers.

7.4 Welfare

Table 14 reports the effects on domestic and foreign firms' profits and on consumer welfare of the incomplete cross-border transmission following a dollar depreciation. The first column of the table reports results for European brands, the second column, for Canadian brands, and the third column, for Mexican brands. Overall, Table 14 shows that the social-welfare effects of a foreign-cost shock are large and unevenly distributed across domestic and foreign firms and domestic consumers.

For the first counterfactual experiment, in which only European brands are affected by the dollar depreciation, European manufacturers' profits fall by 18 percent. Domestic manufacturers benefit marginally: Their profits rise by 0.4 percent. Canadian and Mexican manufacturers do quite well, increasing their profits by over 3 percent. Consumer surplus falls by 5.1 percent and the retailer's profits by 2.6 percent.

These profit and quantity declines may seem a bit high, but they match recent reports of monthly profit and quantity changes for European brands in the U.S. following the dollar's depreciation against the euro. In September of 2004, *Heineken*, the European brand with the largest U.S. market share, announced it planned to raise prices by 2.5 percent in response to the recent weakness in the dollar. Other European brewers were expected to follow *Heineken*'s lead. Before the price changes, *Heineken*'s operating profits were down by 20 percent in euros, though they were higher in dollars. Once the price increases set in late in September and in October, shipments of European brands declined precipitously, by 18 percent for all Dutch brands and by 25 percent for all German brands, in the month of October alone.[23] These numbers are quite close to the 17-percent decline in profits the structural model finds across all European brands following a 10-percent dollar depreciation where their retail prices are adjusted by up to 4 percent.

[23] See "More Heineken Price Hikes Coming," *Beer Marketer's Insights*, Vol. 6, No. 82, September 8, 2004. "Imports Rough Autumn," *Beer Marketer's Insights*, Vol. 6, No. 80, December 24, 2004.

For the second counterfactual experiment, in which only Canadian brands are affected by the dollar depreciation, Canadian manufacturers' profits fall by 5 percent. Domestic manufacturers profits do not change. European and Mexican manufacturers do well, increasing their profits by about 2 percent. Consumer surplus falls by 4.5 percent and the retailer's profits by 2.3 percent.

For the third counterfactual experiment of a dollar depreciation against the Mexican peso, Mexican manufacturers' profits fall by 7.8 percent, the retailer's profits fall by 1.8 percent, and consumer surplus falls by 3.4 percent. European and Canadian manufacturers do well: Their profits rise by 2.5 percent, while domestic manufacturers' profits rise by only 0.1 percent.

Overall, these results indicate that foreign manufacturers generally bear more of the cost (or reap more of the benefit) of a change in the nominal exchange rate than do domestic consumers, domestic manufacturers, or the domestic retailer.

8 Conclusion

This paper makes three contributions. The first is an explanation of an approach I find useful to quantify the effect of a foreign cost 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 develop and estimate a structural econometric model that makes it possible to compute manufacturers' and retailers' pass-through of a foreign cost shock without directly observing 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 unusually detailed dataset with retail and wholesale prices that allows me to decompose the role of local nontraded costs in the incomplete transmission. Third, I quantify the importance of various sources for the process of cross-border transmission, and the implications for social welfare. This paper is the first to quantify the relative importance of two factors – local nontraded costs and markup adjustments – for both manufacturers and retailers in the incomplete transmission of shocks to prices, and the implications for social welfare. My results suggest that markup adjustments by manufacturers and the retailer explain a large part of the incomplete transmission though local-cost components play a nontrivial role. As for welfare, foreign manufacturers generally bear more of the cost (or reap more of the benefit) of a change in the nominal exchange rate than do domestic consumers, domestic manufacturers, or the domestic retailer. The assumption that retailers act as neutral pass-through intermediaries, which is common in the literature, may produce upwardly biased estimates of the role of nontraded costs in the incomplete transmission. Finally, the results suggest some strategic interaction between foreign manufacturers not affected by the exchange-rate change, import-competing domestic manufacturers, and affected foreign manufacturers following a depreciation that may contribute to the incomplete cross-border transmission. Following a dollar depreciation, manufacturers with brands that are close substitutes for affected foreign brands increase their profits by lowering markups to take market share from foreign manufacturers.

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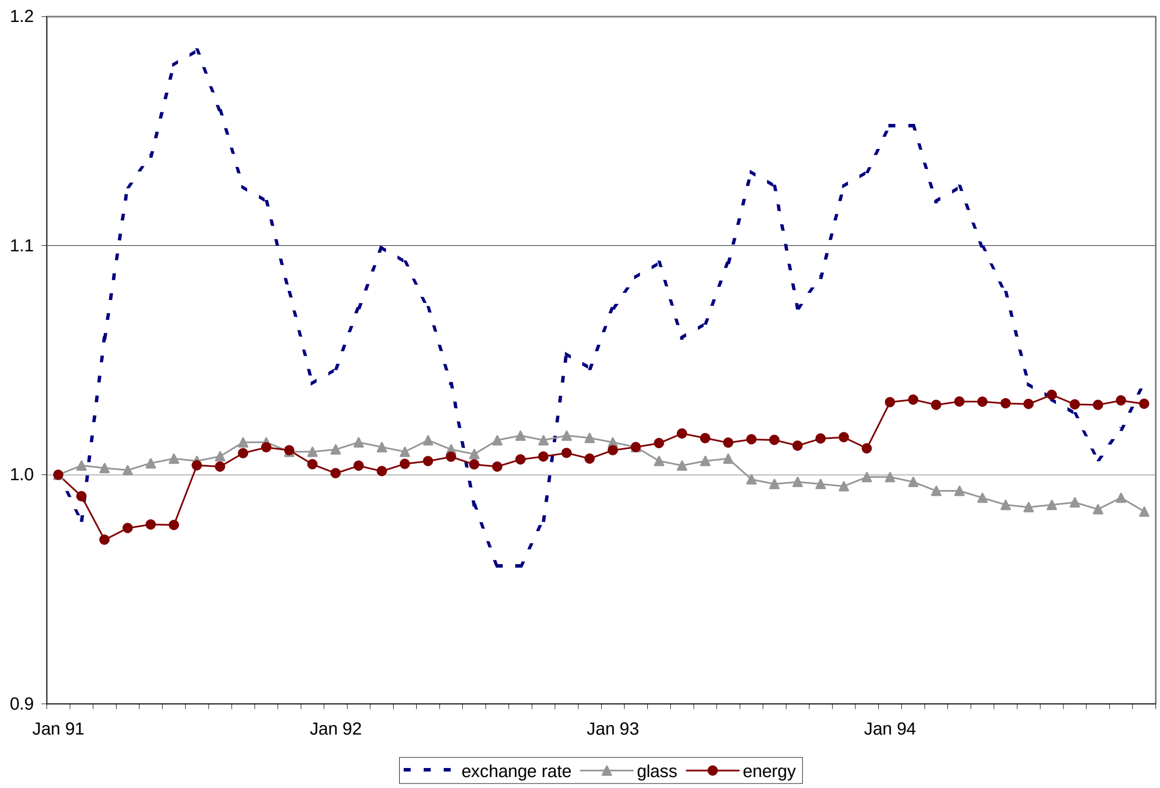


Figure 1: *The nominal exchange rate fluctuates by more than do typical input prices for German brewers.* Each series is normalized to 1 in January 1991. Monthly data. Sources: *BLS*, U.S. Department of Labor; Eurostat; International Financial Statistics, *IMF*.

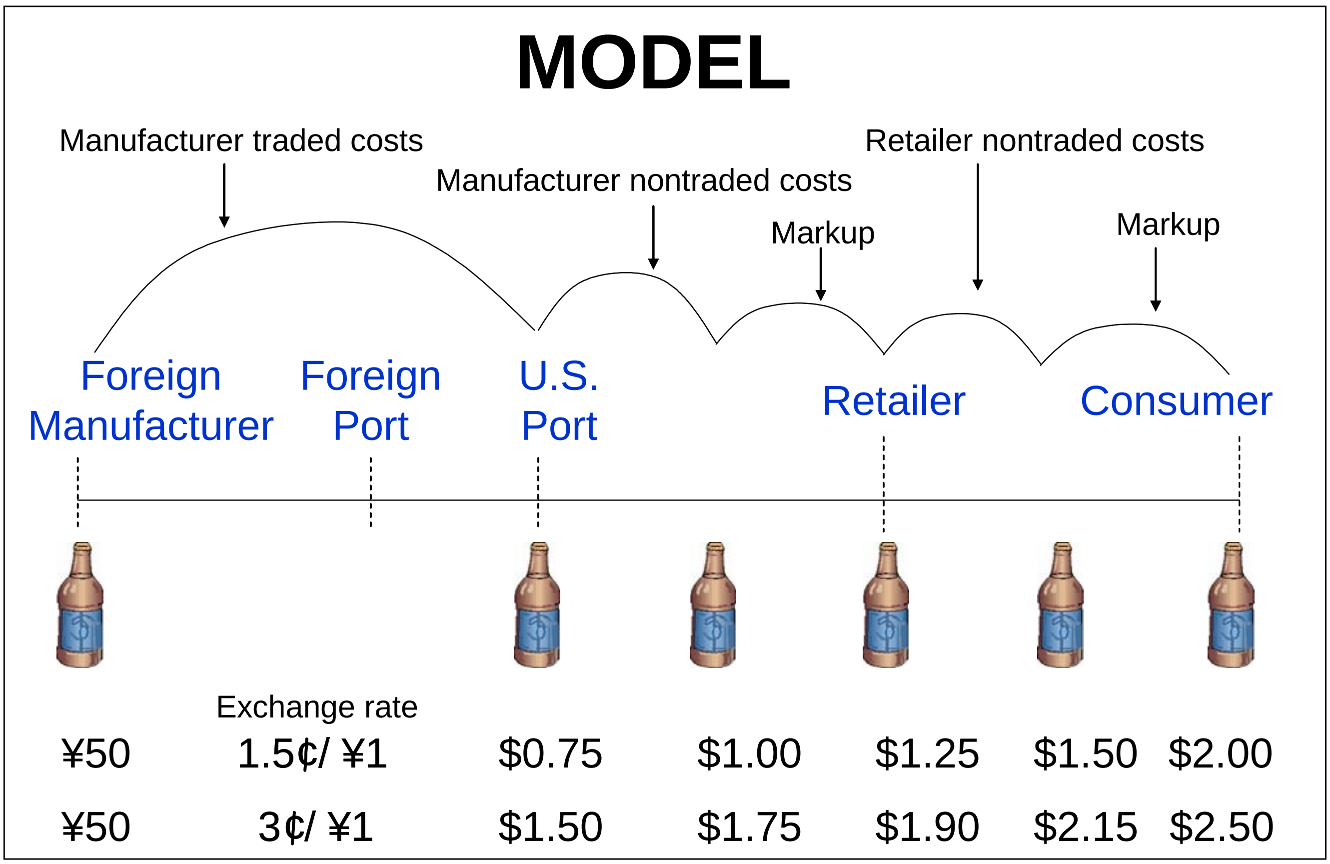


Figure 2: *An illustration of the sources of incomplete transmission.*

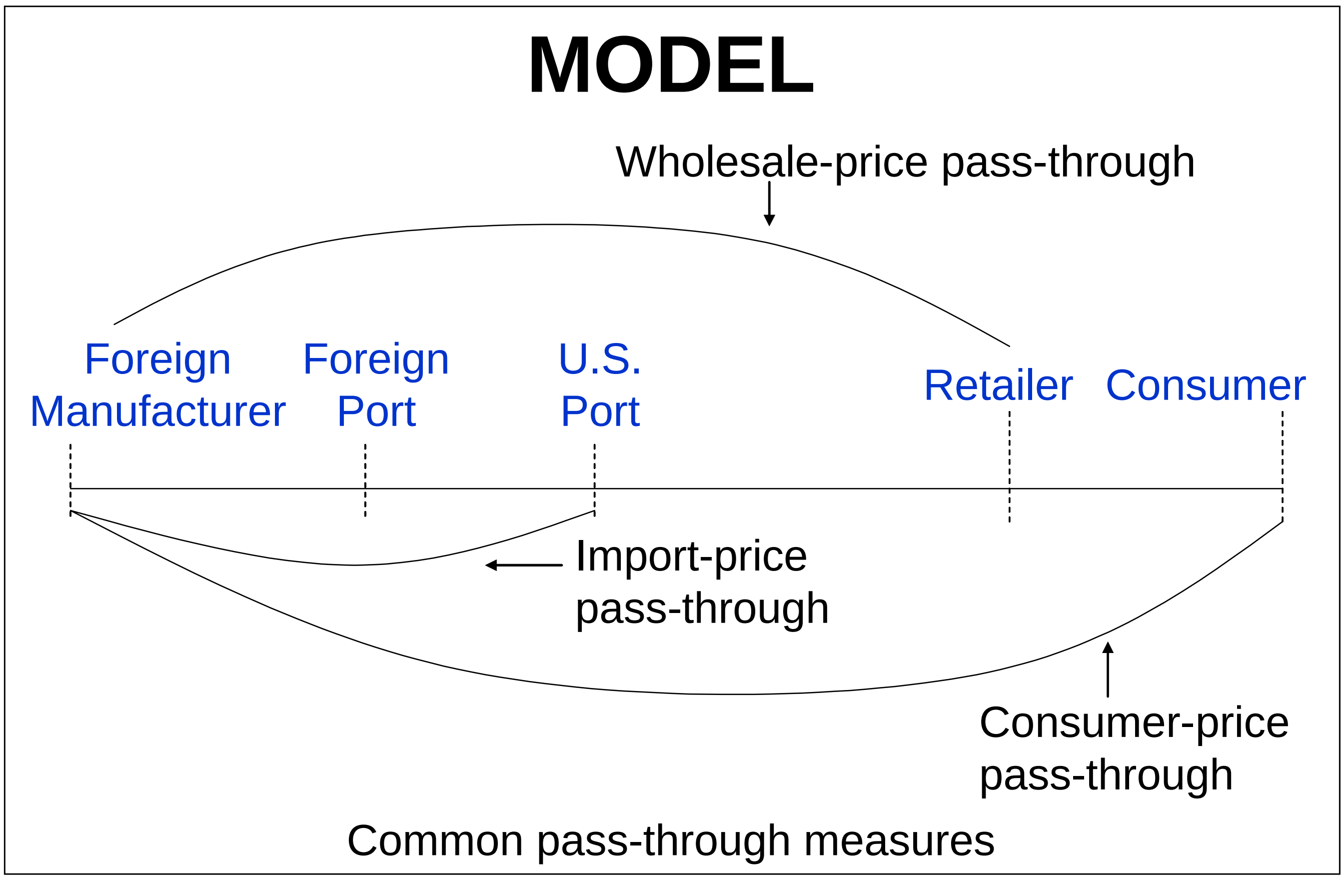
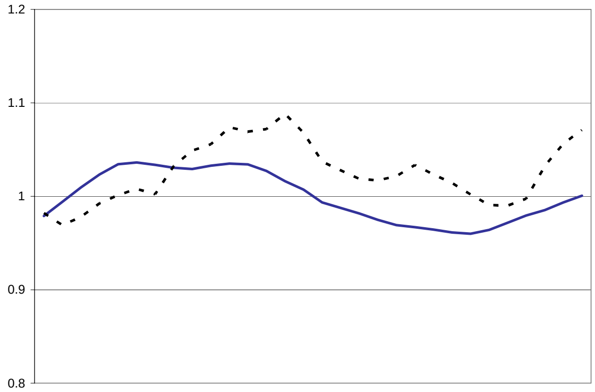
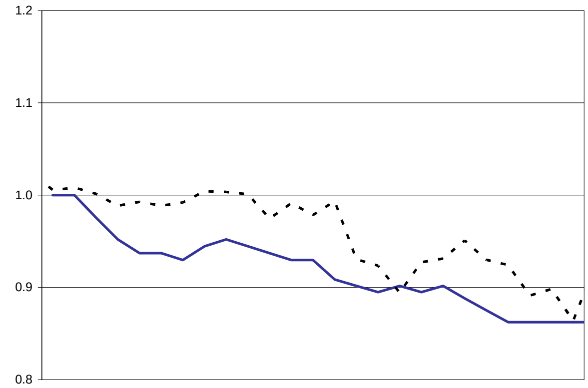


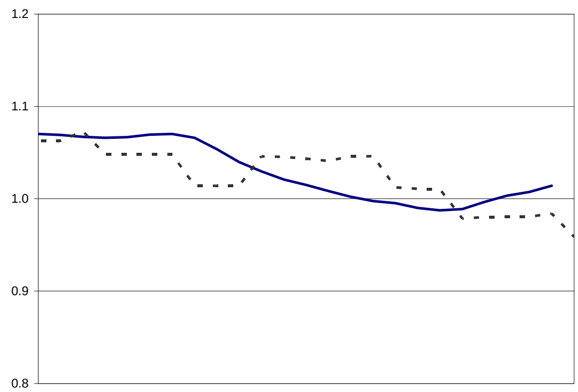
Figure 3: *An illustration of various pass-through measures.*



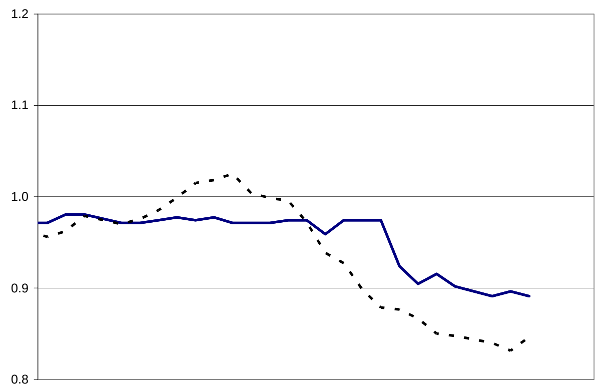
Amstel Light



Fosters



St. Pauli Girl



Tecate

Figure 4. A comparison of observed and derived exchange rates. The derived exchange rate is a 12-month moving average and is the broken line in each figure. Both series are normalized to equal one at the beginning of the sample. The time period is from July 1992 to December 1994. Source: My calculations: IMF.

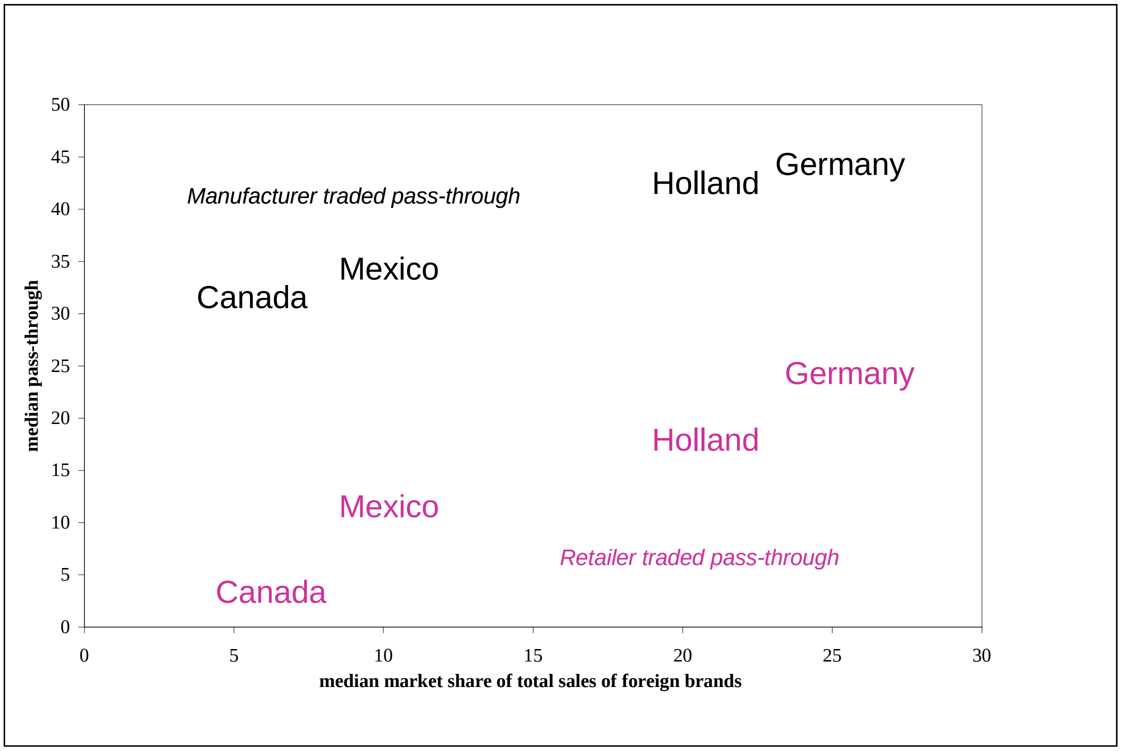


Figure 5: *As a country's brands gain market share, their manufacturer and retailer traded pass-through rises following a 10-percent dollar depreciation. Source: My calculations.*

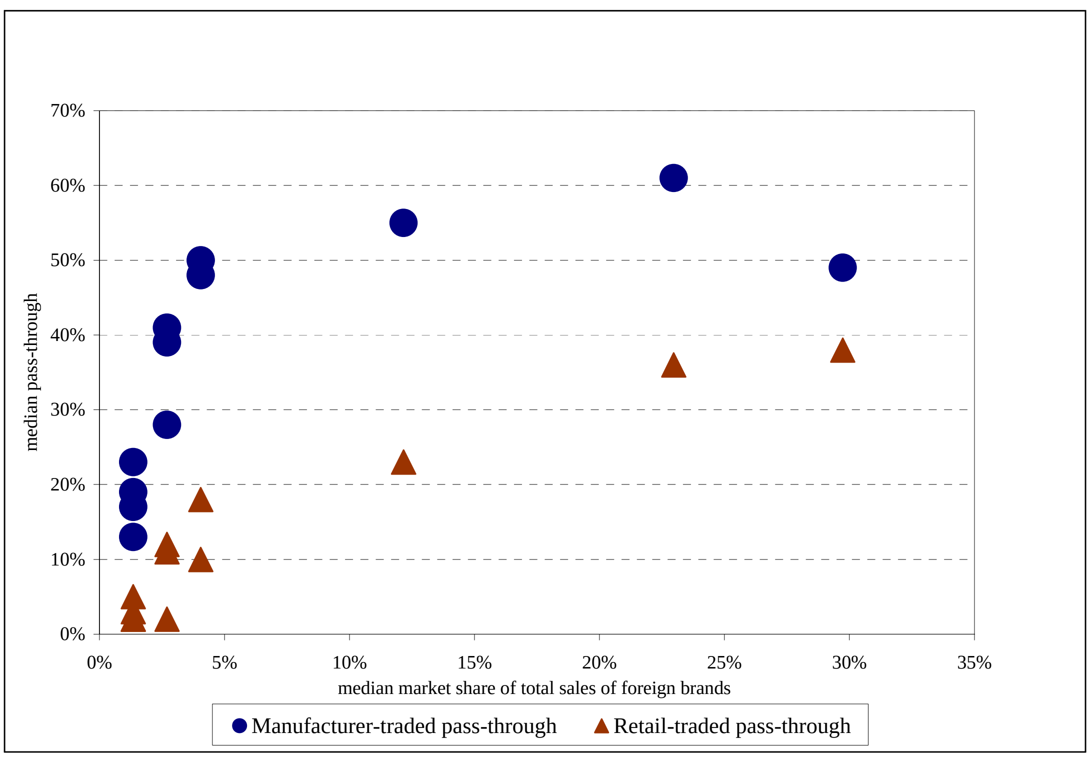


Figure 6: *As brand market share rises, pass-through rises following a 10-percent dollar depreciation. Source: My calculations.*

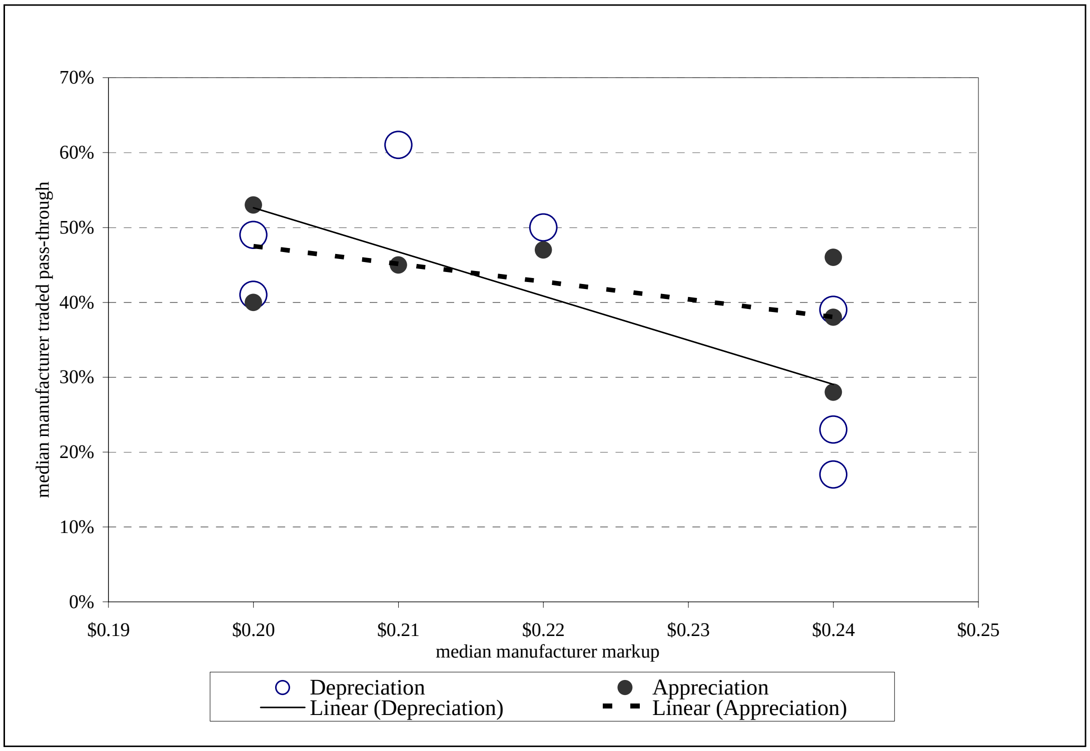


Figure 7: *Manufacturer markups have a negative relationship to manufacturer traded pass-through following a 10-percent dollar depreciation or appreciation. Source: My calculations.*

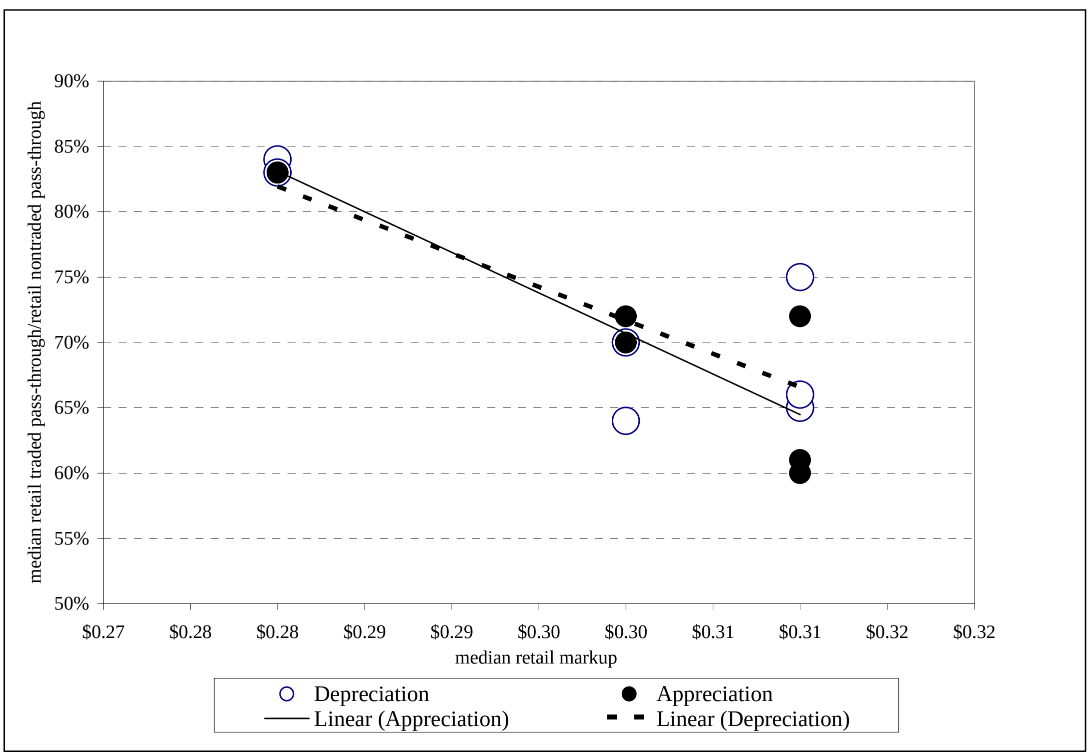


Figure 8: *Retail markups have a negative relationship to retail traded pass-through/retail non-traded pass-through following a 10-percent dollar depreciation or appreciation. Source: My calculations.*

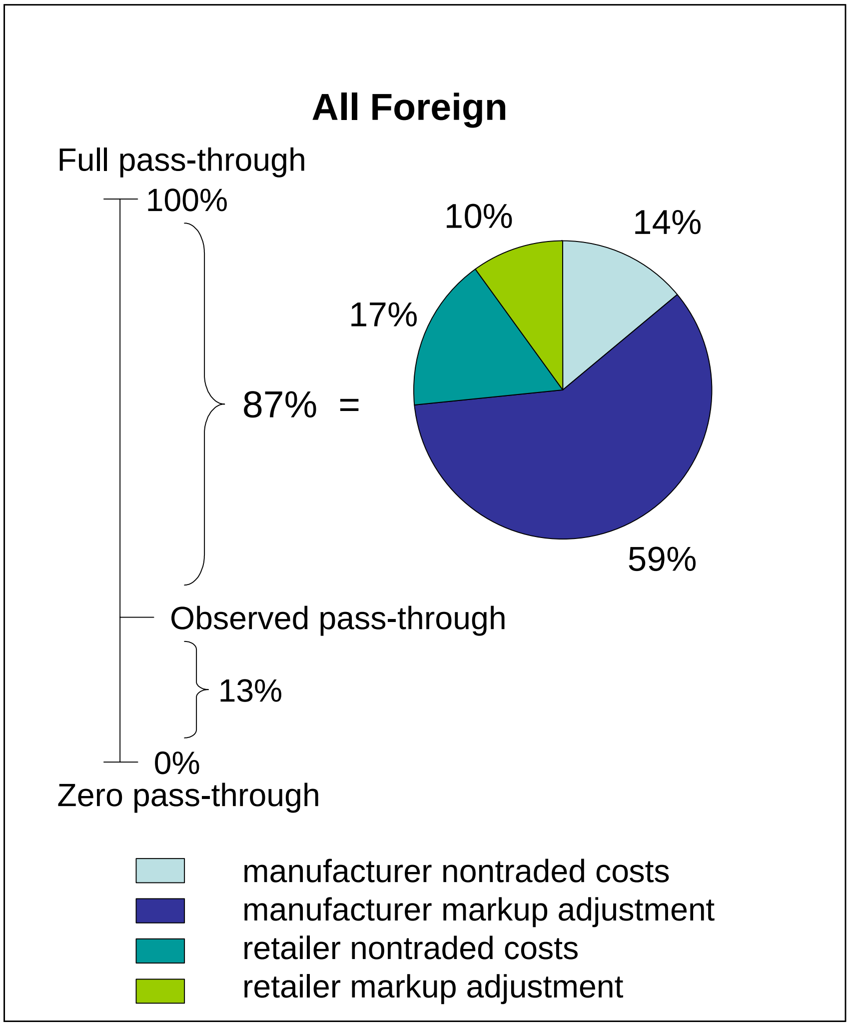


Figure 9: *A decomposition of the sources of foreign firms' incomplete transmission following a 10-percent dollar depreciation. Source: My calculations.*

Description	Mean	Median	Standard Deviation	Min	Max
Retail prices (cents per serving)	71	61	27	27	132
Wholesale prices (cents per serving)	61	51	21	21	105
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.

Retail price		
Exchange rate	.11	.11
	(.01)**	(.03)**
Foreign costs (wages)		.01
		(.001)**
Foreign costs (packaging)		.39
		(.09)**
Domestic costs (rent)		.38
		(.08)**
Domestic costs (wages)		.34
		(.07)**
Feature		-.11
		(.004)**
Constant	.04	-3.42
	(.004)**	(.45)**
Observations	1404	1404
R^2	.15	.46

Table 3: *Some preliminary descriptive results.* Local wages are hourly compensation in local currency terms for the grocery sector in Illinois. The dependent variable is the retail price for each brand. Domestic wages are hourly wages in supermarkets in the Chicago MSA. Domestic rent is hourly wages in supermarkets in the Chicago MSA. The exchange-rate is the monthly average of the previous month's spot rate. Feature is a dummy variable that indicates if the brand was promoted by the store during that month in its weekly circular or in its display within the store. Starred coefficients are significant at the 1-percent level. Source: My calculations.

Retail price	Foreign	Canadian	European	Mexican
Local wages	.55	.76	.46	.85
	(.02)**	(.06)**	(.03)**	(.05)**
Foreign wages	.01	.10	.02	.01
	(.002)**	(.21)	(.07)	(.002)**
Constant	-1.20	-1.00	-.86	-2.69
	(.06)**	(1.49)	(.41)*	(.21)**
Observations	1404	360	819	234
R^2	.38	.42	.27	.58

Table 4: *An estimation of the share of local nontraded costs in retail beer prices by region of origin.* Local wages are hourly compensation in local currency terms for the grocery sector in Illinois multiplied by the exchange rate which is foreign currency units per unit of domestic currency. The dependent variable is the retail price for each brand multiplied by the exchange rate which is foreign currency units per unit of domestic currency. The regression also includes brand dummy variables. Starred coefficients are significant at the 1-percent level. Source: 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 5: *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.

Variable	Mean in Population	Interaction with: Unobservables	Age	Income
Constant	-12.664* (.478)			
Price	-21.743* (7.184)	1.407 (2.122)	3.157* (1.506)	.280* (.136)
Bitterness	1.195* (.039)			
Hops	1.277* (.001)			
Sulfury/Skunky	-1.139* (.061)			
Percent Alcohol	-1.59* (.104)	.028 (.759)	-.143 (.154)	-.014 (.022)
Calories	-.003 (.042)			
Maltiness	-.415 (.478)			
Fruity	-.974* (.046)			
Floral	-1.803* (.103)			
GMM Objective	45.83			
M-D Weighted R^2	.46			

Table 6: *Results from the full random-coefficients model of demand.* Based on 4080 observations. Asymptotically robust standard errors in parentheses. Starred coefficients are significant at the 5-percent level. 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 7: *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	Price	Markup		
	Retail	Manufacturer	Retailer	Vertical
	cents	cents	cents	cents
Domestic Brands				
Bud Light	53	10	15	25
Coors	49	8	13	22
Keystone Light	35	6	9	16
Michelob Light	59	11	18	28
Stroh's	40	7	11	18
All Domestic Brands	49	9	12	21
Foreign Brands				
Amstel	99	22	30	52
Beck's	88	20	28	48
Corona	97	19	29	48
Heineken	99	21	28	49
Molson Light	76	18	28	46
All Foreign Brands	100	20	29	50

Table 8: *Median retail prices and derived price-cost markups for selected brands.* 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
European			
Amstel	50	34	18
Bass	39	26	12
Beck's	49	35	38
Grolsch	17	11	2
Harp	23	15	5
Heineken	61	42	36
St. Pauli	41	27	11
All	30	20	12
Canadian			
Fosters	28	12	2
Guinness	48	24	10
Molson L	19	10	3
All	33	15	6
Mexican			
Corona	55	20	21
Tecate	21	9	2
All	27	11	9
Foreign			
All	36	21	13

Table 9: *Counterfactual experiments: median pass-through of a 10-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 in foreign brands' marginal costs. Retail nontraded pass-through: the retail price's percent change for a given percent change in in foreign brands' marginal costs: Incomplete pass-through is due to the presence of a local component in costs. Manufacturer nontraded pass-through: the wholesale price's percent change for a given percent change in foreign brands' marginal costs. Incomplete pass-through is due to the presence of a local component in costs, and is 97, 79, and 63 percent for European, Canadian, and Mexican brands, respectively. Source: My calculations.

	Manufacturer Traded	Retail Nontraded	Retail Traded
European			
Amstel	47	32	20
Bass	46	31	18
Beck's	40	27	23
Grolsch	28	19	12
Harp	38	25	14
Heineken	45	29	25
St. Pauli	53	34	23
All	44	29	20
Canadian			
Fosters	8	5	4
Guinness	11	5	5
Molson L	3	1	4
All	10	5	5
Mexican			
Corona	19	11	-2
Tecate	8	4	3
All	11	6	1
Foreign			
All	33	22	13

Table 10: *Counterfactual experiments: median pass-through of a 10-percent decrease 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 in foreign brands' marginal costs. Retail nontraded pass-through: the retail price's percent change for a given percent change in in foreign brands' marginal costs: Incomplete pass-through is due to the presence of a local component in costs. Manufacturer nontraded pass-through: the wholesale price's percent change for a given percent change in foreign brands' marginal costs. Incomplete pass-through is due to the presence of a local component in costs, and is 88, 71, and 61 percent for European, Canadian, and Mexican brands, respectively. Source: My calculations.

	Manufacturer		Retailer	
	Nontraded	Traded	Nontraded	Traded
European				
Amstel	4	57	20	20
Bass	4	66	15	16
Beck's	5	77	24	-6
Grolsch	3	81	6	9
Harp	3	78	8	11
Heineken	5	56	30	9
St. Pauli	4	63	16	18
All	4	71	13	13
Canadian				
Fosters	21	52	16	10
Guinness	23	34	27	16
Molson L	22	62	9	7
All	22	49	19	10
Mexican				
Corona	30	19	41	-1
Tecate	23	47	12	7
All	26	44	18	2
Foreign				
All	14	60	17	10

Table 11: *Counterfactual experiments: Decomposition of the incomplete transmission of a 10-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.

	Manufacturer		Retailer	
	Nontraded	Traded	Nontraded	Traded
European				
Amstel	16	51	19	15
Bass	15	51	18	16
Beck's	16	62	17	5
Grolsch	14	68	10	8
Harp	14	58	15	13
Heineken	17	57	21	5
St. Pauli	16	45	25	14
All	16	54	19	11
Canadian				
Fosters	30	66	3	1
Guinness	31	63	6	0
Molson L	30	71	2	-3
All	31	64	5	0
Mexican				
Corona	31	53	7	6
Tecate	31	65	0	-2
All	31	61	1	0
Foreign				
All	23	60	11	6

Table 12: *Counterfactual experiments: Decomposition of the incomplete transmission of a 10-percent decrease 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 Manufacturer	Retail	Quantity	Markup Manufacturer	Retail
European Imports					
Amstel	-15	-16	-12	-6	-5
Bass	-17	-15	-10	-10	-6
Beck's	-21	-16	-18	-1	-2
Grolsch	-16	-7	-1	-15	-6
Harp	-14	-7	-2	-11	-7
Heineken	-20	-19	-20	0	-3
St. Pauli Girl	-16	-14	-9	-9	-6
All European Imports	-17	-12	-9	-9	-5
Competing Imports					
Fosters	1	0	.4	1	-4
Guinness	1	-3	-2	3	-3
Molson Light	3	0	4	-1	-4
Tecate	5	0	2	0	-4
All Competing Imports	3	0	2	0	-3
Domestic Brands					
Budweiser	0	-2	-1	1	0
Bud Light	3	6	7	-1	-1
Coors	-1	-4	-4	4	0
Coors Light	1	1	1	0	0
Michelob Light	7	11	13	-6	-3
Miller High Life	2	4	6	-3	-2
Stroh's	-5	-10	-11	8	2
All Domestic Brands	0	-2	-1	2	-1

Table 13: *Median percent changes in European brands', selected competing foreign brands', and selected domestic brands' profits, quantities, and markups after a 10-percent depreciation in the dollar relative to European currencies.* Median percent change in profits, quantity sold and in the retail and manufacturer product markup over all markets. 4080 observations. Source: My calculations.

	European	Canadian	Mexican
	%	%	%
Retailer Profit	-2.60	-2.30	-1.77
Competing Manufacturer Profit	.40	.05	.13
Other Foreign Brands	3.37	1.70	2.47
Domestic Brands	.25	-.07	-.05
Foreign Manufacturer Profit	-17.46	-5.03	-7.83
Consumer Surplus	-5.09	-4.48	-3.42

Table 14: *Median percent changes in variable profits and consumer surplus following a 10-percent dollar depreciation.* 4080 observations. Source: My calculations.

Supplementary Tables

Variable	Mean in Population	Interaction with: Age	Income
Constant	−4.729		
	(.350)		
Price	−15.403	2.097	.162
	(9.185)	(2.085)	(.180)
Bitterness	.812		
	(.025)		
Hops	.703		
	(.001)		
Sulfury/Skunky	−.759		
	(.035)		
Percent Alcohol	−.94	−.1285	−.012
	(.074)	(.201)	(.054)
Calories	−.0001		
	(.00004)		
Maltiness	−.180		
	(.350)		
Fruity	−.915		
	(.044)		
Floral	−1.683		
	(.066)		
GMM Objective	47.60		
M-D Weighted R^2	.41		

Table 1: *Results from the full random-coefficients model with* $v_i = 0$. Based on 4080 observations. Starred coefficients are significant at the 5-percent level. Asymptotically robust standard errors in parentheses. Source: My calculations. An alternative specification for the random-coefficients demand estimation is presented in this table. The table reports results from estimation of the demand equation while constraining the unobserved shocks, the $v_i's$, to be equal to zero, as a specification check. The coefficients generally fall in absolute value. Most striking is the large fall in the absolute value of the price coefficient as well as its insignificance. The sign on the percent-alcohol variable shifts and the coefficients on age and income, while still positively signed, are no longer significant. These changes in the coefficients indicate that the heterogeneity in the population cannot be fully accounted for by the demographics, and is driven in part by random shocks.

	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 2: *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.