Who Bears the Cost of a Change in the Exchange Rate? Pass-through Accounting for the Case of Beer*

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Abstract

Nominal exchange rates are remarkably volatile. They ordinarily appear disconnected from the fundamentals of the economies whose currencies they price. These facts make up a classic puzzle about the international economy. If prices do not respond fully to changes in the nominal exchange rate, who bears the cost of such large and unpredictable changes: foreign firms, domestic firms, or domestic consumers? This study presents a new analysis of the sources of incomplete pass-through and then uses this analysis to re-examine its implications for social welfare. I develop and estimate a structural model that analyzes the sources of local-currency price stability for a particular industry. The model enables counterfactual simulations that quantify the relative importance of firms' local-cost components and markup adjustments in the incomplete transmission of exchange-rate shocks to prices and the effect of the exchange-rate shock on domestic and foreign firms' profits and on consumer surplus. The model is applied to a panel dataset of one industry with retail and wholesale prices for *UPC*-level products. I find that markup adjustments by manufacturers and the retailer explain roughly half of the incomplete transmission and local-cost components account for the other half. Foreign manufacturers generally bear a greater cost (or reap a greater benefit) following an exchange-rate-induced marginal-cost shock than do domestic consumers, domestic manufacturers, or the domestic retailer.

Keywords: cross-border transmission; pass-through accounting; exchange-rate pass-through; pricing to market.

JEL Classification: F3, F4

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1 Introduction

Nominal exchange rates are remarkably volatile. They ordinarily appear disconnected from the fundamentals of the economies whose currencies they price. These facts make up a classic puzzle about the international economy. If prices do not respond fully to changes in the nominal exchange rate, who bears the cost of such large and unpredictable changes: foreign firms, domestic firms, or domestic consumers? This study presents a new analysis of the sources of this incomplete pass-through 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 simulations to quantify the effect of the exchange-rate change on domestic and foreign firms' profits and on consumer surplus.

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] Though several theoretical papers examine how exchange-rate fluctuations may affect welfare, no published empirical study has formally estimated these costs, as this paper does. In addition, 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 this incomplete pass-through. 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 pass-through within the framework of a structural model.

My general strategy is as follows. The starting point is a structural model of a particular industry which has three elements: demand, costs, and equilibrium conditions. A brand-level demand system is estimated first, independently of the supply side. The source of variation that identifies demand is brands' relative price variation over time. On the supply side, the cost function of a manufacturer selling in a foreign country is specified to allow for a traded, and a non-traded, local (i.e., destination-market specific) component in this manufacturer's costs. The distinction between traded and non-traded costs is based on the currency in which these costs are paid. Traded costs are by definition incurred by the seller in her home country. As such, they are subject to shocks caused by variation in the nominal exchange rate when they are expressed in the destination market currency. In contrast, non-traded costs are defined as those costs not affected by exchange-rate changes. Costs are treated

[1] For example, Betts and Devereux (2000), Corsetti and Dedola (2005), Devereux, Engel, and Tille (2003), Dornbusch (1987), Engel and Rogers (2001), Froot and Klemperer (1989), Krugman (1987), Obstfeld and Rogoff (2001).

[2] See, for example, Goldberg and Verboven (2001), Burstein, Neves, and Rebelo (2003), and Goldberg and Campa (2006). There is limited disaggregated evidence on the sources of incomplete transmission. Prices along the distribution chain, particularly wholesale prices, are typically unavailable, and it is difficult to obtain cost data amenable to comparison from foreign manufacturers.

as unobservable. Assuming that firms act as profit maximizers, the market structure of the industry together with particular assumptions regarding firms' strategic behavior imply a set of first-order conditions. Once the demand side parameters are estimated, these first-order conditions can be exploited to back out the marginal costs and markups in the industry. Based on the specified cost function, marginal costs are further decomposed into a traded and non-traded component. With this decomposition in place, I then examine how the particular components of prices (traded costs, non-traded costs, and markups) respond to exchange-rate changes. The lack of price response is accordingly attributed to either markup adjustment, or to the existence of a local, non-traded cost component.[3] The identification of variable markups relies heavily on having consistently estimated demand parameters or, alternatively, demand substitution patterns. The final step is to quantify the effect of the exchange-rate change on domestic and foreign firms' profits and on consumer surplus.

The model is estimated using an unusual dataset from the beer industry. 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.[4] 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.[5] 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 observe both retail- and wholesale-price data for a single product over time. These data enable me to separate out the role of the retailer's local nontraded costs in incomplete pass-through. in addition, these data are the most disaggregated 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.

In this market, firms pass-through an average of 11 percent of a foreign-cost shock to their retail prices; this leaves 89 percent of the shock to be accounted for. The model finds that firms' markup adjustments and local-cost components each account for roughly half of this remainder. As for welfare, foreign manufacturers generally bear a greater cost (or reap a greater benefit) following a foreign cost shock than do domestic consumers, domestic manufacturers, or the domestic retailer.

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

[3] For example, in Goldberg and Verboven's (2001) study of the European car market, local non-traded costs imply that a 1% change in the bilateral exchange rate changes the costs denominated in exporter currency by 0.35% .

[4] 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.

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

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 (2007). The 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. For the beer market, we know that manufacturers and retailers have contracts they negotiate roughly once a year in which the trade promotion dollars to be allocated over the year, the number of promotions, and a general understanding of the range of prices is agreed upon. It is clear that manufacturers do not set the prices of supermarket retailers in each period, and generally have much less effect on the retailer's behavior than they would like. Indeed, a large marketing literature has sprung up trying to understand why supermarket retailers routinely break promotional agreements with manufacturers and pocket promotional allowances.[6] As for timing, in the case of *Dominick's*, we know the store had several weeks advance notice of a drop in the wholesale price, and optimized independently given that decrease. Hence, assuming the retailer responds to the manufacturer's behavior but not vice versa seems to be a reasonable assumption based on industry lore.

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.[7] 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.[8] In addition, 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.

[6] See, for example, Kumar, Nanda, Surendra Rajiv, and Abel Jeuland. 2001. "Effectiveness of Trade Promotions: Analyzing the Determinants of Retail Pass-Through." *Marketing Science,* vol. 20, no 4, pp. 382-404.

[7] 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.

[8] The breakdown of the Bretton-Woods fixed exchange-rate system in 1973 led to a substantial increase in nominal exchange-rate volatility, while such fundamentals as real output, interest rates, or consumer prices did not exhibit a corresponding rise in volatility. An appendix figure illustrates that the exchange rate is much more volatile in monthly data than are brewers' other typical marginal costs using the example of Germany. 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).

The counterfactual simulations produce four major findings about incomplete pass-through. First, markup adjustments by manufacturers and by the retailer account for roughly half of the incomplete pass-through and local-cost components account for the other half. The model includes two sources of markup adjustment (the manufacturers' and the retailer's). The substantial adjustment of the manufacturer markup leaves little opportunity for the retailer's markup or non-traded costs to play a major role in the incomplete pass-through, as most of the exchange-rate shock has dissipated by the time it reaches the retail level of the distribution chain. Second, foreign manufacturers generally bear greater social-welfare costs (or reap greater social-welfare benefits) following 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 are unchanged, consumer surplus falls by 2.7 percent, and the retailer's profits fall by 1.6 percent, while Mexican manufacturer profits fall by almost 20 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 percentage points) 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 incomplete pass-through 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. 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 just as their foreign competitors face upward cost pressures from a domestic currency depreciation.

The paper 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. Papers in the international-finance literature, such as Burstein, Neves, and Rebelo (2003), Goldberg and Campa (2006), 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 those costs, whether manufacturers or retailers. This study's 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. It also enables one to compute the welfare effects of an exchange-rate shock in a partial equilibrium setting. More generally, it estimates a model with a flexible demand system that allows for variable markups, in contrast to much of the current trade and international macroeconomics literature which relies on a standard Dixit-Stiglitz framework with its constant elasticities of demand and markups.

The empirical framework incorporates two assumptions that affect the decomposition: the first, that manufacturers and retailers set their prices sequentially and independently; and the second, that local costs do not vary following an exchange-rate shock. Regarding the first assumption, the economic model of the industry's vertical relationships determines the accounting procedure's ordering of (and so weighting of) the sources of incomplete pass-through. However, the model makes no *a-priori* assumption regarding the contribution of firms' markup adjustment to any incomplete pass-through, which is determined by the estimated demand substitution patterns via the Bertrand-Nash equilibrium. Regarding the second assumption, the contribution of firms' local costs to incomplete pass-through is affected by the assumption that local costs (which are mainly distribution services) do not change following an exchange-rate shock. This second assumption is motivated by the very low frequency of price adjustment in distribution services observed in microeconomic producer-price data in the U.S. (documented by Nakamura and Steinsson (2007)) and following large exchange-rate devaluations in many countries (documented by Burstein, Eichenbaum, and Rebelo (2005) among others).

While the structural model yields a very rich set of results, it cannot simultaneously model dynamics over time. 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. 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. And unlike commodities like detergent or wine, 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.[9] 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.

The rest of the paper is organized as follows. The next section sets out the theoretical model. Section 3 describes the market and the data along with some preliminary descriptive results. Section 4 goes over the estimation and simulation stages of the empirical framework. Section 5 presents the

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

estimation results, Section 6 the simulation results, and Section 7 concludes.

2 Model

This section describes the supply model and then sets out the random-coefficients model used to estimate demand.

2.1 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 markup 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.

2.1.1 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:

$$\Pi_t^r = \sum_j \left(p_{jt}^r - p_{jt}^w - ntc_{jt}^r\right) s_{jt}(p_t^r) \tag{1}$$

where p_{jt}^r is the price the retailer sets for product j, p_{jt}^w is the wholesale price paid by the retailer for product j, ntc_{jt}^r are destination-market nontraded costs paid by the retailer to sell product j, and $s_{jt}(p_t^r)$ 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_{jt}^r must satisfy the first-order profit-maximizing conditions:

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

This gives us a set of J equations, one for each product. One can solve for the markups by defining $S_{jk} = \frac{\partial s_{kt}(p_t^r)}{\partial p_{jt}^r}$ $j, k = 1, ..., J.$, 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:

$$s_t + \Omega_{rt}(p_t^r - p_t^w - ntc_t^r) = 0 \tag{3}$$

The retailer's marginal costs are then recovered by inverting the multiproduct retailer reaction matrix, $\mathit{\Omega}_{rt}$ for each market t:

$$p_t^r = p_t^w + ntc_t^r - \Omega_{rt}^{-1} s_t = mc_t^r - \Omega_{rt}^{-1} s_t \tag{4}$$

where the retail price of product j in market t will be the sum of its total marginal cost, made up of its wholesale price and nontraded costs, $mc^r_{jt} = p^w_{jt} + ntc^r_{jt},$ and its markup.

2.1.2 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:

$$\Pi^w_t = \sum_{j \in \Gamma_{mt}} \left(p^w_{jt} - tc_{jt} - ntc^w_{jt} \right) s_{jt}(p^r_t\,(p^w_t)) \tag{5}$$

where tc_{jt} are traded costs and ntc^w_{jt} are destination-market nontraded costs incurred by the manufacturer to produce and sell product j. Multiproduct firms are represented by a manufacturer ownership matrix, T_w, with elements $T_w\,(j,k) = \mathit{1}$ 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^w_{jt} must satisfy the first-order profit-maximizing conditions:

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

This gives us another set of J equations, one for each product. Let $\mathit{\Omega}_{wt}$ be the manufacturer's reaction matrix with elements $\frac{\partial s_{kt}(p^r_t(p^w_t))}{\partial tc_{jt}}$, 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 (2007) and Villas-Boas and Hellerstein (2006). 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 ($dp^r_k,\ k = 1, .., N$) and with respect to the manufacturer's price p^w_f with variation dp^w_f :

$$\sum_{k=1}^{N} \underbrace{\left(\frac{\partial s_j}{\partial p^r_k} + \sum_{i=1}^{N} \left(T_r\,(i,j) \frac{\partial^2 s_i}{\partial p^r_j \partial p^r_k} (p^r_i - p^w_i - ntc^r_i - ntc^w_i - tc_i) \right) + T_r\,(k,j) \frac{\partial s_k}{\partial p^r_j} \right)}_{v(j,k)} dp^r_k - \underbrace{T_r\,(f,j) \frac{\partial s_f}{\partial p^r_j}}_{w(j,f)} dp^w_f \tag{7}$$

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 $Vdp^r - W_f dp^w_f = 0$. One can solve for the derivatives of all retail prices with respect to the manufacturer's price f for the fth column of $\Lambda_w : \frac{dp^r}{dp^w_f} = V^{-1}W_{f.}$ 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 $m = 1, 2, ...J$.

Manufacturers' total marginal costs (the sum of its traded and non-traded costs, $tc_t + ntc_t^w$, respectively) are then recovered by inverting the multiproduct manufacturer reaction matrix $\Omega_{wt}.*T_w$ for each market t according to:

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

Product j's wholesale price is the sum of the manufacturer's total marginal costs, made up of its traded and nontraded costs, $mc_{jt}^w = tc_{jt} + ntc_{jt}^w$, and its markup function, $-(\Omega_{wt} * T_w)^{-1} s_t$. In the model, the manufacturer of product j can use its estimate of the retailer's 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 incurs, the retailer's pass-through of manufacturer price changes, and other manufacturers' and consumers' reactions to retail-price changes.

2.2 Demand

The marginal-cost 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.[10]

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

[10] 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.

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:

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} + \varepsilon_{ijt} = V_{ijt} + \varepsilon_{ijt}, \quad i = 1, ..., I., \quad j = 1, ..., J., \quad t = 1, ..., T. \tag{9}$$

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:

$$\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \Pi D_i + \Sigma v_i \tag{10}$$

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

$$u_{ijt} = \delta_{jt} + \mu_{ijt} + \varepsilon_{ijt} \tag{11}$$

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.[11] 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:

$$u_{i0t} = \xi_{0t} + \pi_0 D_i + \sigma_0 v_{i0} + \varepsilon_{i0t} \tag{12}$$

Let A_j be the set of consumer traits that induce purchase of good j. The market share of good j in

[11] 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 the use of a single retailer does not require an assumption of monopoly in the retail market, as the 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.

market t is given by the probability that product j is chosen:

$$s_{jt} = \int_{\zeta \in A_j} P^*(d\zeta) \tag{13}$$

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

$$s_{ijt} = \frac{e^{\delta_{jt}}}{1 + \sum_{k=1}^{J_t} e^{\delta_{kt}}} \tag{14}$$

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:

$$s_{jt} = \int_{\mu_{it}} \frac{e^{\delta_{jt} + \mu_{ijt}}}{1 + \sum_k e^{\delta_{kt} + \mu_{ikt}}} f(\mu_{it})\, d\mu_{it} \tag{15}$$

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:

$$s_{jt} = \frac{1}{N} \sum_{i=1}^{N} \frac{e^{\delta_{jt} + \mu_{ijt}}}{1 + \sum_k e^{\delta_{kt} + \mu_{ikt}}} \tag{16}$$

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.

3 The Market and the Data

This section describes the market my data cover. It then presents some preliminary descriptive results to provide a benchmark for the results from the structural model.

3.1 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, the period of the paper's data. 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.[12] This practice makes the analysis of pricing behavior along the distribution chain relatively straight-forward.

3.2 Data

The 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. [13] This is 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 brands produced by 18 manufacturers.[14]

[12] Features of the *Dominick's* wholesale-price data confirm that brewers control distributor prices to the supermarket. As noted by Asker (2004), one cannot distinguish between different distributors, each with an exclusive territory, by observing the wholesale prices they charge to individual *Dominick's* stores.

[13] Supermarkets sell approximately 20 percent of all beer consumed in the U.S. 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. Canadian Trade Commissioner (2000).

[14] 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

I define a product as one twelve-ounce serving of a brand of beer and quantity as the total number of servings sold per month. Prices and servings sold series for the 34 products in the sample were obtained by aggregation. 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.[15]

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 as all beer sales in the sample's *Dominick's* stores not already included in my sample.[16]

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.[17] I supplement the *Dominick's* data with information on manufacturer costs, product characteristics, advertising, and the distribution of

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. Data on the joint distribution of consumers' ages and incomes come from the U.S. Census. These data are available for each zip code in which a *Dominick's* store is located and are aggregated across the three price zones in my data. Draws are then taken from the joint distribution to construct a certain number of artificial consumers per price zone. The variation in observed consumption patterns across the three price zones, together with the variation in age and income across the zones, identifies the interaction of each demographic variable with consumers' sensitivity to price and preference for the percent alcohol in their beer. 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. The data can be found at http://gsbwww.uchicago.edu/kilts/research/db/dominicks/.

[15] I aggregated data on the same brand sold in different sizes to be a single product. As the data are dominated by six-packs, this aggregation procedure did not significantly affect the price and quantity variation. The period length in the data used for the estimation is one month. The data were aggregated up to a monthly frequency from the original sample period of one week to better capture the effects of exchange-rate movements on prices, and include temporary price markdowns. I define a market as one of *Dominick's* three price zones in one month. 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 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.

[16] 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.

[17] Bonus-buy sales appear to be the most common promotion used for beer which appear in the data as price reductions.

consumer demographics. Product characteristics come from the ratings of a *Consumer Reports* study conducted in 1996.

3.3 Preliminary Descriptive Results

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:

$$\ln p_{jt}^r = \alpha \ln e_{jt} + \beta \ln w_{jt}^d + \gamma \ln w_{jt}^f + \delta \ln I_{jt} + \varepsilon_{jt} \tag{17}$$

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 1 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 1 reports the coefficients from an *OLS* estimation of equation (17), 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 pass-through elasticity, to be compared below with the results from the structural model.

4 Empirical Approach

The empirical approach has two components: estimation and simulation. At the estimation stage, I estimate the demand parameters, the traded and non-traded costs, and the markups of the retailer and manufacturers. At the simulation stage, I assess the overall impact of an exchange-rate shock on firms' pricing behavior by using simulations to compute the industry equilibrium that emerges following a significant appreciation of the relevant foreign currency, and comparing it to the original industry equilibrium.

4.1 Estimation

The estimation stage consists of the following four steps:

1. **Demand estimation.**

   The first step is to estimate the parameters of the demand system, as described in detail in section 4.3.

2. **Back out retailer markups and total marginal costs $\mathbf{mc}_{jt}^r$.**

   Once the parameters of the demand system have been estimated, I compute the market-share function $s_{jt}(p_t^r)$ as well as the own- and cross-price derivatives $\frac{\partial s_{kt}}{\partial p_{jt}^r}$. Then I use the retailer's first-order conditions for each product j to back out the retailer's total marginal costs for product $j, \mathbf{mc}_{jt}^r$. The retailer's nontraded costs $\mathbf{ntc}_{jt}^r$ are then given by the difference between the retailer's total marginal costs and the wholesale prices it pays, where the latter are observed in the data: $\mathbf{ntc}_{jt}^r = \mathbf{mc}_{jt}^r - \mathbf{p}_{jt}^w$.

3. **Back out manufacturer markups and total marginal costs $\mathbf{mc}_{jt}^w$.**

   The procedure here is similar as that used to derive the total marginal costs for the retailer. Manufacturers behave according to their first-order conditions, so I use equation (8) to back out the manufacturer total marginal cost $\mathbf{mc}_{jt}^w$.

4. **Model manufacturer marginal costs parametrically as a function of observables.**

   The manufacturer first-order conditions allow me to back out the *total* marginal cost of the manufacturer; however they do not show how to decompose this cost into a traded and non-traded component. To accomplish this, I model the manufacturer's total marginal costs parametrically as a function of observables, and estimate this function. Specifically, I assume that the manufacturer total marginal cost mc_{jt}^w takes the form:

$$mc_{jt}^w = \exp(\theta_j + \omega_{jt})(w_t^d)^{\theta_{dw}}(e_{jt}w_t^f)^{F_j*\theta_{fw}}(p_{bjt})^{D_j*\theta_{dp}}(e_{jt}p_{bjt})^{F_j*\theta_{fp}} \tag{18}$$

   or, in log-terms:

$$\ln mc_{jt}^w = \theta_j + \theta_{dw}\ln w_t^d + F_j * \theta_{fw}\ln(e_{jt}w_t^f) + D_{j*}\theta_{dp}\ln(p_{bdt}) + F_{j*}\theta_{fp}\ln(e_{jt}p_{bjt}) + \omega_{jt} \tag{19}$$

   where w_t^d and w_t^f denote local domestic and foreign wages respectively, e_{jt} is the bilateral exchange rate between the producer country and the U.S., p_{bjt} is the price of barley in the country of production of brand j, F_j is a dummy that is equal to 1 if the product is produced by a foreign supplier, and zero otherwise, and D_j is a dummy that is equal to 1 if the product is produced by a domestic supplier, and zero otherwise. For the function to be homogeneous of degree 1 in factor prices, I require $\theta_{dw} + F_j * \theta_{fw} + D_j * \theta_{dp} + F_j * \theta_{fp} = 1$. This equation can be estimated by ordinary least squares, and this allows me to separate the manufacturers' total marginal costs into a traded and a non-traded component. By definition the traded cost refers to the part of the marginal cost that is paid in foreign currency and hence is subject to exchange-rate fluctuations. For domestic producers the traded component will be zero by definition. Foreign producers selling in the U.S. will generally incur both traded and local non-traded costs. The latter are captured in the above specification by the term $(w_t^d)^{\theta_{dw}}$ that indicates the dependence of foreign producers' marginal costs on the local wages in the U.S. The specification in (19) can be used to demonstrate two important facts regarding foreign suppliers' costs. First, foreign producers selling to the U.S. will typically experience substantially more volatility than domestic producers due to their exposure to exchange-rate shocks. Second, as long as the local non-traded cost component is positive (so that $\theta_{jdw} > 0$), the dollar-denominated marginal cost of foreign producers will change by a smaller proportion than the exchange rate. This incomplete marginal-cost response may partially explain the incomplete response of prices to exchange-rate changes, which is examined further in the simulations.

4.2 Simulations

The simulation stage consists of the following five steps:

1. **Simulate an exchange-rate shock to foreign brands' traded costs**.

   Simulate an exchange-rate shock as a change in the traded component of the jth product's manufacturer marginal cost, $d \ln tc_j$, which is the component denominated in foreign currency. Compute the new vector of traded marginal costs, tc_t^*.

2. **Compute a new Bertrand-Nash equilibrium.**

   Substitute the new vector of traded marginal costs, tc_t^*, into the system of J nonlinear equations that characterize manufacturer pricing behavior, and then find the wholesale price vector p_t^{w*} that will solve the system:

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

   Next, substitute the vector p_t^{w*} into the system of J nonlinear equations for the retail firm, and then find the retail price vector p_t^{r*} that will solve it:

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

3. **Compute pass-through elasticities.**

   Use the new equilibrium wholesale and retail prices to compute pass-through elasticities. Pass-through to the wholesale price is given by $(d\ln p_j^w/d\ln tc_j)$, and to the retail price by $(d\ln p_j^r/d\ln tc_j)$.

4. **Separate the pass-through elasticities into the part due to the presence of local costs and the part reflecting markup adjustment.**

   Using the estimation results on the traded and non-traded components of manufacturer and retailer costs respectively, I can further separate the pass-through elasticities into the part that is due to the presence of non-traded costs and the part that reflects markup adjustment. Given the Cobb-Douglas specification for the manufacturer marginal cost described earlier, the contribution of local costs to generating incomplete pass-through will be captured by the coefficient on domestic wages θ_{dw}. The contributions of manufacturer non-traded costs and markup adjustment to the $1-$ $(d\ln p_j^r/d\ln tc_j)$ part of the original shock not passed through to the retail price are given by $1-(d\ln(ntc_j^w+tc_j)/d\ln tc_j)$ and $(d\ln p_j^w/\ln(ntc_j^w+tc_j))$, respectively, and the contributions of the retailer's non-traded costs and markup adjustment to the incomplete pass-through are given by $(d\ln(p_j^w+ntc_j^r)/d\ln p_j^w)$ and $(d\ln p_j^r/d\ln(p_j^w+ntc_j^r))$, respectively. So the contribution of manufacturer non-traded costs to the incomplete retail pass-through is given by: $\Big(1-(d\ln(ntc_j^w+tc_j)/d\ln tc_j)\Big)\,/\,\Big(1-(d\ln p_j^r/d\ln tc_j)\Big)$ and the contribution of manufacturer markup adjustment to the incomplete retail pass-through is given by: $(d\ln p_j^w/\ln(ntc_j^w+tc_j))/\Big(1-(d\ln p_j^r/d\ln tc_j)\Big)$. Similarly, the contribution of the retailer's non-traded costs to the incomplete retail pass-through is given by: $(d\ln(p_j^w+ntc_j^r)/d\ln p_j^w)/\Big(1-(d\ln p_j^r/d\ln tc_j)\Big)$ and finally, the contribution of the retailer's markup adjustment to the incomplete retail pass-through by: $(d\ln p_j^r/d\ln(p_j^w+ntc_j^r))/\Big(1-(d\ln p_j^r/d\ln tc_j)\Big)$.

5. **Use the new equilibrium prices and quantities to compute changes in domestic and foreign firm markups, sales, and profits, and in consumer welfare.**

   An advantage of the structural model is that it can be used to both simulate a new post-shock equilibrium and to analyze the change in consumer welfare following the shock. The measure of the change in consumer welfare is the change in consumer surplus, which is measured as the *average* change in consumers' indirect utility, V_{ijt} in equation (9), following the change from an initial vector of retail prices before the exchange-rate shock p_{pre}^r to the new vector of retail prices after the shock p_{post}^r: $\frac{\sum_{i=0}^{I}\left(\ln[\sum_{j=0}^{J}V_{if}^{post}]-\ln[\sum_{j=0}^{J}V_{if}^{pre}]\right)}{I}$ where I is the total number of simulated consumers in the demand estimation and V_{if}^{pre} and V_{if}^{post} are defined by (9) using the pre-shock and post-shock predicted prices, respectively. Two assumptions underlie these welfare calculations, the first, that product characteristics (observed or unobserved) do not change following the exchange-rate shock, and the second, that the utility of the outside good remains unchanged, as I discuss further in Hellerstein (2004).

4.2.1 Discussion

The empirical framework incorporates two assumptions that affect the decomposition, the first, that manufacturers and retailers set their prices sequentially and independently, and the second, that local costs do not vary following an exchange-rate shock. Regarding the first assumption, the economic model of the industry's vertical relationships determines the accounting procedure's ordering of (and so weighting of) the sources of incomplete pass-through. If an exchange-rate shock is a signal whose strength diminishes as an import goes from the dock to the consumer (that is, as local costs and markups are added to its original cost at the dock), then the decomposition's purpose is to identify how and where along this distribution chain the diminution first occurs. The supply model provides the order in which firms decide to incur local costs and set markups along the distribution chain. To be consistent, each of these decisions must be introduced in this same order in the accounting procedure.

The paper is careful and explicit in the assumptions it makes about the industry's vertical relationships: It draws on both industry lore and formal nonnested tests to choose the model that best fits the data (Hellerstein 2004). The nonnested tests, developed by Villas-Boas (2007) compare observed and derived markups under different assumptions about the industry's vertical relationships. The industry features that generate the observed markups thus determine the choice of model for the industry's vertical relationships, which in turn determines the pass-through results from the counterfactuals. The paper's vertical model of independent and sequential optimization assumes that the manufacturer sets its markup over its total marginal costs after an exchange-rate shock, and the retailer then sets its markup over its total marginal cost (which is the sum of the manufacturer's new wholesale price and the retailer's local costs). The accounting procedure considers the contribution of each of these components to incomplete pass-through in the same order as firms' decisions along the distribution chain. To summarize, the model makes no a-priori assumption about the contribution of firms' markup adjustment to the incomplete pass-through. This is determined by the estimated demand substitution patterns via the Bertrand-Nash equilibrium.

Second, the contribution of firms local costs to the incomplete pass-through is affected by the assumption that local costs (which are mainly distribution services) do not change following the exchange-rate shock. This second assumption is motivated by the very low frequency of price adjustment in distribution services observed in microeconomic producer-price data in the U.S. (documented by Nakamura and Steinsson (2007)) and following large exchange-rate devaluations in many countries (documented by Burstein, Eichenbaum, and Rebelo (2005) among others).

4.3 Demand Estimation

The pass-through 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.[18] 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 (2007), 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:

$$s_t\left(x_t, p_{t,} \delta_t | \theta_2\right) = S_t \tag{20}$$

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 (*16*). 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.[19]

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

$$\Delta\xi_{jt} = \delta_{jt} - \beta_j d_j - \alpha p_{jt} \tag{21}$$

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 (*9*) and mean unobserved characteristics. The mean utility term here denotes the part of the indirect utility expression in equation (*11*) that does not vary across consumers.

[18] 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.

[19] See Nevo (2000) for details.

4.3.1 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* interacted with the relevant bilateral exchange rate for foreign brands. 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. Given the well-known border effect on prices one should expect a somewhat weaker relationship between wages and prices for foreign products than for domestic products. The model's first-stage results, reported in Table 3 and in the appendix, indicate that foreign products' input prices appear to be valid instruments, as I discuss further in the next section.

5 Estimation Results

This section presents the demand estimation results and then the derived markups and non-traded costs.

5.1 Demand: Logit Model

Table 3 reports results from the demand estimation using the multinomial logit model. Due to its restrictive functional form, this model will not produce credible estimates of pass-through. But 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.[20] Table 3 suggests input costs are valid instruments for the demand estimation. First, Table 3 reports that the first-stage's partial F-test of the IV specification is high at 17.42 and is significant at the 1-percent level: Its null hypothesis of zero-coefficients associated with the instruments is rejected. The results of this partial F-test are valid for the random-coefficients model as well. The partial R^2 for the instruments in the first stage is also high, at 0.97-0.98, and provides additional evidence that these are strong instruments. Second, the consumer's sensitivity to price should increase after instrumenting for unobserved changes in characteristics. That is, consumers should appear more sensitive to price once I instrument for the impact of unobserved (by the econometrician, not by firms or consumers) changes in product characteristics on their consumption choices. The fact that the price coefficient falls from -5.62 in the OLS estimation to -8.34 in the IV estimation provides further evidence that the instruments are sufficiently strong to control for the endogeneity of price in the demand estimation. Finally, the Hausman exogeneity test for the price variable, at 10.28, is significant at the 1-percent level, suggesting there is a gain from using instrumental variables over OLS when estimating demand.[21]

5.2 Demand: Random-Coefficients Model

Table 4 reports results from estimation of the demand equation (21). I allow consumers' age and income to interact with their taste coefficients for price and percent alcohol. The identification of the interaction of consumer characteristics and taste coefficients is made possible by zip-code level variation in demographics and consumption patterns. Census data on the joint distribution of consumers' ages and incomes come are available for each zip code in which a *Dominick's* store is located and are aggregated across the three price zones in my data. Draws are then taken from the joint distribution to construct a certain number of artificial consumers per price zone. The variation in observed consumption patterns across the three price zones, together with the variation in age and income across the zones, identifies the interaction of each demographic variable with consumers' sensitivity to price and preference for the percent alcohol in their beer. The demand estimation follows industry lore in allowing for heterogeneous consumer tastes with respect to brands' prices and percent alcohol. Industry studies of beer consumers consistently find that: (1) the preference for light beers (beers with roughly half the alcohol content of regular beers) is stronger among higher-income consumers; (2) the sensitivity to price is lower among higher-income consumers; and (3) for a given income level, younger consumers have a higher sensitivity to price and a stronger preference for regular beers than does the average consumer, hence the focus of the demand estimation on characterizing

[20] 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.

[21] The second and fourth columns of Table 3 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. 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.

consumer heterogeneity in both age and income. The other characteristics considered in the demand estimation generally exhibit less variation than do price and percent alcohol, and there is less industry lore about them on which to base a heterogeneous demand estimation. For example, the negative taste coefficient on skunky beer is roughly the same across age and income levels, and similarly, there is no obvious variation in preferences for malty, bitter, or fruity flavors in beer that correspond to the demographic data we have available for *Dominick's* consumers.

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 mean coefficient on price across consumers and products is -21.74 and it is significant at the 5-percent confidence level. The coefficients on the characteristics generally appear reasonable. As consumers' age and income rise, they become less price sensitive: Older consumers tend to be less sensitive to prices, as do higher-income consumers. 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. 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.

5.3 Demand Elasticities, Markups, and Nontraded Costs

Table 5 reports a sample of the median own- and cross-price elasticities for selected brands. The cross-price elasticities are generally intuitive: They 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.

These demand elasticities in turn determine each product's markup (defined as price less marginal cost) and margin (defined as (price-marginal cost)/price)), which are reported in Appendix B's Table 2. The median retail markup for domestic brands is 12 cents while for imported brands it is over twice that at 29 cents. The median retail margins are roughly the same across the two market segments, at 27 and 30 percent for domestic and foreign brands, respectively. At the manufacturer level, the median domestic markup is 9 cents and the median foreign markup is 20 cents, while the median domestic margin is 24 percent and the median foreign margin is 31 percent. Foreign brands' median retail price of one dollar is about twice that of domestic brands, at 49 cents.[22]

To estimate the supply side of the structural model, we need to estimate the share of local nontraded costs in foreign manufacturers' total marginal costs in a separate regression. Ideally, one would directly observe the share of local costs in total costs, but such data are typically unavailable. I use the regression described in equation (19) to obtain an estimate of the local content of foreign manufacturers' total marginal costs. This local content is reflected in the magnitude of the *domestic U.S. wages* coefficient that captures the cost share accounted for by domestic labor. As discussed earlier (see section 3.1), because distributors' pricing is coordinated by brewers, I treat the manufacturer and distributor as one entity, so local manufacturing costs include marketing and distribution costs incurred by the distributor. The results, reported in Table 2, indicate that the share of variation in foreign brands' total marginal costs attributed to movements in local costs is about 40 percent. Hence, in this market, a large part of foreign manufacturers' costs of selling in the U.S. market appears not to be affected by exchange-rate fluctuations, which alone should generate significant inertia in local-currency prices.

Finally, Figure 1 compares observed bilateral nominal exchange rates and derived manufacturer traded costs over the sample period for selected foreign brands. If most of the variation in manufacturers' traded costs results from nominal exchange-rate fluctuations, as assumed in the structural model, then the two series should covary significantly. The observable comovement between the two variables suggests the structural model identifies nominal exchange-rate movements reasonably well for the sample's foreign brands. This serves as a robustness check that the counterfactual simulations primarily capture the response of consumers and firms to exchange-rate shocks, and not to other movers of foreign manufacturers' traded costs.

6 Results from the Counterfactual Simulations and the Welfare Analysis

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

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

6.1 Foreign Brands' Pass-Through

The counterfactuals consider bilateral movements of the dollar against foreign currencies that tend to move together over the sample period. This requires four counterfactual experiments to be run to generate results that characterize the responses of each of the sample's foreign brands to a dollar depreciation. Any movement of the dollar against the Japanese yen, the Mexican peso, or the Canadian dollar is assumed to be bilateral. Any movement of the dollar against one European currency is assumed to occur against all European currencies. As background for this feature of the model, the appendix shows that over the sample period, European currencies tended to move together against the dollar while the other three currencies moved more independently both with respect to European currencies and to one another.

My method for calculating statistics at various levels of aggregation is as follows. The most disaggregated category in the data is the product which is defined as a 12-ounce serving of an individual brand (e.g. *Bud Light*). For each counterfactual, I first calculate the unweighted median pass-through elasticity (or other statistic, such as the accounting contribution or the percent change in markups) across markets for an individual product. These results are essentially the same for means: I display medians to eliminate sensitivity to outliers. I then construct aggregate statistics by taking weighted medians over these unweighted median pass-through elasticities (or other statistic). The weights I use are computed as the average servings sold over the 120 markets in the sample. In all the aggregate statistics I present, I focus on weighted medians across products.

The counterfactual simulations first consider the effect of a 10-percent appreciation of the relevant foreign currency against the dollar. The first counterfactual experiment examines how European manufacturers and the retailer adjust their prices following a ten-percent appreciation of European currencies against the dollar. Its results are reported in the top panel of Table 6. The first two columns of Table 6 report manufacturer and retailer pass-through elasticities. The median manufacturer pass-through ranges from 25 percent for *Amstel* to 40 percent for *Heineken*: It is 35 percent across all European brands. The retailer's median pass-through is 23 percent across all brands. The second counterfactual experiment considers how Canadian manufacturers and the retailer adjust their prices following a 10-percent appreciation of the Canadian dollar against the U.S. dollar. Manufacturer pass-through elasticities are quite similar to those for the European case: Their median ranges from 37 percent for *Molson Golden* to 43 percent for *Guinness*, and is 33 percent across all Canadian brands. The retailer's median pass-through is 16 percent. The third counterfactual considers how a Japanese manufacturer and the retailer adjust their prices following a ten-percent appreciation of the yen against the dollar. The median manufacturer pass-through is 12 percent and the median retail pass-through is 2 percent, and cannot be distinguished statistically from zero. The final counterfactual experiment considers how Mexican manufacturers and the retailer adjust their prices following a ten-percent appreciation of the Mexican peso against the dollar. Manufacturer pass-through is 35 percent and the retailer's pass-through is 24 percent. The last line of Table 6 reports the median pass-through elasticities across all four counterfactual scenarios. The median manufacturer and retailer pass-through elasticities following a dollar depreciation are 32 and 20 percent, respectively. The retailer's pass-through is roughly the same magnitude as the 11-percent retail pass-through produced by the simple regression in section 3.3, and implies that the structural model may correctly identify the sources of the incomplete pass-through in this market.[23]

The last four columns of Table 6 evaluate the relative importance of markup adjustment and local costs for the incomplete pass-through observed in each counterfactual. Manufacturers' markup adjustment plays a significant role in the incomplete transmission of the original shock to retail prices. Following a 10-percent dollar depreciation, it is responsible for just under half, or 47 percent, of the observed retail-price inertia. Manufacturers' local-cost components account for 39 percent of the incomplete pass-through, while the retailer's local-cost component and markup adjustment account for 6 and 8 percent, respectively. Overall, local-cost components account for 45 percent of the observed price inertia following a depreciation and firms' markup adjustments for 55 percent.

6.2 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 7 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 appreciation in European currencies on selected brands' profits, price-cost markups, and quantities sold. The first two columns of Table 7 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 give the median percent change in the manufacturer and retailer markups by brand. Comparing the first two columns of Table 7 to the last three columns gives some indication of the underlying sources of variation in a brand's total profits following the exchange-rate shock: 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, referred to hereafter as "competing domestic brands." As Column 1 of Table 7 shows, only superpremium or light beers' profits rise following the depreciation: Manufacturer and retailer profits rise for *Bud Light* by 3 and 5 percent, *Michelob Light* by 7 and 10 percent, and *Miller High*

[23] The pass-through elasticities from the counterfactual simulations generally resemble those of previous studies and of the reduced-form regression discussed above. 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. 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 35 and 30 percent over the course of a month, respectively, following a dollar depreciation, for the two German brands in the sample: *Beck's* and *St Pauli Girl*.

Life by 2 and 4 percent. The profits of non-import-competing domestic brands such as *Budweiser* or *Coors* change very little or decline. Premium brands that are not light beers such as *Bud* and *Coors* 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 not affected by the cost shock act like import-competing domestic brands, though manufacturers are less likely to cut markups. Manufacturer profits rise by 9 percent for *Molson Golden,* by 5 percent for *Tecate*, and by 2 percent for all competing import brands. These strategic interactions between manufacturers provides an explanation for the puzzle of incomplete pass-through: 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.

6.3 Welfare

Table 8 describes the mean effect on domestic and foreign firms' profits and on consumer welfare of firms' incomplete pass-through following a dollar depreciation. It reports 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 16 percent. Domestic manufacturers' profits do not change. Other foreign manufacturers do well, increasing their profits by over 2 percent. Consumer surplus falls by 3.6 percent and the retailer's profits by 2 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 retail 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. After prices increased in late September, 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.[24]

Table 8 reports that for the other counterfactuals considered (for Mexican, Canadian, or Japanese brands) competing domestic brands benefit more than do competing foreign brands, in contrast to the results from the European counterfactual. A likely explanation for the difference is that cross-price elasticities are as high or higher between competing domestic brands and North American or Japanese brands than between competing domestic brands and European brands. For the second counterfactual experiment, in which only Canadian brands face a dollar depreciation, Canadian manufacturers' profits fall by 15 percent. Domestic manufacturer profits do not change, though profits from competing domestic brands rise by 1.2 percent. Other unaffected foreign manufacturers also lose market share to competing domestic brands: Their profits fall on average by 2 percent. Consumer surplus falls by 4.6

[24] 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.

percent and the retailer's profits by 1.3 percent. For the third counterfactual experiment, in which only the Japanese brand *Sapporo* is affected by the dollar depreciation, its manufacturer's profits fall by 6 percent. Domestic manufacturers profits are basically unchanged, while and other foreign manufacturers see their profits fall marginally, by 0.77 percent, while competing domestic brands benefit, increasing profits by 1 percent. Consumer surplus falls by 3.3 percent and the retailer's profits by 1.4 percent. For the final counterfactual experiment of a dollar depreciation against the Mexican peso, Mexican manufacturers' profits fall by almost 20 percent, the retailer's profits by 1.6 percent, and consumer surplus by 2.7 percent. Other foreign manufacturers' profits fall marginally, by 0.71 percent, while domestic manufacturers' profits are basically unchanged. Competing domestic brands benefit, increasing their profits by 1.2 percent. Overall, these results indicate that foreign manufacturers generally bear greater costs (or reap greater benefits) following a change in the nominal exchange rate than do domestic consumers, domestic manufacturers, or the domestic retailer. The results also show that strategic interactions between competing domestic and foreign brands are key to understanding the market-level impact of an exchange-rate shock on profits and welfare.

7 Conclusion

This paper makes three contributions. The first is an explanation of an approach I find useful to quantify the effect of an exchange-rate 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 an exchange-rate shock without directly observing firms' marginal costs. Using the estimated demand system, I conduct counterfactual simulations 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 firms incomplete pass-through, and the implications for social welfare. My results suggest that markup adjustments by manufacturers and the retailer explain roughly half of the incomplete pass-through and local-cost components account for the other half. As for welfare, foreign manufacturers generally bear greater costs (or reap greater benefits) following a change in the nominal exchange rate than do domestic consumers, domestic manufacturers, or the domestic retailer. The common assumption in the literature that retailers act as neutral pass-through intermediaries may produce upwardly biased estimates of the role of nontraded costs in incomplete pass-through. 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 an exchange-rate change that may contribute to incomplete pass-through. 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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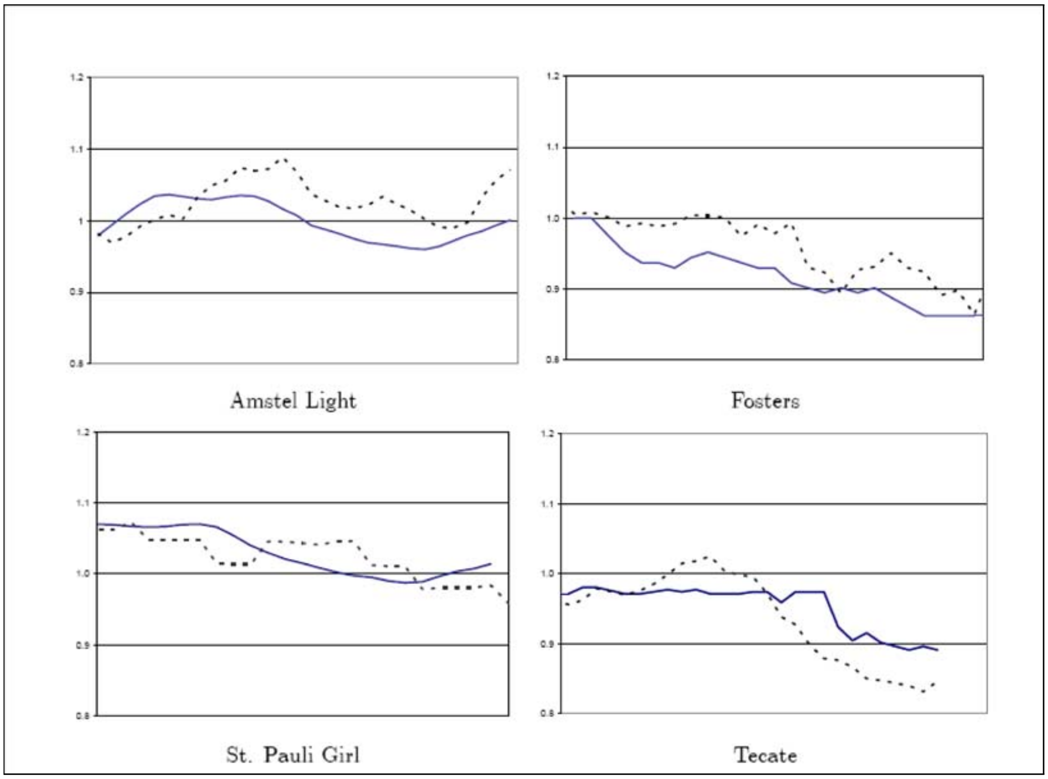

Figure 1: *A comparison of observed nominal exchange rates and derived manufacturer traded costs.* The observed bilateral nominal exchange-rate is the solid line and the derived manufacturer traded cost is the broken line in each figure. Both series are normalized to equal one at the beginning of the sample and are 12-month moving averages. The time period is from July 1992 to December 1994. Source: Author's calculations; IMF.

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 1: *Some preliminary descriptive results.* The dependent variable is the retail price for each brand. Domestic wages are hourly wages in supermarkets in the Chicago MSA. Domestic rents are commercial rents 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 or *5-percent level.

Domestic U.S. wages	.38
	(.11)**
Price foreign barley	.24
	(.05)**
Foreign wages	.39
	(.07)**
Observations	4080

Table 2: *Results from constrained linear regression of foreign manufacturer backed-out total marginal costs on determinants.* The dependent variable is the manufacturer's total marginal costs backed out from applying firms' first-order conditions in the structural model. Local costs are hourly wages in distribution and transportation sectors in the U.S. Foreign costs are hourly wages in the beverage industry from the *BLS*'s Foreign Labor Statistics Program interacted with the monthly average of the nominal exchange rate. The price of barley is from the U.S. Department of Agriculture and is interacted with the monthly average of the nominal exchange rate. Includes brand, month, and price-zone fixed effects.

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 3: *Diagnostic results from the logit model of demand.* Dependent variable is $ln(S_{jt}) - ln(S_{ot})$. Regressions include brand fixed effects. Huber-White robust standard errors are reported in parentheses. 4080 observations. Instrumental variables are wages are 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. Source: Competitive Media Reporting, 1991-1994.

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

Table 4: *Results from the full random-coefficients model of demand.* Asymptotically robust standard errors in parentheses. Starred coefficients are significant at the 5-percent level. 4080 observations.

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 5: *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.

	Pass-through Manufacturer	Pass-through Retailer	Decomposition Manufacturer Local Costs	Decomposition Manufacturer Markup Adjustment	Decomposition Retailer Local Costs	Decomposition Retailer Markup Adjustment
Europe						
Amstel	25	10	38	44	6	7
	(12)**	(6)	(10)**	(12)**	(2)**	(1)**
Beck's	35	27	36	44	5	8
	(14)**	(6)**	(12)**	(16)**	(2)*	(3)*
Heineken	40	25	39	41	3	7
	(13)**	(7)**	(13)**	(19)**	(2)	(2)**
All	35	23	38	47	4	7
	(11)*	(7)**	(12)**	(14)**	(3)	(2)**
Canada						
Guinness	43	15	41	42	10	9
	(17)*	(7)*	(17)**	(15)**	(2)**	(3)**
Molson G	37	24	47	34	3	13
	(10)**	(5)**	(11)**	(13)**	(2)*	(3)**
All	33	16	42	41	5	14
	(12)**	(7)*	(14)**	(14)**	(2)*	(4)**
Japan						
Sapporo	12	2	36	53	3	6
	(6)*	(4)	(6)**	(9)**	(2)*	(2)**
Mexico						
Corona	37	26	40	48	5	8
	(11)**	(8)**	(5)**	(17)**	(2)*	(1)**
Tecate	10	1	35	48	2	11
	(3)**	(11)	(12)**	(14)**	(1)	(2)**
All	35	24	40	48	5	9
	(11)*	(9)*	(7)**	(15)**	(2)*	(3)**
All Foreign	32	20	39	47	6	8
	(12)**	(9)*	(8)**	(19)**	(3)*	(4)*

Table 6: *Counterfactual simulations: Decomposition of the incomplete pass-through of a 10-percent appreciation of the relevant foreign currency to consumer prices.* The first two columns report the incomplete pass-through of the exchange-rate shock to the manufacturer and retailer's prices as an elasticity: Pass-through to the manufacturer price is given by $(d\ln p_j^w/d\ln tc_j)$, and to the retail price by $(d\ln p_j^r/d\ln tc_j)$. The third column reports the contribution of manufacturer non-traded costs to the incomplete retail pass-through, given by: $\left(1-(d\ln(ntc_j^w+tc_j)/d\ln tc_j)\right)/\left(1-(d\ln p_j^r/d\ln tc_j)\right)$; The fourth column the contribution of manufacturer markup adjustment to the incomplete pass-through, given by: $(d\ln p_j^w/\ln(ntc_j^w+tc_j))/\left(1-(d\ln p_j^r/d\ln tc_j)\right)$; The fifth column the contribution of the retailer's non-traded costs to the incomplete pass-through, given by: $(d\ln(p_j^w+ntc_j^r)/d\ln p_j^w)/\left(1-(d\ln p_j^r/d\ln tc_j)\right)$; The sixth column the contribution of the retailer's markup adjustment to the incomplete pass-through, given by: $(d\ln p_j^r/d\ln(p_j^w+ntc_j^r))/\left(1-(d\ln p_j^r/d\ln tc_j)\right)$. Each row entry for an individual product (e.g. *Bud Light*) gives the unweighted median statistic for the product over the sample's 120 markets. Summary statistics denote the weighted median across a category's products, with weights computed as the product's average volume sold over the sample's 120 markets.

Product	Profit Manufacturer	Profit Retail	Quantity	Markup Manufacturer	Markup Retail
European Imports					
Amstel	-11	-9	-6	-5	-6
	(5)*	(4)*	(2)*	(2)*	(1)**
Beck's	-18	-15	-16	-2	-3
	(6)**	(4)**	(4)**	(1)*	(1)*
Heineken	-16	-13	-15	0	-2
	(5)**	(4)**	(5)**	(0)*	(1)*
All	-16	-14	-15	-2	–3
	(6)**	(4)**	(5)**	(4)	(2)*
Competing Imports					
Fosters	4	0	3	2	-4
	(1)**	(1)	(1)*	(1)	(1)**
Molson Golden	9	11	14	-5	-6
	(5)*	(4)**	(6)*	(2)*	(2)**
Sapporo	5	-1	-1	0	-2
	(3)*	(1)	(1)	(0)*	(1)*
Tecate	5	0	2	0	-4
	(3)*	(0)	(2)	(0)*	(2)*
All	2	-2	-1	1	-1
	(1)*	(0)*	(2)	(0)	(1)
Domestic Brands					
Budweiser	0	-2	-1	2	0
	(0)*	(1)*	(0)**	(0)**	(0)*
Bud Light	3	5	7	-1	-1
	(1)*	(2)*	(2)**	(0)**	(0)**
Coors	0	-4	-4	4	0
	(0)**	(1)**	(1)**	(1)**	(0)*
Michelob Light	7	10	13	-6	-3
	(2)**	(5)*	(5)**	(2)**	(2)*
Miller High Life	2	4	6	-3	-1
	(1)	(1)**	(2)**	(1)*	(1)
All	0	-2	-1	2	-1
	(0)	(0)**	(0)**	(0)**	(0)**

Table 7: *Median percent changes in European brands', selected competing foreign brands', and selected domestic brands' profits, quantities, and markups after a 10-percent appreciation of European currencies relative to the dollar.* The first two columns report the percent change in manufacturer and retailer profits, respectively, the third column the percent change in volume sold, and the final two columns the percent change in the manufacturer or retailer markup. Each row entry for an individual product (e.g. *Bud Light*) reports the unweighted median value for each statistic over the sample's 120 markets. Summary statistics across products in a category (e.g. Domestic Brands) denote the weighted median across the category's products with weights defined by each product's average volume sold over the sample's 120 markets. 4080 observations.

	European	Canadian	Japanese	Mexican
	%	%	%	%
Retailer Profit	-1.97	-1.27	-1.43	-1.55
	(.5)**	(.5)**	(.3)**	(.2)**
Competing Manufacturer Profit	.04	-.15	-.16	-.07
	(.3)	(.0)	(.1)	(.1)
Other Foreign Brands	2.28	-2.02	-.77	-.71
	(1.1)*	(1.2)	(.3)*	(.4)
Domestic Brands	.01	-.07	-.16	-.05
	(.3)	(.1)	(.2)	(.1)
Competing Domestic Brands	1.32	1.17	1.07	1.16
	(.6)*	(.5)*	(.5)*	(.6)*
Foreign Manufacturer Profit	-15.70	-14.85	-5.99	-18.88
	(7.1)*	(5.3)**	(3.7)	(8.3)*
Consumer Surplus	-3.61	-4.59	-3.26	-2.68
	(.5)**	(.5)**	(.4)**	(.6)**

Table 8: *Median percent changes in variable profits and consumer surplus following a 10-percent dollar depreciation.* Each column reports the results from the counterfactual experiment of a bilateral movement of the dollar against the currency or currencies listed in the column heading. The first four row entries report the weighted median percent change in the retailer's or selected manufacturers' profits following the exchange-rate shock. These statistics are computed by taking each product's unweighted median percent change in profits across the sample's 120 markets, and then weighting it by its average volume sold over the sample's 120 markets. The first row reports the weighted median percent change in the retailer's profits following the exchange-rate shock, and includes all the sample's products, both domestic and foreign for every counterfactual. The second row reports the weighted median percent change in competing manufacturer profits, which includes all manufacturers not affected by the shock, whether domestic or foreign (e.g. the European counterfactual includes in this category all domestic, Canadian, Japanese, and Mexican brands). The third row reports the weighted median percent change in profits of foreign brands not affected by the shock (e.g. for the European counterfactual this category includes Canadian, Japanese, and Mexican brands). The fourth row reports the weighted median percent change to domestic brands' profits, and the fifth row the same statistic for competing domestic brands' profits, which are those domestic brands with higher-than-average cross-price elasticities with foreign brands, and include *Bud Light, Coors Light, Michelob Light, Miller Genuine Draft, Miller High Life, Miller Lite*, and *Rolling Rock*. The sixth row reports the weighted median percent change in the profits of foreign manufacturers affected by the exchange-rate shock (e.g. in the European counterfactual, this category includes all European brands). The final row reports the average percent change in consumer surplus over time and across the simulated individuals from the demand estimation. 4080 observations.