Structure of the WIC Model

The WIC model builds on existing economic theory by generalizing the standard multi-firm single-product Cournot oligopoly model to a new setting. The WIC model features differentiated brands of formula, heterogeneous consumers that are segmented by income, and the roles of WIC and its rebate program. A key feature of the WIC model's specification is the presence of not one but two formula brands (two "products"), a feature that is required to identify the simultaneous interactions between the prices of contract and noncontract brands of formula under a sole-source contract.

The theoretical device of aggregating products or brands into a "composite" product is common in economic theory. Although there were as many as four manufacturers in a given market area at some time during the companion volume's 1994-2000 study period, a two-brand model is sufficient to capture the basic theoretical interactions between a contract brand and a single "noncontract brand" which represents an aggregation of all other (noncontract) brands.

Basic Assumptions

In the WIC model, the geographic extent of the market corresponds to a local market area, i.e., retail prices are determined by factors that exist locally.[3] This treatment ignores retail prices prevailing in other market areas and assumes, reasonably, that households do not travel to any other market area to obtain formula. So, for example, households in San Diego would not buy infant formula in Los Angeles.

Households obtain formula not only from supermarkets, but also from mass merchandisers and drugstores. Supermarkets are the major source of infant formula, with 69 percent of infant formula products (in 2000) provided by supermarkets, while mass merchandisers accounted for about 28 percent and drugstores for less than 4 percent. For the empirical analysis in Oliveira et al., data were available for estimating the number of *discount stores* (such as Wal-Mart, K-Mart, and Target) that sell infant formula in a market area. The WIC model and the empirical analysis both include the number of discount stores (adjusted for population) as a determinant of demand for infant formula in the *supermarket* sector. The opportunity for consumers to substitute between supermarkets and discount stores limits the ability of supermarkets to raise their formula prices.

The supermarket sector is characterized by a set of chains each of which owns a set of supermarkets (or "stores") distinguished by geographic location. The WIC model treats a chain, rather than an individual supermarket, as the decisionmaking "firm."[4] It is assumed that the chain establishes a single price for the one or more supermarkets it owns: price differences across supermarkets within a chain are ruled out. Although not all supermarkets are equally convenient to a representative consumer, it is assumed that a representative consumer has a choice between various supermarkets belonging to *separate* chains in a market area, which limits the ability of any one chain to raise the price of formula in the supermarkets it owns.

[3] In the empirical implementation of the WIC model, the geographic extent of the market corresponds to a U.S. "market area" as defined by Information Resources, Inc. (IRI).

[4] Any measure of supermarket concentration is based on the market shares of "firms." To adopt any measure, a modeling decision must be made for whether an individual supermarket or a chain constitute the "firm." The empirical analysis in Oliveira et al. uses the shares of chains to measure concentration, prompted by the notion that chains "compete" with other chains but stores within chains do not economically "compete" with one another due to their common ownership. (The concentration measure in Oliveira et al. does include the share of an individual supermarket if that store is a so-called "independent.")

As in the Cournot model, market price in the WIC model is the same for all firms (chains) and is determined as a result of a Nash game in which any given chain treats the output (quantity of formula) of the *other* chains as exogenous when choosing its own output to maximize its profits. All chains choose their outputs simultaneously.

Previous models of oligopoly suppose either that *M* firms each produce a single homogeneous product or that *M* firms each produce a differentiated product of which there are *M* varieties, one for each firm. In either type of model, each firm has but a *single* choice variable (either quantity or price) for its single product. A distinctive feature of the WIC model is that it contains not one but *two* brands of infant formula that are offered by *each* of the *M* different supermarket chains.[5] A chain must therefore choose two levels of output—one for each brand—for its supermarkets. Thus, interdependency exists not only between firms, as in the Cournot model, but also between brands: a chain takes into account the effect on its profits from brand 1 when it is considering brand 2, and vice versa. The incentive a chain has to raise or lower its price for any one brand is affected by the extent to which its customers would substitute to the other brand on the chain's own shelf. The interdependency between the two brands' prices gives rise to a corresponding interdependency between the WIC model's two inter-firm Nash games.

[5] An appendix to the paper defines all symbols used in the paper, in order of introduction.

Cost Factors

The marginal cost to a chain for a unit (can) of formula includes its wholesale cost plus the retailing costs of inventory, shelf space, stocking, and checkout. The wholesale cost is thought to be far larger than retailing costs. The WIC model allows the two brands to have different marginal costs, c_1 and c_2, but assumes that marginal costs do not vary across chains within local markets. A chain's total cost function for a brand of infant formula (as a "stand-alone" product, separate from the chain's many other products) is given by:

$$(1)\quad C_{k,i}\left(q_{k,i}\right) = c_k q_{k,i},\ k = 1,2 \quad i = 1,\ldots,M$$

The wholesale price schedules of infant formula manufacturers incorporate bulk discounts. Buyers who purchase formula by the truckload (i.e., 40,000-44,000 pounds) obtain the manufacturer's lowest wholesale price. For example, in 2000 (the last year of the study period in Oliveira et al.) Mead-Johnson charged a truckload price of $2.94 per unit (13-ounce can) for its milk-based liquid concentrate formula. A chain that bought half that paid a few pennies more, totaling $2.98 per unit. Thus, in general, a chain's marginal cost does in fact depend on the amount purchased, in contrast to the specification in (1).

Although a chain that bought a single 12-can case of that same formula paid substantially more—$3.41 per unit—a key feature of the price data examined in Oliveira et al. prompts the WIC model's assumption that marginal cost is the same across chains. The supermarket retail price data are not chain-specific but instead are averages across a market area's supermarkets based on data from a survey. To be included in the survey a chain had to have at least $2 million in sales annually (in total for all items in all stores). Thus, prices charged by local corner grocery stores and others with sales below that threshold are not included. It was thought the surveyed chains typically pay the truckload price for formula. For large-scale chains that purchase by the truckload or more, wholesale prices can indeed be treated as constant on the margin and identical across such chains.

Even though the supermarket price data could include prices for medium-sized chains that pay more than the truckload price, the truckload price can be a proxy for their wholesale costs. After all, wholesale cost differences across chains on the order of a few pennies are small relative to the retail price differences across market areas that the regressions seek to explain. Furthermore, wholesale prices charged by a manufacturer tend to move together: changes in the wholesale price paid by the medium-size firms parallel the changes in the truckload price that was included in the regression. For these reasons, the regression specification in Oliveira et al. included a single wholesale price for a brand—the truckload price—thereby setting aside bulk discounts. Thus, the WIC model's assumption that a chain's marginal cost is constant and equal across chains—at least for the chains in the price survey—was thought to be reasonable for the WIC model's purposes of supporting and coinciding with the regression analysis.

A final issue is whether marginal cost would increase if all chains in a local market area increase their purchases simultaneously due to an increase in market demand. Infant formula manufacturers establish national price schedules, so that the wholesale prices faced by any one local market area are constant not only at the chain level but for the local market area as well.

Demands of Out-of-Pocket Households

In the market area, there are N households with one infant who is fed infant formula. Each household is a member of one of three distinct formula-buying groups or market segments: high-income households (H), low-income non-WIC households (L), or low-income households that receive vouchers in the WIC program (W), where $H + L + W = N$. It is useful for the income "cutoff" that divides low-income from high-income households to be set above the income threshold for WIC income eligibility (185 percent of poverty) instead of equal to or below that threshold. This assumption means that, by definition of the term *low-income*, there is some positive number of low-income non-WIC households ($L > 0$) even under full funding for WIC and full participation by eligible households; otherwise an entire category of households, L, awkwardly "appears" or "disappears" based on whether or not WIC has full funding and full participation by eligible households.[6]

The WIC model contains two brands of infant formula. The pair of brands will be interpreted two different ways when analyzing sole-source contracts:

- the two brands each represent two different manufacturers' national brands in a given market area;

[6] In this framework, the term "low-income households" refers to the total $L + W$, which includes the low-income households that participate in WIC (W) and the low-income non-WIC households (L) who purchase formula out of pocket.

- the two brands each represent a *single* national brand in a given market area, under the alternative conditions of being the contract brand or being a noncontract brand.

The first interpretation is the most straightforward one. It will be used to compare the retail price of a national brand (e.g., Carnation) that is the contract brand in the market area with the retail price of a different national brand (e.g., Mead-Johnson) that is a noncontract brand in the same market area; alternatively, the model's noncontract brand could represent an aggregation of all noncontract brands. The second interpretation applies to a particular national brand (e.g., Carnation) as it transitions in a given market area between being a noncontract brand and being a contract brand. This second interpretation is adopted to isolate the effects of a change in contract brand status, holding constant which national brand (and its brand-specific factors) is examined. Under either interpretation, brand 1 will be treated as the contract brand and brand 2 as the noncontract brand.

Per-household demand curves for brands 1 and 2 for supermarket infant formula purchased by the representative out-of-pocket low- and high-income households are:

(2a) $q_{1,j}\left(P_1, P_2\right) = a_1 + u - b_j P_1 + sP_2,\ j = L, H$

(2b) $q_{2,j}\left(P_1, P_2\right) = a_2 - u - b_j P_2 + sP_1,\ j = L, H$

where b_j , $j = L, H$, is an own-price slope term the value of which depends on the income level of the household, s is a cross-price slope term, u is a parameter capturing what the model calls the *tag-along effect*, and a_1 and a_2 are brand-specific constants. Each of the parameters is considered in turn.

The own-price slope terms b_L and b_H in (2) reflect how readily the two groups of out-of-pocket consumers, L and H, substitute away from (towards) supermarket formula in response to an increase (decrease) in the supermarket price. Substitutes for supermarket formula include home-prepared formula, the introduction of cow's milk and/or solid foods into the infant's diet at an earlier age, and formula obtained from a discount store. As substitutes become closer, out-of-pocket consumers become more price-sensitive and the two slope terms become larger (in absolute value). For example, the greater the presence of discount stores in a local market, the greater the price sensitivity of supermarket customers to the supermarket price, and the larger (in absolute value) will be the own-price slope terms slope terms b_L and b_H. The relative importance of the various substitutes is not identified; however, intuition suggests that most households would use discount store formula rather than, say, switch to home production of formula in response to a supermarket price increase. [7] The combined strength of all substitution possibilities is reflected in the magnitudes of b_L and b_H.

[7] Another imaginable substitution behavior in response to an increase in the supermarket price of infant formula is for a household to switch from formula-feeding to breastfeeding. However, the empirical analysis in Oliveira et al. treats the household's decision to breastfeed or to formula-feed as exogenous, depending on such factors as level of education of the mother, supportiveness of breastfeeding by the mother's mother and other family and friends, social acceptance of breastfeeding activities, and availability and ease of obtaining breastfeeding counseling.

A fundamental aspect of the model's structure is that out-of-pocket low- and high-income households differ in their own-price sensitivities, specifically, that $b_L > b_H$.[8] Thus, if price rises by a given dollar amount, *both* types of households purchase *less* supermarket formula—but a low-income non-WIC household is relatively *more* responsive to the price increase, switching to substitutes (perhaps especially discount store formula) more readily than high-income households.[9]

The cross-price term s shows how readily a household's reduction in quantity demanded for a brand (in the supermarket sector), due to an increase in that brand's (supermarket) price, is retained within the supermarket sector by an increase in quantity demanded for the substitute brand off the supermarket shelf. For example, if P_1 increases then $q_{1,j}$ falls by b_j in (2a) and $q_{2,j}$ rises by s in (2b). It is assumed that only *part* of the decrease in $q_{1,j}$ is shifted to $q_{2,j}$, i.e., that a (representative) household makes *some* use of substitutes other than the alternative brand on the supermarket shelf (perhaps especially formula obtained at a discount store). Mathematically, this assumption means that $b_j > s$ for both out-of-pocket groups. Because allowing group-specific differences in s does not yield additional insight, s is assigned the same value for both the high-income and low-income non-WIC households (unlike the own-price terms b_j, which do differ by group). The assumption that the own-price effect on a brand's quantity demanded is larger than the cross-price effect is economically reasonable. This assumption also allows the model's mathematical solution to yield positive prices in equilibrium.

The introduction of the parameter s into the WIC model makes the model interesting and powerful. If instead s is omitted from the model by setting $s = 0$, then households exhibit *no* inter-brand substitution at all and respond to a brand's price increase in the supermarket sector by buying the same brand in the discount store sector (or by making other substitutions). If $s = 0$, demands for the two brands are independent and the two-product WIC model separates into two one-product models, in which case supermarkets would establish each brand's price without any particular reference to the other brand's price (in the same way supermarkets establish prices for, say, apples and hairbrushes). Although a strength of the model is that it *allows* for s to be positive, it is worth noting that s is not *required* to be positive either for solving the theoretical model or for estimating its empirical counterpart, which estimates statistically from price data whether or not s is positive.

The non-negative term u is common to the demand functions for both brands, although it differs in sign: for brand 1 (the contract brand) a positive u adds to quantity demanded in (2a), while for brand 2 (the noncontract brand) a positive u diminishes quantity demanded in (2b) by precisely the same amount. The parameter u represents the combined influence of two conceptually distinct effects that the model calls a *medical promotion effect* and a *shelf-space effect*. Either of these effects augments demand for the contract brand at the expense of the noncontract brand under sole-source (but not open market) contracts.

[8] The price elasticity of demand ε, (the percentage change in quantity demanded that results from a 1-percent change in price, in absolute value) is the most common measure of price sensitivity. In (2), out-of-pocket low-income consumers are more price sensitive than high-income consumers at any given price regardless of whether slopes or elasticities are used to measure price sensitivity. For the WIC model, with its Cournot-like linear demand curves, group-specific slopes are easier to discuss and compare than are elasticities.

[9] The own-price demand terms b_L and b_H differ only between income groups and not across brands. It was thought that the econometric specification in Oliveira et al. would be little changed if the WIC model were to specify own-price terms that differ by both income group and by brand.

When a State has a single contract brand, doctors or hospitals may tend to promote that brand either through recommendations or the provision of formula samples. Such promotions may lead to a brand-inducement behavior by which the (representative) non-WIC household favors the contract brand when making its out-of-pocket formula purchase. The model does not require that all out-of-pocket households must behave this way, but if some proportion of them do then *u* will be positive for the representative household.[10]

A second, distinct effect occurs if (at least some) non-WIC households favor the brand that has a greater presence on the supermarket shelf. Given that a sole-source contract is in effect, and that WIC formula is estimated to account for over half of infant formula sales, the contract brand is likely to have more shelf space than the noncontract brand. This greater shelf space may contribute, in itself, to greater sales to non-WIC households.[11]

The medical detailing and shelf-space effects are combined in the model to form a single effect, *u*, which the model calls the *tag-along effect*. This effect captures the extent to which the designation of brand 1 as the WIC contract brand results in sales to *non-WIC* households that accompanies or "tags along" with the sales to *WIC* households. The two components of the tag-along effect were identified as theoretical possibilities for infant formula demand by the U.S. Government Accounting Office (1998), which referred to them as "spillover" effects. The tag-along effect is modeled as a one-for-one tradeoff or substitution between the contract and noncontract brands. The tag-along effect is zero ($u = 0$) if:

- consumers do not respond to additional medical promotion or shelf space that the contract brand receives; or
- the contract brand does not receive additional medical promotion or shelf space; or
- there is no single contract brand, i.e., there is an open market contract or if there is no rebate program in effect.

An interpretation of the brand-specific constants a_1 and a_2 in (2) is based on considering consumption outcomes given that infant formula is free to households (making $P_1 = P_2 = 0$) and given any of the conditions above that make $u = 0$. Let *z* represent any household's *saturation level* of formula, an amount of formula beyond which a household would not consume (per unit of time) even if formula were available to the household in unlimited quantities for free.[12] If there were but one brand of formula, say brand 1, then that brand's constant in (2a) would itself equal *z*. However, given that there are two brands, then on average across households the consumption level *z* would be divided based somehow on households' *non-price brand preferences*, for which a_1 and a_2 are measures. Non-price brand preferences reflect some combination of "innate" tastes, recommendations by doctors or hospitals, and other non-price factors. If brand preferences are "symmetric," then for the representative household, $a_1 = a_2 = a = z/2$, in which case each brand would be consumed by half of the households. More generally, the share of total formula consumption in the market that brand *k* would receive would be $a_k/(a_1 + a_2)$.

[10] Whether a manufacturer is the contract or a noncontract brand in a given area, the manufacturer has an incentive to promote its brand in the medical community so that doctors and hospitals may recommend the brand to patients. Some purchases by some patients may be attributable to this promotion activity, and such behavior could be incorporated in the WIC model through the demand-specific constants a_1 and a_2. A relatively successful medical promotion by the manufacturer of brand 1 would, other factors constant, be captured by $a_1 > a_2$. The "medical promotion effect" that is incorporated into *u* specifically represents one-for-one demand gains and losses between brands that are attributable strictly to whether or not a brand is designated the contract brand in the area.

[11] Empirical work on wine sales (Folwell and Moberg, 1993) found that "facings" (a measure of shelf space) had an effect, separate from the effect of price, on the quantities purchased of wine. A study on juices (Brown and Lee, 1996) found that the number of facings affected the prices of juices.

[12] In fact, saturation levels would differ across households due to physiological differences of infants. The term *z* can be thought of as the average consumption of formula for the representative household if formula were free and unlimited.

Demand of WIC Households

In the absence of the WIC program, WIC households would be paying out of pocket, in which case it will be assumed that their demand would resemble the demand of out-of-pocket low-income households given in (2a) and (2b). Under the WIC program, WIC households receive vouchers for a fixed amount of formula (the *WIC allocation*). It will be assumed the WIC allocation equals the saturation level z.[13] The per-household demand curve for brands 1 and 2 of supermarket formula for the W households in WIC is given by:

(2c) $q_{k,W} = \delta\theta_k vz, k = 1,2$

where v represents the *fraction* of vouchers that a representative WIC household redeems in the supermarket sector (as opposed to other retail outlets), θ_k represents the share of supermarket formula demand by a representative WIC household that is provided by brand k; and δ is a zero-one dummy variable signifying whether or not the WIC State agency uses the retail food delivery system to distribute WIC formula. Each parameter is considered in turn.

The term v reflects *cross-sectoral* substitution behavior of *WIC* households. It is likely that the opportunity to substitute between supermarket formula and discount store formula is important mainly for *non-WIC* households: WIC households have no particular reason to seek out infant formula from discount stores (which are assumed to be more distant and less convenient, in general) because WIC households do not pay out of pocket for formula. If WIC households simply obtain *all* of their formula in supermarkets (at the same time they do grocery shopping), then $v = 1$. More generally, other values for v allow changes in the presence of discount stores in a market area to have some impact on WIC households.

Under sole-source WIC contracts, the term θ_k is a dummy variable: the contract brand (brand 1) receives all of the formula demand of WIC households, making $\theta_1 = 1$, while $\theta_2 = 0$ for the noncontract brand (brand 2). In contrast, a WIC household uses vouchers for the brand of its choice under either open market contracts or under the counterfactual scenario in which WIC has no rebate program at all. The WIC model assumes for these two cases that θ_k in (2c) equals $a_k/(a_1 + a_2)$, the same values already identified for out-of-pocket households when formula is free based on non-price brand preferences. Regardless of the presence and type of contract, the brand-share terms θ_1 and θ_2 sum to 1.

The dummy variable δ equals 1 if the WIC State agency uses the food delivery distribution system to distribute WIC formula, and 0 otherwise. As of September 2000, $\delta = 1$ for all but two States.

A key feature of the specification in (2c) is that supermarket prices do not appear in the expression. The formula demand of WIC households is completely insensitive to price (perfectly inelastic) because the WIC program—not the WIC household—pays for the formula.

[13] If, instead, the WIC allocation were sufficiently close to zero, WIC households would likely be willing to pay the retail price (at least at sufficiently low retail prices) to supplement their relatively "small" allocation with out-of-pocket purchases. Because supplementation is not considered to be a widespread phenomenon, supplementation is excluded here by the assumption the WIC allocation and the saturation level are equivalent.

Even though it may be reasonable to model the demand of any one WIC household using (2c), overall WIC demand for all *W* households as a group may not be price insensitive. Suppose retail price increases are not offset by Congressional appropriations for WIC, and—despite WIC's priority system—some number of eligible infants are not able to participate in WIC as a result. *W* then depends negatively on retail price and overall WIC demand is price-sensitive. Nevertheless, even if overall WIC demand is not perfectly inelastic, it is presumed that the degree of price sensitivity is sufficiently low and/or the retail price at which these effects would be felt is sufficiently high that this possibility can be neglected. At least to a first approximation, it will be assumed that *W* is fixed and that overall WIC demand is perfectly inelastic (at least within the relevant retail price range). This assumption yields WIC-related price effects that are both mathematically tractable and relatively easy to interpret. Despite the inelastic specification for WIC demand, any possibility of an infinite price/infinite profits outcome is simply ruled out *a priori*.

Brand Demand for the Supermarket Sector

Summing (2a), (2b), and (2c) across market segments for each brand yields two total demand equations given by:

(3a) $Q_1(P_1, P_2) = Hq_{1,H}(P_1, P_2) + Lq_{1,L}(P_1, P_2) + Wq_{1,W} = A_1 + \theta_1 Q_W + U - BP_1 + SP_2$

(3b) $Q_2(P_1, P_2) = Hq_{2,H}(P_1, P_2) + Lq_{2,L}(P_1, P_2) + Wq_{2,W} = A_2 + \theta_2 Q_W - U + SP_1 - BP_2$

where the market-level terms are aggregates of per-household terms given by $A_1 = (H + L)a_1$, $A_2 = (H + L)a_2$, $U = (H + L)u$, $S = (H + L)s$, and $B = Hb_H + Lb_L$. The term Q_W equals $W\delta vz$, the market-level WIC demand for all formula; the division of Q_W between brands depends on the brand-share terms θ_1 and θ_2.

As in any model that involves aggregation of market segments, the location of equilibrium in relation to the "kink" points of total market demand needs to be addressed. It will be assumed that, in Nash equilibrium, supermarket chains serve *both* out-of-pocket segments (rather than just the high-income households alone). This assumption in effect stipulates that the equilibrium price of each brand is sufficiently low that each brand's equilibrium output exceeds the output level of the kink point between the demands of the *H* and *L* households. The possibility of serving only the WIC segment (an infinite price/infinite profits outcome) was ruled out above. All three segments—*L*, *H*, and *W*—are in fact served in the actual formula market, and that observed outcome follows from the assumption that price is sufficiently low to serve the *L* households.

The assumption that $b_j > s$ for both *L* and *H* households was already adopted for both economic plausibility and meaningfulness of the model's solution. The assumption implies that B > S in (3).

As noted previously, one factor that affects supermarket price is the ease of switching to formula sold in the discount store sector. Thus, b_L and b_H in (2) and *B* in (3) may depend positively on the number of discount stores, holding other factors constant—the price sensitivity of demand for *super-*

market formula increases due to an increase in the number of *discount* stores. However, a scaling factor is needed because market areas differ in "size." Oliveira et al. use the size of a market area's total population as a scaling factor. Thus, no effect on supermarket formula demand—and, in turn, no effect on retailer's profit-maximizing price—would be predicted if one market area has double the number of discount stores of another but also serves twice the population, making a "typical" discount store equally convenient or accessible to the representative household in the two market areas. Let D represent the ratio of the number of discount stores to total population. An increase in D increases the price sensitivity of either out-of-pocket segment and increases B in (3).

Another parameter in (3) that may be affected by D is v, the fraction of vouchers that are redeemed in supermarkets (under the assumption that WIC households consider the availability and convenience of discount stores when making their plans for shopping trips). An increase in D is likely to result in WIC households making larger overall expenditures in the discount store sector, increasing voucher redemptions at discount stores and decreasing v.

Finally, the size of the tag-along effect U is unlikely to be a simple constant that is independent of any other factors. In particular, the amount of additional shelf space or medical promotion gained by a brand due strictly to its status as the contract brand may depend largely on how much formula is provided to WIC households. For simplicity, it will be assumed that under the sole-source contract the tag-along effect is given by:

$$(4)\quad U = hQ_w,\ 0 \le h < 1$$

so that U is simply proportional to the amount of WIC formula.[14]

Solving (3a) and (3b) simultaneously, with (4), results in market demand curves (inverse demand functions) once prices are expressed as functions of quantities demanded:

$$\text{(5a) } P_1 = \frac{BA_1 + SA_2 + [B(\theta_1 + h) + S(\theta_2 - h)]Q_W}{B^2 - S^2} - \frac{B}{B^2 - S^2}Q_1 - \frac{S}{B^2 - S^2}Q_2$$
$$= \alpha_1 - \beta Q_1 - \gamma Q_2$$

$$\text{(5b) } P_2 = \frac{BA_2 + SA_1 + [B(\theta_2 - h) + S(\theta_1 + h)]Q_W}{B^2 - S^2} - \frac{B}{B^2 - S^2}Q_2 - \frac{S}{B^2 - S^2}Q_1$$
$$= \alpha_2 - \beta Q_2 - \gamma Q_1$$

where the derived parameters α_1, α_2, β, and γ are introduced to simplify further development of the model. The assumption that $b_j > s$ means that $B > S$, which in turn implies that β and γ are each positive.

If consumers exhibit no substitution behavior at all between brands, so that $s = 0$ at the household level, then $S = 0$ in (3), $\gamma = 0$ in (5), and each brand's demand curve becomes a function of the brand's quantity only and is independent of the quantity of the other brand.

[14] It should be noted that the tag-along effect may be influenced by the distribution system. After all, there can be no shelf-space effect for the contract brand if WIC formula is not distributed through the retail food delivery system. On the other hand, the medical promotion effect may operate independently of the distribution channel. Rather than separating out these influences, the model simply assumes that the tag-along effect U requires that distribution be conducted through the retail food delivery system (implicitly giving full weight to the shelf-space effect, and none to the medical promotion effect).