Results of the WIC Model

An examination of (9), (10), and (12) shows whether equilibrium levels of a chain's quantities, the market quantities, and prices respond positively or negatively to a change in any one factor, holding other factors constant. This chapter focuses on price effects, although brief attention is given to quantity effects. It is important to distinguish which price effects are due to WIC *per se* as a government-funded formula-subsidizing program, which are due to WIC's rebate program, and which are due to sole-source procurement.

The chapter begins by discussing price effects associated with changes in marginal cost, price-independent brand preferences, and population. The chapter continues with a discussion of price effects under two scenarios:

- the presence of the WIC program (without rebates) relative to the absence of the WIC program;
- an increase in the relative size of WIC (without rebates).

The remainder of the chapter then considers each of the following WIC-related factors in turn:

- an increase in the relative size of WIC if WIC has rebates generated by open market contracts;
- the use of open market contracts relative to the absence of any rebate contracts;
- an increase in the relative size of WIC if WIC has rebates generated by sole-source contracts;
- the use of sole-source contracts relative to the use of open market contracts;
- the use of sole-source contracts relative to the absence of the WIC program; and
- the use of home delivery or direct distribution for distribution of WIC formula relative to the use of the retail food delivery system.

A central variable of the WIC model is the relative size of WIC, w, measured by the ratio of WIC to non-WIC formula-fed infants. A challenge in reviewing price effects occurs because there is a multiplicative interaction in (12) between w and its coefficient, which contains the parameters θ_1, θ_2, δ, and h. Thus, the price effect due to a marginal increase in w depends on whether WIC has a rebate program, whether the rebate program uses an open market contract or sole-source procurement, and on the distribution system used for WIC formula.[16] In the end, it turns out that price effects are easiest to consider by reviewing them in a particular sequence.

[16] An analogous mathematical structure is found in the familiar Distance-Speed-Time relationship D = ST, where the multiplictative interactions between S and T implies that the Distance effect of a change in Speed depends on the level of T and the Distance effect of a change in Time depends on the level of S.

Effects of Marginal Cost, Brand Preferences, and Population

Marginal Cost. In (12), a brand's price depends positively on the brand's own marginal cost. A second result of (12) is that a brand's price does *not* depend on the marginal cost of the competing brand, e.g., c_2 is not a factor that affects P_1* (hereafter, the asterisk that denotes equilibrium values will be implicit). However, that result depends on particular features of the WIC model: a more general model may find that P_1 is affected by c_2 . A third outcome of (12) is that its price-cost relationship matches precisely the Cournot model's price-cost relationship. Thus, the special features of the WIC model that distinguish it from the Cournot model do not change the role of marginal cost: in both models, a one-unit change in c_k raises P_k by $M/(M+1)$.

Econometric Specification of Wholesale Cost. A brand-specific retail price regression in Oliveira et al. includes the brand's wholesale cost as an independent variable, since wholesale cost is a major determinant of marginal cost. Furthermore, the price regression *excludes* the wholesale costs of other brands. This econometric specification is restrictive in that, as noted above, a more general theoretical model may find that in principle a brand's retail price may be affected by wholesale prices of other brands. The exclusion of wholesale prices of other brands in the regressions is motivated less by the results of the WIC model *per se*—although the WIC model identifies certain conditions under which the specification is a correct one—and more by the very high correlation between the wholesale prices of various manufacturers. Severe multicollinearity problems would be introduced in a retail price regression if all wholesale prices were included in any one brand's regression.

Although the WIC model, like the Cournot model, predicts that a price regression's coefficient on wholesale cost should be a positive fraction equaling $M/(M+1)$, that particular outcome depends strongly on the linear demand specification used by the two models. Alternatively, a constant-elasticity demand formulation cannot be ruled out as a possibility (although it cannot be readily incorporated into the formal WIC or Cournot models), in which case a regression coefficient on wholesale cost would exceed 1. In summary, a price regression's coefficient on wholesale cost is certainly expected to be positive, though not necessarily fractional.

Price-Independent Brand Preferences. Price-independent brand preferences are measured by a_k, the constant term in demand in (1). An increase in a_k results in an increase in the brand's retail price in (12). There is no empirical measure for a_k, and the term is simply absorbed by the constant in a brand's price regression. It is worth identifying a_k as a distinct term in the model even though it is not empirically measured because it is useful to note that observed cross-brand variation in retail prices may be due in part to unobserved cross-brand variation in a_k.

Population Effects. The expressions in (10) and (12) exhibit a fundamental structural difference: the number of non-WIC households, Y, is a component of Q_k but not of P_k. These results imply that the "scale" of demand—

whether a market area's demand is "big" or "small" on account of population size—affects only Q_k but not P_k. In other words, if the numbers of H, L, and W households were to each increase proportionately, either over time or relative to another market area, then Q_k would increase by that same proportion but P_k would remain unchanged. Given that infant formula can be sold at a constant marginal cost (by assumption), variation in the size of a market area does not affect equilibrium prices.

Econometric Specification for Population. If a market area's population were to be included in a brand's price regression, the coefficient is expected to be statistically insignificantly different from zero. The sign of the variable's coefficient may be either positive or negative due to randomness in the data, but no systematic (statistically significant) relationship is predicted between price and population.

Effects of Relative Size of WIC, Without Rebate Contracts

Two Price-Increasing Effects. In this section, let $\theta_k = a_k/(a_1 + a_2)$, $\delta = 1$, and $h = 0$. Two scenarios will be considered to examine price effects due to WIC: $w > 0$ vs. $w = 0$, which compares the presence of WIC with the absence of WIC; and a marginal increase in w.

To keep the sequential discussion of the effects of WIC and the rebate program organized, we temporarily assume that WIC does not have a rebate program. This assumption is referred to as *counterfactual* since WIC currently does have a rebate program; the assumption could just as well be called an *historical* assumption since it describes WIC prior to the implementation of the rebate program. Examination of the counterfactual facilitates considering the effects of WIC, as a government-funded formula-subsidizing program, prior to and separately from considering the effects of WIC's rebate program. In the absence of the infant formula rebate program, it is supposed that all WIC formula is distributed using the retail food delivery system, making $\delta = 1$ in (12).

Under the counterfactual, WIC households themselves choose whether to redeem vouchers for brand 1 or for brand 2. As a result, θ_k in (12) is positive for both brands, equaling the value of $a_k/(a_1 + a_2)$ as noted earlier in the section "Demand of WIC Households". There is no tag-along effect under the counterfactual, so $h = 0$ in (12).

It is accurate to say that WIC "adds" to the overall market demands for infant formula. After all, WIC provides vouchers to (low-income) households which those households use to obtain more formula than they would have paid for if they were not WIC participants. However, given the assumption of constant marginal cost, the price effect of WIC can not be attributed to its role in increasing demand—whether the "scale" of demand is small or large affects only Q_k—but instead to WIC's effect on the *price sensitivity* of demand. Specifically, WIC decreases the price sensitivity of demand in the overall infant formula market, which in turn increases the P_k established by profit-maximizing supermarket chains.

This effect can be separated conceptually into two aspects. One aspect was identified in an analysis of WIC and the formula market by Salant (2003), while another was identified by Post and Wubbenhorst (1989).

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.

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 supermarket chains 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* ($b_L > b_H$).[17] Formally, let the numerical values of W, L, and H in the *absence* of the WIC program (the counterfactual) be represented by W', L', and H', where $W' = 0$, $L' = L + W$ (the WIC households all fall below the model's income cutoff that demarcates low- from high-income households; see the section "Demands of Out-of-Pocket Households"), and $H' = H$ (the number of high-income households is the same with or without WIC). The overall price sensitivity of the out-of-pocket households is *always* a weighted average of b_L and b_H, but the numerical *value* of that weighted average depends critically on whether or not WIC is present. In the *presence* of WIC, the numerical value of that weighted average is given by (11). Let b_0 designate the value of the weighted average in the *absence* of WIC, where

$$(13)\ b_0 = \left(\frac{H}{H+(L+W)}\right)b_H + \left(\frac{(L+W)}{H+(L+W)}\right)b_L$$

Comparison of (13) and (11) shows that $b_0 > b$. As WIC "removes" some low-income households from the out-of-pocket segment of the market, the mix of out-of-pocket households that remain is less price sensitive: the weights on b_L and b_H are shifted more towards towards b_H, lowering the weighted average below b_0. A decrease in the price sensitivity of out-of-pocket households raises P_k in (12)—a result that will be established formally below. Thus, holding other factors constant, each of the M supermarket chains will find it profit-maximizing to increase the retail price of infant formula in the presence (versus the absence) of WIC.

[17] The WIC model, like Salant, does not consider how in the absence of WIC some of the low-income households may choose breastfeeding rather than purchase formula out of pocket.

We call this 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. Salant himself noted that this effect is analogous to pricing effects that seem to be found in the markets for certain pharmaceutical products. Prior to the introduction of generic pharmaceutical products that are substitutes for brand-name products, it might have been predicted that the entry of generic products would (as substitutes) lower the price of the brand-name product due to the increase in "competition." However, it was observed that in some instances the price of the brand-name drug *increased* after generic drugs entered the market. One explanation is that those consumers who were most price sensitive switched to the generic drug, leaving the less price sensitive (or so-called "brand-loyal") customers in the market for the brand-name product. In response to the decrease in elasticity in demand facing its product, a profit-maximizing pharmaceutical company will raise the price on its brand-name drug.

Another mechanism by which WIC decreases the price sensitivity of demand was identified by Post and Wubbenhorst. 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." The WIC model calls this mechanism the *voucher effect*. In (12) the voucher effect is present given that $\delta = 1$, in which case price is affected by w through a mechanism other than the price-sensitivity term b. As w increases from zero (in the absence of WIC) to a positive value (in the presence of WIC), 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.[18] The profit-maximizing supermarket chains respond to the reduction in price sensitivity by raising the equilibrium retail prices of infant formula when WIC is present.

Although the out-of-pocket composition effect and the voucher effect both affect the mix of households in the infant formula market, the two 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.

The voucher effect reflects the WIC model's general principle that the scale of demand is unimportant. A change in the *absolute* size of WIC—whether WIC is "big" or "small" as measured by W—does not necessarily change price: if a change in W is accompanied by a proportionate change in Y, then w is unchanged and price is unaffected. In contrast, a change in the *relative* size of WIC, as measured by w, does affect price even if overall population is fixed.

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 WIC households price insensitive—as Post and Wubbenhorst emphasized—which "adds" those *same* households *back into* the retail food system. 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—zero—is *smaller* than for high-income households).[19]

[18] The voucher effect is also a particular type of "composition" effect, involving the composition of overall market demand and the relative numbers of WIC and non-WIC households.

[19] 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 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.

The discussion has introduced the out-of-pocket composition effect and the voucher effect while considering the presence vs. the absence of WIC. Similarly, an expansion of WIC—represented by a marginal increase in *w*—would also increase price as a result of the same two mechanisms.

Effects of Relative Size of WIC, Formal Derivation. The formal derivation of the price effects of changes in *w* focuses on P_1 in (12a) and, for generality, does not here set zero values for particular parameters such as δ or *h*. The total effect on price due to a change in *w* is given by:

$$(14)\quad \frac{dP_1\left(w,b(w)\right)}{dw} = \left[\frac{\partial P_1}{\partial w}\right] + \left[\frac{\partial P_1}{\partial b}\right]\left[\frac{db}{dw}\right]$$

As discussed earlier, the relative size of WIC affects prices through two mechanisms. These two mechanisms correspond to the voucher effect and the out-of-pocket composition effect, respectively, which are represented by the first term on the right in (14) and by the product of the final pair of terms.

The voucher effect is given by the partial effect of *w* on price, which is non-negative:

$$(15)\quad \frac{\partial P_1}{\partial w} = \delta \frac{\left[b\theta_1 + s\theta_2\right]vz}{(M+1)\left(b^2 - s^2\right)} \geq 0$$

The voucher effect is strictly positive if δ = 1, i.e., if WIC formula is distributed using the retail food delivery system.

Examination of the out-of-pocket composition effect begins by identifying the relationship between *b* and *w*, which can be expressed as

$$(16)\quad b(w) = b_0 - \left(\frac{H}{N}\right)\left(b_L - b_H\right)w$$

where b_0 is the weighted average price sensitivity in the absence of any WIC program from (13). Recalling that price sensitivity is relatively large for low-income households (making $b_L > b_H$), an increase in *w* reduces *b*, i.e., db/dw < 0.

The remaining term in (14) represents the partial effect of *b* on price:

$$(17)\quad \left[\frac{\partial P_1}{\partial b}\right] = -\left[\frac{\left(b^2+s^2\right)\left(a_1 + \delta\theta_1 vzw\right) + 2bs\left(a_2 + \delta\theta_1 vzw\right) + \delta(b-s)^2 hvzw}{(M+1)\left(b^2-s^2\right)^2}\right] < 0$$

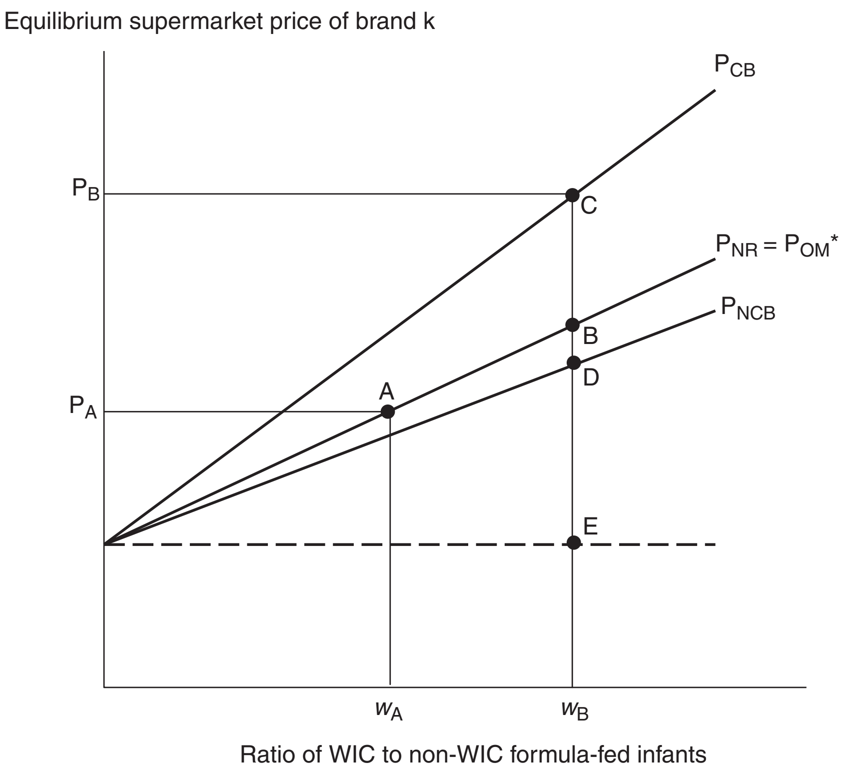
The value of the expression is negative whether δ equals 1 or zero and *h* is zero or positive. Because *db/dw* < 0 and the partial effect of *b* on P_1 is also negative, the out-of-pocket composition effect is positive. If δ = 1 the voucher effect and the out-of-pocket composition effect both work in the same direction, making the total effect of *w* on P_1 unambiguously positive.

If δ = 0, the effect of w on P_1 remains positive due to the out-of-pocket composition effect alone.

Evaluation of the second derivative (not shown) demonstrates that P_1 is convex in w. For some analyses, such as behavior towards risk, the curvature properties of a relationship between two variables is central. However, in the graphical analysis below, the major results of the WIC model can be portrayed most easily by treating the relationship between P_1 and w as approximately linear.

Graphical Illustration. Figure 1 illustrates the relationship between the equilibrium price and w on the graphical line labeled P_{NR} for "no rebate." When considering P_{NR}, the variable P_k on the vertical axis can be thought of simply as the equilibrium price of *either* brand in (12); the interpretations of other graphical curves in Figure 1 are considered below.

Figure 1
Retail prices vs. relative size of WIC under various contract systems



*One relationship between price and w is labeled both P_{NR} and P_{OM}, signifying that the same relationship exists whether no rebates are in effect or an open market contract is in effect (given that marginal cost of infant formula to supermarkets is held constant).

Source: Economic Research Service/USDA.

Along P_{NR} all other price-determining factors besides w are held constant. The slope of P_{NR} measures the price effect on P_k due to a marginal change in w. In general, the value of this price effect does depend on which brand is considered (inasmuch as θ_k in (12) can be brand specific).

The figure illustrates the price effects due to:

- the presence of the WIC program (under the counterfactual assumption of no rebates) relative to the absence of the WIC program;
- an increase in the size of WIC (under the counterfactual);

When considering the *presence* versus the absence of WIC, the relevant change is from a zero value of w to a positive value, say w_A. When considering an *expansion* of WIC, the relevant change is an increase in the value of w, say from w_A to w_B. In either case, the change in w results in a retail price increase. Of course, the magnitudes can differ, with a movement from the intercept to point A in the former case and from point A to point B in the latter case. However, the qualitative results—the direction of price effects—are the same for both cases.

Econometric Specification. The price regressions in the companion volume contain three independent variables of particular interest:

- median household income (I), as a measure of central tendency of the income distribution
- the poverty rate (R)
- the ratio of WIC to non-WIC formula-fed infants (w).[20]

The regression includes I and R to capture the effects of differences across out-of-pocket households of (income-dependent) price sensitivities and the relative frequencies of out-of-pocket households at various income levels.

As R increases, it is likely that the share of L out of all out-of-pocket households increases as well, increasing b in (11) and decreasing P_k. Although the income cutoff for R is (by definition) the poverty line and the income cutoff between the WIC model's low- and high-income populations is set above the income threshold at which a household qualifies for WIC (185 percent of the poverty line), R is used in the companion volume as a rough proxy for the overall shape of the income distribution within a market area.[21] The predicted sign for the regression coefficient on R is negative.

The inclusion of I in the price regression introduces an empirical element that the WIC model has not fully considered. As a simplified theoretical model, the WIC model sets but *two* values for price sensitivities, given by b_H and b_L , and focuses on the mix of L and H households as the varying determinant of the overall price sensitivity of the out-of-pocket households (in (11)).[22] However, in actual market areas, each household's level of income can vary, and each level of income may be associated with a particular value of price sensitivity: instead of just two price-sensitivity values of b_H and b_L there may instead be a range of many (unobserved) income-dependent values. Thus, the many possible levels of household incomes and price sensitivities and the frequency distribution of households together determine b, a market area's overall price sensitivity for out-of-pocket households.

The variables R and I together capture, as effectively as can be done with available data, the factors that influence b and the out-of-pocket composi-

[20]The same symbol w is used to designate both this ratio (for the regression analysis) and the WIC model's ratio of WIC to non-WIC formula-buying households. Strictly speaking, the two ratios do differ slightly to the extent that a household may have more than one formula-fed infant.

[21]Although R and I are likely to be (negatively) correlated, the inclusion of R in the regression does not capture how an area's low *median* household income results in a low price: R can only capture the role of income *distribution* inasmuch as the regression also contains I. If I were omitted, then the coefficient on R would measure the combined effects of low median income and of income distribution.

[22]These two values are set for any given value of D, the ratio of discount stores to population. As discussed, a change in D does change the price sensitivities to a new pair of values.

tion effect. If R and I were not included in the regression, the coefficient on w would measure a combination of the voucher effect and the out-of-pocket composition effect. Because R and I are included in the regression, the remaining role for w is to capture the voucher effect alone.

Effects of Relative Size of WIC, With Open Market Contract

In this section, let $\theta_k = a_k/(a_1 + a_2)$, $\delta = 1$, and $h = 0$. A marginal increase in w is considered given that manufacturers pay rebates under an open market contract.

The open market contract, even when it was in use, was never as predominant as the sole-source contract. Nevertheless, an open market contract is considered prior to the sole-source contract in order to separate as fully as possible the price effects of a *rebate system* from the price effects of a *sole-source contract*. A key feature that distinguishes a rebate system under an open market contract from a rebate system under a sole-source contract is that the open market contracts generate rebates *without* affecting the relative demands for different brands, while sole-source contracts channel all WIC demand to a single contract brand.

Under the open market contract, just as under the no-rebates counterfactual already considered, WIC households choose whether to redeem vouchers for either brand 1 or brand 2. Under the open market contract, θ_k in (12) are positive for both brands, equaling the same values of $a_k/(a_1 + a_2)$ introduced for the counterfactual. Because there is no single contract brand, the tag-along effect remains zero ($h = 0$). Given these common specifications for the values of θ_k and h, the value of the coefficient of w under the open market contract *matches* the value of the coefficient under the counterfactual, given by (14). Thus, the effect of a change in the relative size of WIC is the same regardless of whether WIC has no rebate program or WIC has a rebate program that uses open market contracts.

Effects of Open Market Contracts. In this section, let $\theta_k = a_k/(a_1 + a_2)$, $\delta = 1$, and $h = 0$. The effect of open market contracts *per se* is considered.

It is important to distinguish between two different questions:

- What is the price effect of a change in the relative size of WIC if there is an open market contract?
- What is the price effect of an open market contract (versus no open market contract)?

The first question has already been answered, and the answer involves the value of the *slope* of the relationship between P_k and w; the slope of the relationship happens to be the same with or without an open market contract. However, just because the slope is unaffected by the open market contract does not mean that *price* is unaffected. Price can be affected by the open market contract due to a change in:

- w, which changes the location of equilibrium price on a given curve; and

- marginal cost c, which changes the curve's location.

Thus, even though the same terms appear in (12) whether the counterfactual or open market contracts are considered, the values of two of the terms (w and c) may depend on which of the two scenarios is considered. Initially, marginal cost will be held constant, in which case any change in retail price due to the open market contract occurs along the same P_{NR} line associated with the no-rebate counterfactual. It is for this case that Figure 1 relabels P_{NR} as P_{OM} for "open market" contract.

Under the counterfactual no-rebate assumption, WIC is financed by Congressional appropriations alone. Suppose in this case that the relative size of WIC is w_A in Figure 1, with an equilibrium price of P_A on the line P_{OM}. Once rebates are received, suppose that Congress maintains the amount of appropriations steady—so that rebates fully supplement those appropriations—or that Congress lowers appropriations, but by less than the amount of the rebates. Either way, total WIC funding grows and the WIC program supports more participants.[23] To the extent that more infants participate in WIC as a result of the rebates, w increases (say to w_B) and retail price increases from P_A to P_B on P_{OM}, holding other factors (such as marginal cost) constant.

In this scenario, when WIC receives rebates from open market contracts, the relative size of WIC increases and price increases. Some analysts may therefore attribute the price increase to the rebates, concluding that the rebates "caused" a retail price increase. However, other analysts might attribute the price increase not to the rebate program *per se* but instead to the increase in the relative size of WIC. This alternative way of describing the price increase and its "cause" is based on the view that Congress can support any particular size of WIC it chooses—be it w_A or w_B—either by appropriations alone or by some mix of appropriations and rebates. In this view, Congress can achieve any particular w with or without rebates, making the relative size of WIC the only critical factor in determining retail prices. This view considers the method of financing—the mix between appropriations and rebates—to be important for *budgetary* considerations, but secondary (actually, ineffectual) in determining retail price at any *given* value for w.

Throughout the rest of this report the WIC model treats wholesale prices as exogenous, but here a relaxation of that assumption is considered. The graphical curve P_{OM} depends in part on marginal cost, which in turn depends on manufacturers' wholesale price. If manufacturers increase wholesale prices in response to the payment of rebates or to the relative size of the WIC program (which itself can depend on rebates, as just noted), then retailers' marginal costs rise, which would increase retail prices. Noting that marginal cost in (12) is a component of the intercept of P_{OM} in Figure 1, an increase in marginal cost would shift P_{OM} parallel upwards (not shown). In this case the lines P_{OM} and P_{NR} would differ, and retail price would be affected not only by any increase in w associated with rebates but also by the upward shift in P_{OM}. Having identified this possible repercussion from the rebate program on wholesale price, the remainder of this report returns to concentrating on retailer behavior and again treats wholesale prices as exogenous.

[23]An implicit assumption is that there had been eligible households with infants who are not participating in WIC that would participate if additional funding were available, so that an increase in total WIC funding is indeed associated with an increase in w.

Effects of Relative Size of WIC, With Sole-Source Contract

In this section, $\theta_1 = 1$, $\theta_2 = 0$, $\delta = 1$ and $h = 0$. Even though this section examines sole-source contracts, which means there is a single contract brand, the tag-along effect will be still be treated as zero; the tag-along effect is examined separately below.

There are four questions (each involving two prices) that will be answered in this section and the following two sections:

- What are the effects on contract and noncontract brand prices due to an increase in the relative size of WIC, given that a sole-source contract is in effect?
- What are the effects on the prices of a national brand serving as either the contract or noncontract brand as a result of changing from an open market contract to a sole-source contract, at a given w?
- What are the effects on a national brand's prices as it changes in contract brand status?
- What are the effects on the prices of a national brand serving as either the contract or noncontract brand as a result of changing from the absence of WIC (and its rebate program) to the presence of WIC and a sole-source contract?

Under the sole-source contract, the contract brand receives all of the WIC demand, making $\theta_1 = 1$, while the noncontract brand receives none of the WIC demand, making $\theta_2 = 0$. Given that $\delta = 1$ and $h = 0$, (12) becomes:

$$(18a)\ P_1{}^* = \frac{(ba_1 + sa_2)}{(M+1)(b^2 - s^2)} + \frac{M}{(M+1)} c_1 + \frac{bvz}{(M+1)(b^2 - s^2)} w$$

$$(18b)\ P_2{}^* = \frac{(ba_2 + sa_1)}{(M+1)(b^2 - s^2)} + \frac{M}{(M+1)} c_2 + \frac{svz}{(M+1)(b^2 - s^2)} w$$

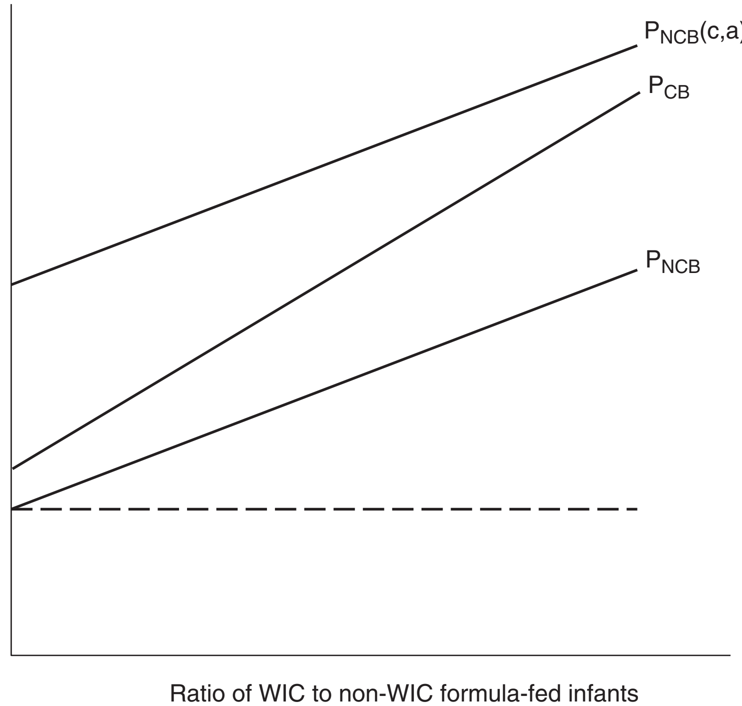
Figure 2 makes a comparison of price curves for two *different* national brands: the P_{CB} and P_{NCB} curves refer, respectively, to the curves for the contract brand (e.g., Mead-Johnson) and the noncontract brand (e.g., Carnation). The figure shows that the intercept of P_{CB} is above the intercept of P_{NCB}; the reverse is true for the intercept of the curve $P_{NCB}(c,a)$, which will be considered below. Difference in intercepts could be due to a difference in non-price brand preferences, as measured by a_1 and a_2, to a difference in the marginal costs of the two brands, or both.

In Figure 2, P_{CB} has a positive slope, which reflects the coefficient on w in (18a). Given that brand 1 receives all WIC demand, it is intuitive that an increase in w results in an increase in P_1.

One might at first expect that an increase in the size of WIC will have *no* effect on the price of the noncontract brand, which receives none of the

Figure 2
Retail prices vs. relative size of WIC for two national brands

Equilibrium supermarket price of Brand K



Source: Economic Research Service/USDA.

WIC demand (either before or after the increase in the relative size of WIC). If there is no WIC-related price effect on the noncontract brand, its price curve would be the (unlabelled) horizontal dashed line. What is perhaps unexpected is that the price curve for the noncontract brand is given by P_{NCB}, which lies above the horizontal line. According to (18b) and its graphical illustration as P_{NCB}, an increase in the relative size of WIC results in an increase in the price of the noncontract brand P_2.

The mechanism by which *w* affects the price of the noncontract brand is through the demand substitution behavior of the *non-WIC* households. An increase in *w* results in profit-maximizing supermarket chains establishing a higher P_1 along P_{CB}, and (at least some) non-WIC households respond to this increase in the price of brand 1 by switching demand to brand 2 (strictly speaking, the price sensitivity of demand for brand 2 must be affected, not merely the scale or size of demand). Supermarket chains respond to the change in the demand for brand 2—which was caused by their very own increase P_1 in the first place—by increasing P_2.[24]

As mentioned previously, one of the powerful features of the WIC model is that it permits (but does not require) substitution behavior between brands. In (2), the parameter that captures the extent to which non-WIC households substitute between brands within the supermarket sector is *s*, which appears in the numerator in (18b). If non-WIC households do not substitute at all between the brands, then $s = 0$ in (18b) and the price curve for the noncon-

[24]If a *nonequilibrium* situation were being examined, the increase in the price of brand 2 would result in (at least some) non-WIC consumers switching to brand 1, resulting in nudge up in the price of brand 1 and a nudge down in the price of brand 2, which would result in a further chain of effects between the prices of the two brands (with each link in the chain growing progressively smaller). However, an advantage of the formal mathematical approach used by the WIC model is that it examines the equilibrium outcome of that entire process (through the *simultanteous* determination of the prices of the two brands), so that the entire sequence or chain of interactions between the two brands results in a final outcome that is portrayed in (14) and Figure 2. The changes in the equilibrium prices P_1 and P_2 already take into account all the interactions.

tract brand would be represented by the dashed horizontal line. The P_{NCB} curve in Figure 2 assumes that $s > 0$. This report adopts that assumption hereafter. The econometric analysis in Oliveira et al. subjects this assumption to a statistical test.

There is a difference between the positive slopes of P_{CB} and P_{NCB} because b appears in (18a) and s appears in (18b). The closer s is to b—the better brand 2 can substitute for brand 1—the closer P_{NCB} comes to being parallel to P_{CB}, making the price effect of w on the contract and noncontract brands more similar. The WIC model stipulated that $b > s$, making P_{CB} steeper than P_{NCB}.

Figure 2 illustrates one additional curve labeled $P_{NCB}(c,a)$, where the notation emphasizes how marginal cost and non-price brand preferences affect the location of the price curve. In contrast to P_{NCB}, $P_{NCB}(c,a)$ is located above rather than below P_{CB}. As price curves for a noncontract brand, $P_{NCB}(c,a)$ and P_{NCB} share a common slope (which is exceeded by the slope of P_{CB}). Figure 2 shows the price effect due to a change in w is greater for the contract brand than for the noncontract brand regardless of whether the contract brand's retail price is high or low relative to the noncontract brand's retail price (i.e., regardless of whether the noncontract brand's price lies on $P_{NCB}(c,a)$ or P_{NCB}).

Oliveira et al. found that, within market areas, there is not a clear and consistent relationship between a formula's being the WIC contract brand and that formula being sold at the highest average retail price. However, comparing the retail prices of contract and noncontract brands of formula does not necessarily identify WIC-related price effects since *other factors may affect retail prices*. Retail prices of two national brands do reflect the relative size of WIC and which of the two national brands holds the rebate contract. But retail prices also reflect non-price brand preferences and marginal cost. While non-price brand preferences are not measured empirically, differences across national brands in wholesale prices are measurable. A comparison of P_{CB} and P_{NCB} shows how a particular national brand can be the contract brand in a market area and have a higher retail price than a noncontract brand due to a relatively high wholesale price for the contract brand. In contrast, the expectation that the contract brand has the highest retail price would not be met if P_{CB} is compared with $P_{NCB}(c,a)$. Due to a relatively low wholesale price, a national brand associated with P_{CB} has a retail price below the noncontract brand price on $P_{NCB}(c,a)$. The empirical analysis in Oliveira et al. is designed to separate the retail price effects due to contract brand status from the effects due to wholesale prices.

Contract Systems, Contract Brand Effects, and Distribution Systems

Effects of Sole-Source Contracts Compared With Open Market Contracts. In this section, $\delta = 1$ and $h = 0$ and a comparison is made between $(\theta_1, \theta_2) = (1, 0)$ and $\theta_k = a_k/(a_1 + a_2)$.

This section begins with a comparison of retail prices under a sole-source contract with retail prices under an open market contract. A key difference between the two types of contracts is whether WIC households can select between brands 1 and 2 or if WIC households must purchase a single contract brand.[25] Then the section examines how retail prices compare between a sole-source contract and the absence of the WIC program.

Returning to Figure 1, the curves P_{CB} and P_{NCB} straddle the curve P_{OM}, radiating from the same intercept. Now the interpretation of Figure 1 is that it applies to any single national brand under varying conditions. Under an open market contract, the retail price of the national brand is at point B, given w_B. Suppose that a sole-source contract is adopted instead of an open market contract, and the national brand is awarded the rebate contract. The price effect of a sole-source contract for the contract brand, relative to an open market contract, is to increase retail price from point B to point C. The reason for this price increase is *not* due to a "rebate system" per se: the open market contract also generates rebates. Instead, the movement from point B to point C is because the share of WIC demand received by the given national brand increases from a fraction, given by $a_k/(a_1 + a_2)$ under the open market contract, to 100 percent.

Suppose instead that a sole-source contract is adopted instead of an open market contract, and the national brand is not awarded the rebate contract, becoming the noncontract brand. The price effect of a sole-source contract for the noncontract brand, relative to an open market contract, is to decrease the retail price from point B to point D. The reason for this price decrease for the noncontract brand is that its share of WIC demand drops from a fraction (under the open market contract) to 0 percent. Even though the national brand loses its fractional share of WIC demand, its retail price does not drop from point B to the dashed horizontal line at point E. The demand substitution from the contract brand to the noncontract brand exhibited by non-WIC households helps sustain the retail price of the noncontract brand, making the decrease in its retail price smaller than would be the case if there were no substitution behavior.

Effects of Contract Brand Status. In this section, $\delta = 1$ and $h = 0$ and a comparison is made between $\theta_k = 0$ and $\theta_k = 1$ for a given manufacturer's brand.

Given that a sole-source contract is in effect, the price effect for a national brand changing status from noncontract to contract is represented by a move from point D to point B; alternatively, the move from point B to point D represents the price effect of changing status from contract to noncontract. These changes are the price effect of a change in *contract brand status*. The price effect of contract brand status depends on the relative size of WIC. If w is small, the contract brand status makes little difference in a national brand's retail price, whereas if w is large, the change from contract to noncontract status—from having all of the WIC demand to having none of the WIC demand—results in a large price effect.

[25]A second difference between open market and sole-source contracts can be important in practice. Although both types of contracts generate rebates, historically the amount of rebates obtained from a sole-source contract is larger than the amount from an open market contract. This difference in turn could affect w and therefore retail prices. However, since the theoretical effects of rebates were already identified in the discussion of the open market contracts, it will be assumed hereafter that the rebate levels of the open market and sole-source contracts are the same. This assumption is adopted to concentrate on the effect that results from channeling all WIC demand to a single contract brand, holding other factors constant. The size of the differences in rebates may be of great importance in a practical comparison between the two types of contracts.

Effects of Sole-Source Contract Compared With the Absence of WIC. In this section, let $(\theta_1, \theta_2) = (1, 0)$, $\delta = 1$, and $h = 0$.

The answer to a simple question such as “What are the price effects of sole-source contracts?” depends on what conditions are being compared with the sole-source contracts. One alternative condition to a sole-source contract, considered above, is an open market contract. This section examines a condition in which WIC and its rebate program are absent.

Figure 1 shows that in the absence of WIC w is 0, resulting in a retail price of the national brand at the intercept or, equivalently, at point E. If the WIC program is adopted and a sole-source contract is used, the effect on the retail price of the national brand depends of course on whether the national brand is awarded the WIC contract or not. Retail price increases from E to C for the contract brand, while retail price increases only from E to D for the noncontract brand.

In this section, the price effect of a sole-source contract—compared with the absence of WIC—is to increase the retail price of formula for *both* the contract (E to C) and noncontract brands (E to D). As previously noted, the price effect of a sole-source contract—compared with an open market contract—is to increase the retail price of the contract brand (B to C) and *decrease* the retail price of the noncontract brand (B to D). The seemingly simple question “What are the price effects of using a sole-source contract?” results in two answers that have different magnitudes and even different signs. This is but an example of the general principle that it is important to identify the alternative condition when investing the theoretical or empirical effect of a change in policy, economic, or demographic variables.

Tag-Along Effect. In this section, let $(\theta_1, \theta_2) = (1, 0)$ and $\delta = 1$. A comparison is made between $h = 0$ and $h > 0$.

The tag-along effect, the composite of the medical promotion effect and the shelf-space effect, represents certain demand-shifting behaviors that favor the contract brand at the expense of the noncontract brand. Reintroducing a positive h shows that the tag-along effect *enhances* the positive effect w has on the contract brand’s P_1, entering the numerator of (18a) positively, but (partially) *offsets* the positive effect w has on the noncontract brand’s price P_2, entering the numerator of (18b) negatively.

Qualitatively, Figure 1 is not affected the tag-along effect. If the tag-along effect is present, the price effect of a change in w is greater for the contract brand and smaller for the noncontract brand, creating a gap in Figure 1 between the P_{CB} and P_{NCB} curves that widens more quickly.

The price regressions in Oliveira et al. have no separate measure for the tag-along effect, which is simply treated as a fixed parameter and absorbed into the regression coefficients on w.

Alternative Distribution Systems. In this section, a comparison is made between $\delta = 0$ and $\delta = 1$, given that $\theta_1 = 1$ and $\theta_2 = 0$.

If a WIC State agency does not use the retail food delivery system to distribute WIC formula, WIC consumers obtain formula either by the direct distribution system (as in Mississippi) or the home distribution system (as in Vermont). Alternative distribution systems involve contracts between State WIC agencies and manufacturers but the contracts do not, strictly speaking, involve rebates from manufacturers. Instead, State WIC agencies purchase directly from the manufacturer. Nevertheless, direct distribution and home distribution strongly resemble a rebate system in that they are all designed for cost-containment.

Under direct distribution or home distribution, a marginal change in the relative size of WIC (or the presence of WIC vs. the absence of WIC) increases retail prices due to the out-of-pocket composition effect alone, which operates through changes in *b*. WIC "removes" low-income households from the general market, but the voucher effect is absent because WIC does not "add" these same WIC households back into the retail food delivery system. In this case, $\delta = 0$ in (12), canceling the term that contains *w* explicitly, and setting the partial derivative in (15) to 0. The out-of-pocket composition effect is still positive, but because the voucher effect does not augment it, the retail price is lower than it would be if the retail food delivery system were used, holding other factors constant.[26]

[26]While it might be thought that a lower retail price is desirable (from a consumers' perspective), a State that uses direct distribution or home distribution bears the administration costs of operating the State's formula distribution system, and such costs must be funded somehow. An assessment of the many pros and cons of adopting alternative distribution systems is beyond the scope of this report.

The empirical analysis in Oliveira et al. focuses on price data from market areas in which the retail food delivery system is used.

Effect of Market Structure Conditions

Discount Stores. Another factor that affects retail price is a household's ability to buy formula at discount stores. It was discussed earlier how an increase in *D*, the ratio of the number of discount stores to total population, can be expected to increase the price sensitivity of demand for supermarket formula, as measured by *b*. An increase in *b*, in turn, decreases P_k. In addition, an increase in *D* and the convenience of discount stores to WIC households may lower *v*, the fraction of formula WIC households receive in supermarkets, thus decreasing P_k further.

Concentration (M). An increase in *M*, the number of (equally sized) firms, lowers *concentration* whether concentration is measured by the Herfindahl-Hirschman Index, the four-firm concentration ratio, or any other measure of concentration. As in the Cournot model, if $M = 1$, the result in the WIC model is a monopoly outcome (although here it is an outcome associated with *one* monopoly supermarket chain pricing *two* interdependent brands). As *M* increases without limit, concentration falls, market output and price approach the outcome of a perfectly competitive market in which price equals marginal cost (for each brand). Thus, in the WIC model an increase in *M* is associated with a decrease in price (for each brand), just as in the Cournot model.

Oliveira et al. considers how an increase in concentration may be associated with a decrease (rather than an increase) in the retail price of infant formula, but that discussion lies outside the scope of this report.

Summary of Econometric Specification

An econometric specification that is consistent with the WIC model is given by:

$$(19)\ P_{i,t}^{k} = \beta_0 + \beta_1\left(CB_{i,t}^{k}\right)*\left(w_{i,t}\right) + \beta_2(1 - CB_{i,t}^{k})*\left(w_{i,t}\right) + \beta_3\left(WC_t^{k}\right)$$
$$+ \beta_4\left(D_{i,t}\right) + \beta_5\left(HHI_i\right) + \beta_6\left(I_{i,t}\right) + \beta_7\left(R_{i,t}\right) + \varepsilon_{i,t}$$

where

- $P^{k}_{i,t}$ represents the retail price of brand *k* formula in market area *i* in time period *t*;
- $CB^{k}_{i,t}$ 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;
- $w_{i,t}$ represents the ratio of WIC to non-WIC formula-fed infants in market area *i* in time period *t*;
- WC^{k}_{t} 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 *M*-firm Herfindahl-Hirschman Index for market area *i* in 2000;
- $I_{i,t}$ 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

It is expected that $\beta_1 > 0$, measuring the price effect on the contract brand of a change in *w*, and that $\beta_2 > 0$, measuring the price effect on the noncontract brand of a change in *w*. It is also expected that $\beta_3 > 0$, $\beta_4 < 0$, $\beta_5 > 0$ (based on the WIC and Cournot models), $\beta_6 > 0$, and $\beta_7 < 0$.