

## Appendix C—The Economic Model of the Retail Infant Formula Market

This appendix summarizes the results of an economic model (hereafter, “WIC model”) of the factors that influence the supermarket retail prices of infant formula, with special attention devoted to the role of WIC and its infant formula rebate program. The WIC model generalizes the standard multi-firm Cournot oligopoly model to a new setting that features two differentiated products, heterogeneous consumers who are segmented by income, and the presence of WIC and its rebate program. A forthcoming companion report, *An Economic Model of WIC, the Infant Formula Rebate Program, and the Retail Price of Infant Formula*, provides the formal mathematical development of the WIC model and examines the model’s results more fully.

Under sole-source procurement, the formula provided by the contract-winning manufacturer receives *all* of the infant formula demand of WIC households (hereafter, “WIC demand”) and all other manufacturers’ brands receive *none* of the WIC demand.<sup>1</sup> In September 2000, each of the WIC State agencies of the 50 States was using sole-source procurement. A critical feature of the WIC model’s specification is its inclusion 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.

The WIC model constitutes the theoretical framework for the specification and interpretation of the regression models presented in this report. Of the various factors that may affect supermarket retail prices of infant formula, two WIC-related factors receive particular attention:

- the effects on the prices of the contract and noncontract brands of formula of an increase in the *relative size of WIC* (as measured by the number of formula-fed WIC infants relative to the number of formula-fed non-WIC infants)
- the effects on the price of a manufacturer’s infant formula product of a change in the product’s contract brand status between being the contract brand and being a noncontract brand.

The WIC model focuses on the retail markup in supermarkets.<sup>2</sup> It treats the wholesale price as an exogenous variable independent of a manufacturer’s contract brand status in any one market area. The model assumes a manufacturer’s wholesale price of formula is the same across supermarkets, but does not restrict the manufacturers’ wholesale prices to equal one another.

The WIC model assumes that there are three distinct formula-buying groups or market segments:

- H* - high-income households;
- L* - low-income non-WIC households; or
- W* - low-income households that receive vouchers in the WIC program.<sup>3</sup>

<sup>1</sup> An exception to this general statement is that the WIC State agency can issue formula provided by a different manufacturer to accommodate religious eating patterns or when medical documentation supports the use of another infant formula product.

<sup>2</sup> Because the behavior of supermarket retail prices can be expected to differ systematically based on the distribution system used by a State, the discussion in this appendix and the report’s regression analysis both consider only those market areas in which the retail food delivery system is used (as opposed to the Direct Distribution system, used in Mississippi, or the Home Distribution system, used in Vermont).

<sup>3</sup> The model sets the income “cutoff” that divides *low-income* from *high-income* households above the income threshold for WIC income eligibility (185 percent of poverty) instead of equal to or below that threshold. Thus, by definition of the term *low-income*, there is some positive number of low-income non-WIC households ( $L > 0$ ) even if all households (with infants) with income below 185 percent of poverty participate in WIC.

Two fundamental aspects of the model's structure pertain to the price responsiveness of these three groups: (1) The model assumes a low-income non-WIC household is relatively more responsive to an increase in the price of an infant formula product, switching to substitutes (perhaps especially discount store formula) more readily than do high-income non-WIC households; and (2) It assumes that a WIC household does not respond at all to an increase in price—i.e., that WIC demand is completely insensitive to price (perfectly inelastic)—because WIC households receive food instruments (“vouchers”) for a fixed amount of formula rather than paying out of pocket as low-income non-WIC and higher income households do. Salant (1999) and Post and Wubbenhorst (1989) each adopted one of these assumptions about price sensitivities. Their two arguments regarding the effects of WIC, relative to the absence of WIC, are compatible and both are adapted here to consider the price effects of an increase in the relative size of WIC.

Salant considered the behavior of a monopolistic infant formula manufacturer and examined major manufacturers' wholesale price series. Based on a “reservation price” monopoly model, Salant argued: “by removing the portion of the population with the lowest reservation price for infant formula from the general market, the WIC program inevitably raised the profit-maximizing monopoly price ... What previously restrained [the monopolist] was the recognition that a price increase would drive away the poorer customers; but once the WIC program absorbs these customers, the monopolist has nothing further to lose if he raises the price ... As more infants are added to the WIC program, the model predicts that the [monopolist] will continue to raise the price to non-WIC customers.”<sup>4</sup> The pricing behavior identified by Salant does not require that the firm be a monopolist or a manufacturer: his economic reasoning also applies to the WIC model in which multiple supermarkets engage in (imperfect) competition in the establishment of a retail price.

Salant's argument that WIC “removes” from the general market the (low-income) households with the *lowest reservation price* is recast by the WIC model as the argument that WIC “removes” from the general market the (low-income) households that are relatively *more price sensitive*. When the relative size of WIC increases, some additional low-income non-WIC households leave the out-of-pocket segment of the market and enter the WIC segment, changing the mix of out-of-pocket households towards relatively more *H* and less *L*. This change in the mix lowers the overall price-sensitivity of the out-of-pocket households, which is a weighted average of their segment-specific price sensitivities. As a result of the increase in the relative size of WIC, each of the supermarket chains will find it profit-maximizing to increase retail price (of the contract brand), holding other factors constant. The WIC model calls this price-increasing effect of WIC the *out-of-pocket composition effect* because the effect depends on whether out-of-pocket demand is composed of relatively few or many low-income households.

The second mechanism by which WIC decreases the price sensitivity of demand was identified by Post and Wubbenhorst (1989). They argued that by providing WIC households with vouchers, the WIC program produces a “customer that is essentially unconcerned with the price she or he is paying.” When the relative size of WIC increases, the mix of demands in total market demand is changed, with relatively fewer *price-sensitive* out-of-pocket households and relatively more *price-insensitive* WIC households resulting in a decrease in overall price sensitivity. As a result of the increase in the relative size of WIC, each of the supermarket chains will find it profit-maximizing

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<sup>4</sup> Salant noted that this effect is analogous to pricing effects that seem to be found in the markets for certain pharmaceutical products. In some instances, the price of a brand-name drug *increased* after entry into the market by generic drugs. One explanation is that consumers who were most price sensitive switched to the generic drug, leaving the less price-sensitive customers in the market for the brand-name product and prompting an increase in the brand-name product's price. Similar pricing behavior was found in a broad study of thirty-two processed food and beverages industries by Ward et al. (2002), who found that brand-name firms' prices tend to rise when the share of private-label firms increase.

to increase retail price (of the contract brand), holding other factors constant. The WIC model calls this price-increasing effect of WIC the *voucher effect*.

While WIC does “remove” a set of low-income households from the out-of-pocket segment of the retail food system, as Salant emphasized, WIC also provides vouchers that make the WIC households price insensitive, as Post and Wubbenhorst emphasized, which “adds” those *same* households *back into* the retail food system. Supermarket retail price (of the contract brand) is positively related to the relative to size of WIC due to both mechanisms. Although the out-of-pocket composition effect and the voucher effect both affect the mix of households in the infant formula market, the two effects are different: the former changes the mix within the group of out-of-pocket households, while the latter changes the mix between the out-of-pocket households and the WIC households. A way of describing both effects at once is to state that WIC *converts* out-of-pocket low income households (whose price sensitivity is *greater* than for high-income households) into WIC households (whose price sensitivity—of zero—is *smaller* than for high-income households).<sup>5</sup>

The statistical analysis of the report is based on the retailer-behavior hypothesis, which states that supermarket infant formula prices (P) are determined, in part, by the *relative size of WIC* (S). An additional family-behavior hypothesis should be considered, which states that higher infant formula prices lead to increased participation in WIC since the value and attractiveness of the WIC benefit rises when infant formula prices are higher. Thus, the retailer-behavior hypothesis states that P depends on S while the family-behavior hypothesis states that S depends on P. If both hypotheses are valid—in the relevant price range found in the 1994-2000 sample—then observed data for P and S are generated by two simultaneous equations.<sup>6</sup> The report focuses exclusively on the retailer hypothesis, treating S as an exogenous factor, based in part on the belief that the vast majority of eligibles participated in WIC during the 1994-2000 period. While one can easily imagine that some, even many, WIC-eligible families are indeed attracted to WIC and apply for the program due (in part) to infant formula prices, that scenario by itself does not mean that the family-behavior hypothesis is pertinent statistically *in the relevant price range*. It is thought that those families who base WIC participation decisions on infant formula prices do so well before infant formula prices reach the levels observed in the data, so that—on the margin—variation in price does not affect participation decisions of the remaining eligible nonparticipants. Technically, the family-behavior function  $S = g(P)$  is thought to be strictly concave with a slope  $g'(P)$  approaching zero in the relevant price range.

The designation of a particular manufacturer as the contract brand may do more than bring WIC demand to its product. Non-WIC demand may be drawn to the contract brand for either of two reasons identified by the GAO (1998) and others. First, doctors or hospitals may tend to promote the State’s contract brand, either through recommendations or the provision of formula samples, and such promotions may lead to a brand-inducement behavior by which some number of non-WIC households favor the contract brand when making their out-of-pocket formula purchase. Second, some number of non-WIC households may favor the brand that has a greater presence on the supermarket shelf.

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<sup>5</sup> The concept of *converting* low-income households from non-WIC to WIC participation helps clarify how there are two answers to the seemingly simple question: “Are WIC households more sensitive or less sensitive to price than high-income households?” The answer depends on whether the price sensitivity of WIC households is considered *ex ante* or *ex post* to their participation in WIC.

<sup>6</sup> It is believed that during 1994-2000, WIC funding was sufficient to support participation by all eligible households who chose to enroll their infants in the program. If WIC funding had been more limited, then it is possible that an increase in infant formula prices would have *decreased* WIC participation by (formula-fed) infants—even if it increased the number of applicants—because less formula can be purchased with a fixed limited budget when price increases.

While it may be intuitive that an increase in the relative size of WIC induces supermarkets to increase the retail price of the sole brand of formula for which WIC vouchers can be redeemed, it may at first seem unlikely that an increase in the relative size of WIC has any price effect on the noncontract brands. However, the WIC model identifies a possible connection between the prices of the contract and noncontract brands. Non-WIC households may consider various manufacturers' brands to be substitutes for one another. If so, then changes in the relative size of WIC (S) do not leave the price of the noncontract brand unaffected. Instead, as illustrated in appendix figure C-1, suppose the value for the relative size of WIC is 3 in market area B (meaning that three-fourths of the area's formula-fed infants are WIC participants) while the corresponding value for market area A is 1 (meaning that half of the area's formula-fed infants are WIC participants). Then supermarkets in B establish a price for the contract brand that is high compared with the price of the contract brand in A. This difference in turn results in a shift in demand by non-WIC households from the contract to the noncontract brand in B that is large compared with the corresponding shift in A. This in turn results in supermarkets in B establishing a price for the noncontract brand that is higher than the price of the noncontract brand in A. The three main results exhibited by the figure are:

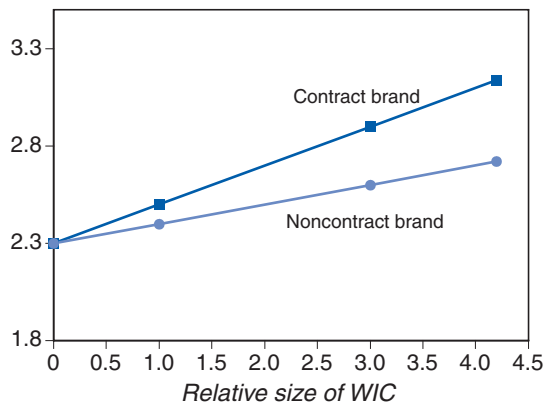
- For a market area's contract brand, an increase in the relative size of WIC increases supermarket retail price, holding other factors constant; this change corresponds to a movement along the price line for the contract brand.
- For a market area's noncontract brand, an increase in the relative size of WIC increases supermarket retail price, holding other factors constant; this change corresponds to a movement along the price line for the noncontract brand.
- For a given manufacturer in a given market area, if its product is the contract brand, then its retail price is higher than the manufacturer's price would be in that area if its product were a noncontract brand, holding other factors constant; this change corresponds to a vertical movement between the noncontract and contract brand price lines at a given value of the relative size of WIC variable.<sup>7</sup>

Supermarkets take consumer substitution behaviors into account when establishing the prices of the interrelated brands. If households do not consider various manufacturers' brands to be substitutes, then an increase in the relative size of WIC increases only the price of the contract brand:

Appendix figure C-1

**Theoretical relationship between retail infant formula prices and relative size of WIC, contract brand vs. noncontract brand**

Dollars per 26 ounces reconstituted



Note: *Relative size of WIC* equals the ratio of the number of formula-fed WIC infants and the number of formula-fed non-WIC infants.

<sup>7</sup> Strictly speaking, appendix figure C-1 is most accurate for this scenario in which the effect of changing a single manufacturer's status between contract brand and noncontract brand is considered. If instead a comparison is made for a given market area between the contract and noncontract brand prices for two different manufacturers, the intercepts of the contract and noncontract brand price lines would not necessarily coincide.

the noncontract brand price line would be horizontal (not shown). The regression analysis reveals what the retail price data show about the slope of noncontract brand price lines, by manufacturer and product type.

As noted, the WIC model assumes that the price sensitivities of high-income non-WIC consumers are lower than those of low-income non-WIC consumers. The regression analysis includes median household income as an independent variable with the expectation that an increase in a market area's household income results in an increase in the retail price established by supermarkets.

The role played by the mix or composition of out-of-pocket households  $H$  and  $L$  was also explained by the model. No readily available data compare the middle and upper reaches of the income distribution for these two household segments. Instead, a market area's Poverty Rate is assumed to capture the general location of the area's income distribution, and the Poverty Rate is included in the price regressions to proxy for the presence of the low-income non-WIC households (whose incomes in fact exceed the poverty line) relative to the high-income non-WIC households at the high end of the income distribution. An increase in the poverty rate is expected to increase the overall price sensitivity of the out-of-pocket segment of the market, and thereby result in a decrease in the supermarket retail price.<sup>8</sup>

According to the WIC model, another factor that affects supermarket price is the ease (of the out-of-pocket households) of switching to lower priced formula sold in the discount store sector in response to an increase in the supermarket retail price. The price sensitivity of demand for *supermarket* formula increases due to an increase in the number of *discount* stores (which compete with supermarkets for infant formula consumers), holding other factors constant, which in turn would induce supermarkets to establish a lower supermarket retail price. In order to adjust for the scale of population in a market area, the regression analysis uses the number of discount stores per 100,000 people as its measure of the presence of discount stores.

An increase in the number of (equally sized) supermarkets lowers supermarket *concentration*, whether concentration is measured by the Herfindahl-Hirschman Index, the four-firm concentration ratio, or any other measure of concentration. Typically, economic theory predicts a positive relationship between concentration and price, reflecting some combination of market power influences and tacit (or explicit) collusion. Indeed, the formal WIC model discussed so far in this appendix predicts a positive price-concentration relationship due to its underlying Cournot model structure. However, formula (and, possibly, a select number of other supermarket products) may exhibit a negative price-concentration relationship—contrary to the Cournot and WIC models—if two conditions are both met.

Suppose that the Cournot model is correct for most supermarket products—i.e., a typical supermarket item has a positive price-concentration relationship. If so, then in a highly concentrated market area a typical item will have a high price-cost margin (relative to the margin in a less concentrated area)—making a marginal customer especially valuable to the supermarket in the highly concentrated area. In addition, suppose that infant formula exhibits what may be called “attractor” characteristics that lead (at least some) customers to change shopping location in pursuit of a low-priced “attractor” item, draws them to the supermarket and results in joint purchases with other items. If both conditions are met, then supermarkets in a high-concentration area may establish a relatively low supermarket price for infant formula as they seek to lure customers to purchase the high-margin

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<sup>8</sup> It would be more difficult to predict the expected sign for the poverty rate if the *relative size of WIC* were not included in the regression. In this case, the poverty rate could reflect two factors—the presence of WIC households (relative to non-WIC households) and the presence of low-income non-WIC households (relative to high-income non-WIC households)—that have price effects of opposite signs.



items (through joint sales). In this case, a *positive* price-concentration relationship for most supermarket items combined with “attractor” characteristics for infant formula result in a *negative* price-concentration relationship for infant formula. At an extremely high level of concentration, holding other factors constant, the supermarket retail price of infant formula could fall so low that it drops below the wholesale cost, making infant formula a loss-leader. While the concept of loss-leader pricing is familiar, the argument here is novel in that it attributes the practice to supermarket concentration (rather than, say, a temporary sales promotion).

As usual, the relationship between an infant formula product’s price and its wholesale cost, paid by the retailer to the manufacturer, is expected to be a positive one.

$$(1) P_{i,t}^k = \beta_0 + \beta_1(CB_{i,t}^k) * (S_{i,t}) + \beta_2(1 - CB_{i,t}^k) * (S_{i,t}) + \beta_3(WC_t^k) + \beta_4(D_{i,t}) + \beta_5(HHI_i) + \beta_6(I_{i,t}) + \beta_7(R_{i,t}) + \varepsilon_{i,t}$$

In summary, an econometric specification that is consistent with the WIC model is given by:

where

- $P_{i,t}^k$  represents the retail price of brand  $k$  formula in market area  $i$  in time period  $t$ ;
- $CB_{i,t}^k$  represents a dummy variable that equals 1 if brand  $k$  is the contract brand in market area  $i$  in time period  $t$  and equals zero otherwise;
- $S_{i,t}$  represents the relative size (ratio) of WIC to non-WIC formula-fed infants in market area  $i$  in time period  $t$ ;
- $WC_t^k$  represents the wholesale cost for brand  $k$  in time period  $t$ ;
- $D_{i,t}$  represents the number of discount stores relative to population in market area  $i$  in time period  $t$ ;
- $HHI_i$  represents the Herfindahl-Hirschman Index for market area  $i$  in 2000, rescaled by a factor of 1,000 for ease of interpretation;
- $I_{i,t}$  represents median household income in market area  $i$  in time period  $t$ ;
- $R_{i,t}$  represents the poverty rate for market area  $i$  in time period  $t$ ;
- $\varepsilon_{i,t}$  represents an error term

An alternative, fixed-effects model could be specified to incorporate effects associated with specific market areas. However, a fixed-effects model would not be able to measure price effects associated with supermarket concentration inasmuch as the data available for concentration for this study were cross-sectional (HHI is measured only for 2000). The results of this study are based on the model outlined above.

It is expected that  $\beta_1 > 0$ , measuring the price effect on the contract brand of a change in  $S$ , the *relative size of WIC*, and that  $\beta_2 > 0$ , measuring the price effect on the noncontract brand of a change in  $S$ . It is also expected that  $\beta_3 > 0$ ,  $\beta_4 < 0$ ,  $\beta_6 > 0$ , and  $\beta_7 < 0$ . The sign on  $\beta_5$ , the coefficient associated with HHI, could be positive if infant formula pricing resembles the pattern predicted by the Cournot and WIC models or negative if supermarket instead adopt the pricing strategies outlined above for an “attractor” item.

The full empirical specification augments the specification outlined in the previous section by including a pair of additional variables to reflect that the number of alternative infant formula products that supermarkets carried varied in the sample by market area and period. The regressions included two dummy variables, *presence of Wyeth* and *presence of private label* to capture this variation. For either brand, Wyeth or private label, the dummy variable equals 1 if that brand is available in a given market area in a given quarter in the same product base and product form as the product modeled in the regression (e.g., if the regression's independent variable is the price of Mead-Johnson milk-based liquid concentrate then *presence of Wyeth* equals 1 for that regression if supermarkets carried Wyeth's milk-based liquid concentrate infant formula product, and equals 0 otherwise). Households may consider Wyeth brand formula or private label formula to be a substitute for one or more of the brands (Mead-Johnson, Ross, Carnation) whose price-determining factors are estimated by the regressions. If so, then the coefficient on the dummy variable for the presence of the alternative brand would be negative.