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by Rui Huang and
Jeffrey M. Perloff

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University of Connecticut
Department of Agricultural and Resource Economics

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Rui Huang*

Jeffrey M. Perloff**

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* Assistant Professor, Department of Agricultural and Resource Economics, University of Connecticut

** Professor, Department of Agricultural and Resource Economics, University of California, Berkeley

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Abstract

The three major infant formula manufacturers bid state by state to be the exclusive provider to poor families under the Women, Infants, and Children (WIC) program, and all three compete for non-WIC customers at grocery stores. Previous studies explained the low WIC prices and the higher retail prices as the result of price discrimination. We propose an alternative spillover model. Grocery stores, which supply both WIC participants and others, provide relatively large amounts of shelf space to the firm that wins the state-level WIC contract. Non-WIC customers, inferring from the large shelf space that the WIC brand is superior, are more likely to buy it. Because the contract winner benefits from a spillover effect in the lucrative non-WIC retail market, firms are willing to bid more aggressively for WIC contracts than in a price discrimination model. The spillover model is more consistent with the data than is the price discrimination model. We show that the retail price markup of the firm that wins the state WIC contract does not change when the contract is awarded, but that its shelf space increases in excess of the share of WIC customers.

WIC Contract Spillover Effects

Under the U.S. Special Nutrition Program for Women, Infants, and Children (WIC), each WIC state agency holds auctions where the low-bidder among the three major manufacturers of infant formula becomes the sole provider of formula to the state agency. WIC state agencies provide WIC participants—low-income families with babies and young children—with vouchers that they can use to obtain the winning brand of infant formula at no personal expense from participating grocery stores. In addition, all three manufacturing firms compete for retail sales to higher-income consumers, who pay the full retail price at grocery stores. Previous studies attributed the low prices to states WIC programs and high prices to wealthier consumers to price discrimination. In contrast, we believe that a spillover model better describes this market. We hypothesize that the winning WIC brand can use a WIC logo in its promotional material and gains additional shelf-space within grocery stores thereby increasing its credibility with non-WIC customers. As a result, the WIC contract winner becomes the dominant player in the non-WIC market. Consequently, the manufacturers are willing to bid a lower price for the WIC contract than in the price discrimination model, so that the price differential between the WIC and non-WIC price that can exceed the differential predicted by the classic price-discrimination model. We use grocery scanner data to empirically examine various implications of our model. We explicitly test the effect of winning the contract on the actual (not estimated) retail price markup and we find no evidence in support of such an effect. We also show how a change in the firm that holds the WIC contract affects the market shares of the winner and other firms.

We start by describing the WIC program and explaining why institutional factors favor our spillover model rather than a price discrimination model. Next, we use some simple theoretical

models to illustrate our basic point. Then we test our predictions of a spillover effect with grocery scanner data.

The WIC Program

The WIC program serves low-income households where the mother is pregnant or postpartum with infants and children who are nutritionally at risk. President Obama's 2010 Budget calls for \$7.777 billion for the WIC program, making it the third largest nutrition assistance program after the Food Stamp Program and the National School Lunch Program. Oliveira and Prell (2004) report that nearly half of all U.S. infants receive WIC benefits. On average 8 million people per month, including almost 2 million children, participated in the program in fiscal year 2006.

WIC purchases of infant formula accounted for over 50% of this product's sales in the United States (GAO 1998). WIC provides participants free supplemental nutritious foods and nutritional counseling. The cost of procuring infant formula is the lion's share of the WIC budget.

Since 1998, Federal law has required that WIC state agencies use cost-containment practices. To contain costs, state agencies (or groups of a small number of states) hold an auction typically every three years in which the three major manufacturers bid to be the sole supplier. In 2000, the three major manufacturers produced 99% of all infant formula: Mead Johnson with 52% of the market, Ross with 35%, and Carnation with 12% (Oliveira and Prell 2004).

The three major infant formula manufacturers bid by offering a rebate—a percentage discount based on their national wholesale price—for each can of formula that WIC participants obtain. The WIC contract is awarded to the manufacturer that bids the lowest net price, which is the wholesale price less the rebate.

A WIC participant uses a voucher issued by the WIC state agency to obtain the contract brand's infant formula products from a retailer. The retailer sends these vouchers to the WIC agency for reimbursement at the retail price. Thus, the retailer receives the same retail price for both WIC and non-WIC consumers. For each WIC purchase, the manufacturer sends a rebate to the WIC state agency. Thus, the cost to the WIC agency is the retail price minus the rebate. Retailers pay the WIC-contract manufacturer the wholesale price for the infant formula it sells to both WIC and non-WIC consumers. Consequently, the WIC manufacturer collects the wholesale price for formula sold to non-WIC consumers but the wholesale price net of the rebate for formula sold to the WIC participants.

In recent years, the size of the discount manufacturers' offer state WIC agencies has grown to as much as 98% off the wholesale price in some states. Rebate savings have remained near \$1.6 billion per year since 1997 after adjusting for inflation, but the amount states pay per can of infant formula has increased since 2002 due to increases in the wholesale prices (GAO 2006b), which affects the number of possible recipients.

Immediately after the WIC sole-source rebate program was instituted in 1989, the wholesale prices paid by non-WIC purchasers rose faster than usual while the net prices paid by WIC agencies decreased. The wholesale prices for non-WIC purchasers increased by 9% at an annual rate in 1989-1990 after adjusting for the general rate of inflation in the economy, compared with increases of about 3% before and after this period (GAO 1998).

Because of this rapid increase in wholesale prices, many politicians and others voiced concerns that the WIC's rebate program was harming non-WIC consumers. In response to a request by the U.S. House of Representatives' Committee on the Budget, the U.S. General Accounting Office in 1998 conducted studies to determine how and why prices in the infant

formula market changed after the introduction of the rebate program (U.S. GAO 1998). In May 1999, the U.S. House of Representatives' Committee on Appropriations expressed concern “that since rebates began infant formula costs appear to have risen far greater than inflation, and the number of suppliers has declined” (H.R. 106-157). A U.S. Department of Agriculture report, Oliveira et al. (2004), concluded that WIC and its infant formula rebate program led to modest increases in retail prices for non-WIC consumers for given wholesale prices, especially in states with relatively large WIC programs.

Much of the formal and informal WIC literature describes the WIC rebate program as enabling price discrimination by the triumvirate of manufacturers where the state pays a relatively low price for relatively poor WIC participants and wealthier non-WIC consumers pay a higher price.¹ In contrast, we believe, based on a careful examination of the institutional features of these markets, that describing the manufacturers’ actions as those of price discrimination is misleading. Rather, we propose a “spillover” model in which the WIC contract winner is motivated to provide low prices to WIC recipients so as to obtain a larger share of sales to non-WIC consumers through a spillover effect.

The U.S. GAO (1998) contended that spillover effects could not be substantial in the WIC infant formula market. According to the GAO study, infant formula industry experts did not think the spillover effects to be significant. Moreover, the GAO study used a simulation exercise (rather than a formal empirical analysis) to examine whether the spillover effects, if any, could generate sufficient increases in non-WIC prices to offset the rebates the manufacturers offer to the WIC segment.²

In contrast, lawyers and politicians have argued that there are substantial spillover effects with respect to another aspect of the WIC program: infant cereal. A June 19, 2003 press release of Senator Schumer of New York (where Beech-Nut is located) stated:

According to Beech Nut, about 50 percent of WIC consumers who purchase infant cereal under the program will continue to stay loyal to that brand once the child switches to jarred food. By contrast if they do not win the cereal contract, they would expect to capture only 10 percent of the business after the child is eating jarred food.

Beech Nut claims that Gerber has gone to extreme efforts to prevent Beech Nut from winning WIC bids, saying it uses its 77.4 percent market share advantage to offer infant cereal under the WIC program at a fraction of its costs, thereby securing exclusive, sole-source WIC cereal contracts. By preventing Beech Nut from becoming the WIC supplier through below-cost bids, Gerber ensures that far fewer retailers will carry Beech Nut infant cereal – for both WIC sales and non-WIC sales.

Thus, the allegation in the Beech Nut case is that winning the WIC contract results in dominance of that brand in the non-WIC retail market and that firms may use below-cost bids to obtain the WIC contract.

There are several possible channels for a spillover effect. Increases in shelf-space for the WIC contract winner within grocery stores may influence non-WIC buyers. The GAO (2006a) reports that some infant formula manufacturers' marketing efforts used the trademarked WIC acronym in promotional materials. Examples include glossy posters for health care providers promoting a formula as "WIC Eligible" in big letters and depicting a flag with the WIC acronym and a consumer advertisement and coupon indicating a formula for babies with colic is "WIC approved in all 50 states." (The GAO recommended a limit to the uses of the WIC acronym or logo in promotional materials.) Although we do not have data that permits us to identify the source of the spillover effect, we are able to identify and measure the spillover effect using grocery scanner data.

Theory

We want a model that is consistent with three properties of this market. First, each manufacturer sets a national wholesale price annually and does not change it during the year (Oliveira and Prell, 2004). Second, the non-WIC relative prices across brands do not change substantially after a new firm wins the WIC contract. Third, when a new firm wins a WIC contract, its share of sales within grocery stores rises substantially immediately and then increases steadily over time for up to a year. We demonstrate the latter two properties in the empirical section.

According to the price-discrimination story, the winning firm sets a high, profit-maximizing price to non-WIC participants. Because the price to the government for WIC purchases is the wholesale price less the rebate, the firm can control the lower price as well by the size of the rebate it offers.

However, such a description is inconsistent with the first two properties of this market. Because the manufacturers bid by offering a percentage discount off the wholesale price, were the contract winner able to set the wholesale price separately for each state and adjust it frequently, the bidding system would be meaningless as the state agency would be unable to predict the ultimate discount it would receive. For this and other reasons, each major infant-formula manufacturer sets a national wholesale price, which is changed annually. As each of these firms is the winning bidder in some states and not in others, it cannot fully control the after-rebate price on a state by state basis.³ Moreover, retail prices do not change following a change in the firm that wins the WIC contract, which is also inconsistent with the state-by-state price discrimination story.

Perhaps most telling, the WIC price is often extremely low—sometimes below marginal cost—and almost certainly inconsistent with the price discrimination, profit-maximizing price. In many states, the net price to the state agency is mere pennies. For example, in Texas, Minnesota, and Iowa in 2002, the WIC agencies paid Mead 50¢ net for powdered infant formula for which Mead's national wholesale price was \$10.59. That is, Mead provided a 95.3% rebate on the wholesale price. Rebates in excess of 90% are common, and some are as high as 98%.

A more accurate description of the equilibrium is that the auction process determines the low, WIC price. The winning firm provides the entire quantity for WIC sales. All the firms compete for the non-WIC customers nationally.

To illustrate the effects of the WIC program, we start by considering how a monopoly would behave. Then, we describe an oligopoly equilibrium. Next, we discuss how the oligopoly equilibrium would change given a spillover effect where the contract winner benefits from an increased demand among non-WIC consumers increases. Finally, we discuss the dynamic adjustment that is associated with the spillover effect.

Monopoly

Suppose that a monopoly sells to n_1 poor people and n_2 rich people, where each poor person has a constant elasticity demand function of $q_1 = p^{\epsilon_1}$ and every rich person's demand function is $q_2 = p^{\epsilon_2}$. Thus, the total demand functions are $Q_1 = n_1 p^{\epsilon_1}$ and $Q_2 = n_2 p^{\epsilon_2}$.

Infant formula can be manufactured at constant marginal cost c . If a monopoly manufacturer can price discriminate, it will charge poor people $p_1 = c/(1 + 1/\epsilon_1)$ and rich people $p_2 = c/(1 + 1/\epsilon_2)$.

If the monopoly cannot price discriminate, it charges everyone the same price. Its total demand is $Q = Q_1 + Q_2 = n_1 p^{\epsilon_1} + n_2 p^{\epsilon_2}$. Differentiating with respect to p , we obtain $dQ/dp =$

$\varepsilon_1 Q_1/p + \varepsilon_2 Q_2/p$. Multiplying through by p/Q , we learn that the weighted sum of the two groups' elasticities is $\varepsilon = s_1 \varepsilon_1 + s_2 \varepsilon_2$, where $s_i = Q_i/Q$. Thus, a profit-maximizing, single-price monopoly charges $\underline{p} = c/(1 + 1/\varepsilon)$.

If the government institutes a WIC program, the monopoly charges the wealthy the profit-maximizing price for that group alone, $p_2 = c/(1 + 1/\varepsilon_2) > \underline{p}$, and the firm sells a fixed quantity to each of the n_1 WIC consumers at a negotiated price. Presumably, the maximum price that the government is willing to pay is less than \underline{p} (and hence less than p_2). The lowest price that the monopoly will offer is one such that its total profit is at least as high as its single-price profit, which is $\pi_s = (\underline{p} - c)(Q_1 \underline{p}^{\varepsilon_1} + Q_2 \underline{p}^{\varepsilon_2})$, ignoring any fixed cost. Thus, the lowest amount it is willing to bid depends on n_1 , n_2 , ε_1 , and ε_2 . In contrast, if it could price discriminate it would set the price p_1 based solely on ε_1 . Thus, its contract price almost certainly differs from the one it would set if it could price discriminate.

Oligopoly

If the industry consists of a Nash-Cournot oligopoly, the single-price equilibrium will be lower than the monopoly equilibrium. In a symmetric Nash-Cournot equilibrium, $p = c/(1 + 1/[f\varepsilon])$, where f is the number of firms and ε is the market elasticity of demand at the equilibrium.⁴ If there are three identical firms that sell products that are viewed as homogeneous by consumers, the triopoly price is $p_3 = c/(1 + 1/[3\varepsilon]) < \underline{p} = c/(1 + 1/\varepsilon)$.

Under the government's WIC program, the firms are asked to bid on an exclusive contract, where the winner is the only firm that supplies the WIC consumers. All the firms compete for the remaining customers. If the WIC bidding process has no effect on wealthier customers, the new price to this group is $p_3^* = c/(1 + 1/[3\varepsilon_2])$, which is greater than p_3 , the single price they charge if they sell to all consumers because market demand is more elastic than the demand for the

wealthy group. The lowest price that a firm would be willing to bid for the WIC contract is c . If one firm bids c , all firms earn the same amount in the new equilibrium.

Spillover Effect

Now suppose that the winner of the WIC contract benefits from a spillover effect.⁵ Grocery stores increase their shelf-space for the WIC winner's brand to ensure that adequate quantities of the winning brand's product are available on its shelf for WIC customers. Many well-to-do customers are influenced by the winning firm's use of the WIC logo and greater shelf space, perhaps reasoning that "The most-popular brand gets the most shelf space, so I'll buy that product." Instead of the three brands splitting sales to wealthier customers equally, the WIC-contract winner now obtains the largest share. Because of these greater sales, a firm may be willing to bid a price at or even below the marginal cost for the WIC contract.⁶ Though the contract winner loses money on its WIC contract sales, it earns a larger non-WIC profit, so that its total profit increases.

Finally, suppose that the spillover effect causes the WIC contract winner's demand curve for wealthier consumers to shift to the right and become less elastic. If so, the WIC contract winner could bid a price that was less than marginal cost for the WIC contract and charge wealthier customers more than the price-discrimination price given no shift in the demand function. Thus, unlike the price-discrimination story, a spillover model can explain the unusual deep rebates observed and the relatively high prices charged to non-WIC customers.

For example, suppose that the spillover effect resulted in the WIC winner becoming a virtual monopoly. It might want to change its price from the triopoly level, $c/(1 + 1/[3\epsilon])$, to nearly the monopoly level for wealthy customers only, $c/(1 + 1/\epsilon_2)$. Although the firms set their prices nationally, even without colluding, they might find it in their best interests to set the monopoly

price and expect to sell substantial quantities only in the states in which they are the WIC winners.

Another possibility is that the various brands face constant elasticity demand curves and the spillover effect causes the constant multiplier of the winner's demand curve to increase and that of the losers' to fall comparably. If so, the brands' retail prices would remain constant, but their shares would adjust accordingly. Indeed, this implication is close to what we report below in the empirical section.⁷

Dynamics

Although the various brands have the same basic components, many doctors and websites for new parents recommend sticking to one brand while the baby is consuming formula.⁸ Consequently, many parents choose a brand initially and then stick to that brand.

As a result, even if a spillover effect occurs and non-WIC parents who are choosing formula for the first time are more like to pick the WIC brand, the effect on sales may be small initially as most parents of older babies do not switch from their former brand, which is the previous WIC winner. Gradually over time, parents of older children stop buying formula and new parents enter the market. Thus, the full spillover effect takes months to be fully revealed. Indeed, if parents on average keep their children on formula for the medically recommended period of time, it may take 9 to 12 months for the full effect to appear.

Conflicting Predictions

The spillover model has different implications than the traditional price discrimination model concerning WIC and non-WIC prices and firms' market shares:

<i>Predictions</i>	<i>Price Discrimination (PD)</i>	<i>Spillover</i>
1. Change in retail (non-WIC) price when WIC auctions started	rises for all firms	may rise for all firms, but need not

2. WIC price relative to <i>MC</i>	greater	could be near or below
3. Change in winner's retail price after obtaining the contract	constant or rise	constant or rise
4. Market share of WIC contract winner	rises by the share of WIC consumers	rise by much more than the share of WIC consumers (non-WIC consumers switch to WIC brand)
5. Market share of WIC contract loser ⁹	falls by the share of WIC consumers	falls by same amount winner's share rises
6. Time for market shares to adjust	immediate adjustment	adjustment takes up to a year

Data

We use Information Resources Incorporated (IRI) grocery scanner data to test our predictions. Ideally, if we had household-level data that identified WIC and non-WIC consumers, we could examine directly whether non-WIC consumers are more likely to purchase the WIC brand than other brands, everything else equal. Unfortunately, we have been unable to obtain a household-level data set that distinguishes between WIC and non-WIC sales and has enough observations for a statistical analysis. One needs a gigantic number of households to obtain a subsample with an adequate number of households with infants for statistical analysis.

We examined an IRI grocery store scanner household-level survey dataset with over 8,000 households who purchased dairy products and found that only 40 households purchased infant formula during a three-year period. Moreover, that dataset does not distinguish between WIC and non-WIC purchases.

Because of data limitations, we examine this question indirectly using an aggregate, grocery store-level scanner data set from IRI.¹⁰ Although this data set does not distinguish between WIC and non-WIC sales, we use its panel structure and the slow adjustment after the WIC contract changes to identify the spillover effect.

The IRI InfoScan weekly scanner data set for 1997-1999 contains grocery store-level infant formula weekly prices, quantities, and other information by product item (Universal Product

Code or UPC). For our empirical analysis, we aggregate each store's powder formula products to two-week (biweekly) intervals, which smoothes random sales fluctuations and eliminates having observation periods in which a few stores have zero sales.

We use changes in the share of sales of the WIC contract winning firm during the sample period to identify the spillover effect. We restrict our sample to the seven states covered by the IRI data in which the WIC contract shifted from one firm to another during the sample period.¹¹ These states are located in the south, mid-west, and north east. Within those states, we have data for 11 cities of various sizes.¹²

The WIC program covers powder and liquid concentrate infant formula formats and, in a few states, the more expensive ready-to-use format. We report results for powdered infant formula, the least expensive form, which accounted for substantially more infant formula sales measured in reconstituted ounces during the 1997-1999 period than did the other physical forms (Oliveira et al., Figure 6.3, 2004). When we conducted the same analysis for concentrate, we observed qualitatively similar results though the spillover effects were larger.¹³

By necessity, we use data for only those stores for which we have information both before and after the WIC contract change. All stores carry the WIC-contract brand. In some stores, one of the non-contract national brands was not sold continuously in every period. We conclude that a store did not carry a brand if none of a brand's UPCs were sold in the store for at least three months. The non-contract brand most likely not to be carried was Carnation, which has the smallest share and the lowest price. A grocery is less likely to carry all three national brands if the store is small so that it has limited shelf space.

For simplicity, we report our analysis based on only stores that carried all three major national brands throughout the entire data period. This restriction reduces our sample of stores

from 65 to 39, but all of the cities are still represented. These 39 stores belong to 18 grocery chains, including national giants Kroger and Albertsons as well as local chains such as Randall's, Rainbow, and Shop N Save.

The 39 stores in our sample are located in 22 zip code areas. For each of the 39 stores, we matched the store zip code with zip code level demographic information from U.S. Census Bureau 2000 Summary Files 1 and 3. Table 1 provides summary statistics for demographic variables such as age, income, and education from the 2000 Census (accessible at "American FactFinder" on the Census Bureau's website). The last column shows the U.S. average. The median age and proportion of the population under five years of age (those children covered by the WIC program) are close to the U.S. averages. The sample contains people who are slightly more likely to be white, have slightly more education, and have higher incomes than the national averages. The fraction of families below the poverty level is only 5.5% in our sample compared to 9.2 nationally, but the local averages in our sample vary from 1.7% to 19.7%. These differences reflect which states changed WIC contract firms during our sample period and how IRI chooses grocery stores for its sample.

For each store, we calculate the quantity shares of the WIC contract winner, the loser (the firm that held the WIC the contract before losing it to the winner), and all other firms. Missouri is the only state that experienced more than one contract changeover during our sample period.¹⁴ For Missouri, we re-label the winner and loser after each contract change. The residual share of the other brands consists almost entirely of the share of the third national brand, but also includes sales by private labels and minor national brands. The shares of the winner, loser, and the others sum to one by definition. In our sample, 65% of the observations are from 30 stores in states

where Mead is the winner, 18% are from 7 stores where Ross is the winner, and the rest are from 13 stores where Carnation is the winner.

Price Predictions

The first price prediction—that the retail price would increase after the introduction of the WIC program—does not allow us to distinguish between the models. Retail prices rose faster than inflation immediately after WIC auctions were instituted (GAO, 1998), which is consistent with both models.

The second prediction concerning the whether the WIC bid price is above or below marginal cost. The price discrimination model predicts that the WIC bid price will be higher than the marginal cost, while the spillover model predicts that manufacturers' WIC bid prices will be very low and may be at or below marginal cost. According to the GAO (1998), the WIC price was within 2¢ to 13¢ of the marginal cost for milk concentrate formula in 1989 and 1990. In recent years, the size of the discount has grown substantially and has been as high as 98% off the wholesale price. State WIC agencies paid an average of 20¢ per can for milk-based concentrate formula in 2004, a savings of 93% off the wholesale price (GAO 2006b). This observation is consistent with the spillover model, but not with the price discrimination model.

The third prediction concerns the effect of winning the WIC contract on the winner's retail price. The price discrimination story suggests that the price would rise because the wholesale price would rise. However, as the wholesale price is set nationally annually, that outcome is unlikely. The spillover model is consistent with a constant or rising retail price.

We investigate whether WIC contract status affects the retail price and retail margins. The retail prices are from Information Resources Incorporated (IRI) grocery scanner data. We obtained average monthly wholesale prices of the three manufacturers for their milk powder

products during the same period from Economic Research Service, USDA. During the relevant period, the wholesale prices were adjusted upward annually in February each year (except Mead's wholesale price remained constant in February 1999).

Our retail margin measure is the Lerner index $L_{jst} \equiv (p_{jst} - w_{jt})/p_{jst}$, where p_{jst} is the retail price and w_{jt} is the national wholesale price for Brand j in Store s in Week t . Given the wholesale and retail price data, we are able to compute Lerner indexes for each store in each week for milk powder products. In most stores, the retail prices are relatively stable. Retail prices either remain constant throughout our data period or increase only once a year immediately after wholesale prices are adjusted upward in February. The retailer Lerner index averages 0.08, however, there are considerable brand level differences. Carnation's markup is about four times larger than that of Mead or Ross even though Carnation's retail price is considerably lower than those of the two large brands. We observe almost no change in the average Lerner indexes before and after contract changes.

We test whether a WIC contract change and WIC contract status affects retail margins within a general differences-in-differences framework. We focus on states where the WIC contract changed from one manufacturer to another during the data period in our sample. In each case, the stores faced constant wholesale prices during the sample period. We estimate

$$L_{jst} = \beta_0 + \beta_1 CC_{st} + \beta_2 WIC_{jst} + \beta_3 CC_{st} * WIC_{jst} + \beta_4 X_{jst} + \varepsilon_{jst},$$

where CC_{st} is a dummy variable indicating whether a WIC contract change occurred (it equals one after the contract changes and zero before the change), WIC_{jst} equals one if the firm is the WIC contract winner, and X_{jst} is a vector of brand, store, and week dummies.

We report the summary statistics of this regression in the first column in table 2. We report the Ordinary Least Square estimation results in the first column of table 3, and report the

coefficients and standard errors clustered at store level in the second column of Table 3. The Mead and Ross brand dummy coefficients are about -0.12, and are statistically significantly different from zero. The contract change dummy and the WIC brand dummy are not statistically significant in either specification, and once we use clustered standard errors to control for correlation of observations within a same store, the interaction term is not statistically significant either. Therefore, the results suggest that given wholesale prices, retailer markups are not higher for WIC brands during the entire data period, or for any of the WIC or non-WIC brands during the period after a WIC contract change, or for new WIC brands after they win the WIC brand status.

Bertrand, Duflo and Mullainathan (2004) pointed out that, in presence of positive serial correlation, differences-in-differences standard errors can be seriously underestimated hence resulting in falsely “significant” effect. They suggested dealing with a potential autocorrelation problem by collapsing the time periods in the data to get averages in the pre-change and post-change period, and then estimating. Using their approach, we find serious positive and significant first and second-order autocorrelation in the Lerner indexes. We therefore restrict our sample to an 8-week period before and after contract change in each store and then compute the average weekly retailer Lerner indices for each of the brands during the pre-change and post-change period respectively. Then we collapse the time periods in our sample and redid the regression. We report the summary statistics for the collapsed sample are reported in the second column of table 2, and the estimation results with both uncorrected standard errors and with clustered errors at market level in the last two columns of table 3. The results were very similar to those from the original sample, with none of the WIC brand dummy, the contract change

dummy or the interaction term between the two statistically significant, and both the brand dummies of Mead and Ross statistically significant and negative (around -0.13 for both of them). Because the collapsed sample focus on a relative short period (eight weeks) after a contract change, we interpret the estimation results as that at the time of contract change, retail markups are constant for all of brands, whether they win WIC brand status or not.

Therefore, we draw two conclusions from the price regression results. First, the retail Lerner indexes, and therefore retail prices for all brands (given constant wholesale prices), do not change at the time that a new contracts is issued. Hence, changes in retail prices cannot explain changes in market shares of the brands when WIC contracts change, which we will exploit in next section of share analysis. Second, retailers do not appear to charge a higher markup for WIC brands than non-WIC brands. This is probably because retail prices of infant formula are quite sticky and retailers only adjust retail prices when there is a change in wholesale prices, which are set nationally by manufacturers and not adjusted on a state basis.

Share Predictions

We can use grocery scanner data to investigate the market share predictions. First, we use simple summary statistics and plots to illustrate how market shares change after contract. Even without controlling for other factors, the three spillover model's market share predictions are obviously true. We then use a multinomial logit analysis to control for other factors and confirm these patterns.

Plots

Even a cursory examination of the data produces results that illustrate our stylized facts and are consistent with our theory. Panels a through d of figure 1 show the quantity shares for 20

biweekly periods before and 20 biweekly periods after the WIC contract changed for the winning firm, the losing firm, and the remaining firms (primarily the third national manufacturer). Panel a covers seven stores in Pennsylvania and Georgia where the WIC contract changed from Mead to Ross. Panel b summarizes results for 19 stores in Texas, Minnesota and Iowa where the WIC contract went from Ross to Mead. Panel c summarizes results for 11 Missouri stores when the WIC contract changed from Carnation to Mead. Panel d shows average shares in 11 Missouri stores and 2 Florida stores where the WIC contract shifted from Mead to Carnation.

Prediction four says that the winner's share should rise by the WIC purchases according to the price discrimination story and by more according to the spillover model. Prediction five says that the contract loser's shares should fall by a comparable amount. Prediction six says that adjustment should be immediate according to the price discrimination story and should take up to a year according to the spillover model.

These plots are consistent with the spillover model's predictions. All WIC participants must switch to the new WIC contract brand after a new WIC contract winner is announced. As they cannot buy and store substantial quantities of formula under the program, they need to switch brands within the first few weeks. Thus, the contract winner's share in the first few weeks reflects all the WIC participants and possibly some non-participants who switch. The losing firm's share falls by a comparable amount (and total volume remains constant). If the share of the contract winner continues to grow thereafter, the increase must be due to non-WIC consumers.

We'll describe these effects for panel a, where the contract changed from Mead to Ross, but the results are qualitatively the same in the other three panels. Immediately after the firm holding the WIC contract changes, the share of the new WIC contract winner increases substantially,

while the loser's share falls comparably. In panel a, the winner's (Ross's) share increased by about 20% from 40% one biweek period before the change to 60% two biweek periods after the change, while the loser's (Mead's) share fell by 19% from 50% to 31%. This change in shares immediately after the contract changes should include all the WIC purchases.

Consistent with the spillover model, but not with the price discrimination model, the shares of the WIC contract winner continued to increase gradually over time over the following weeks, while the shares of the losers decayed by comparable amounts. In panel a, for the period starting from two biweekly periods after the change (that is, after the initial spike) to 20 biweekly periods after the change, Ross's share rose from 60% to 69%, while Mead's share fell from 31% to about 21%. This adjustment period takes months, as the spillover model predicts. Consistent with both models' predictions, the share of the "other" brands, usually the third national brand and sometimes a private label, remains relatively stable before and after the change.

These shifts in brand shares before and after changes in WIC contract are not caused by changes in the demographic composition of the store's customers. We examined the aggregate consumer demographics for this store using the demographic information of the households who have purchased dairy products in these stores and could not find any significant changes in the demographics over the entire sample period.

In the pure price discrimination story, the changes in WIC-contract winner's share should equal that of the share of WIC participants in the market. If the change in the share exceeds the size of the WIC market, then we can conclude something besides price discrimination is at work, such as a spillover effect.

For these 23 stores, the average increase in the contract winner's share in the first biweekly period after the change is 18%. Similarly, the average increase by the twelfth biweekly period

(half a year) after the contract change is 57%. The corresponding average decrease in the contract loser's share is 13% and 57% respectively. Thus, the large adjustments we see in market share over the first half year following a contract change are consistent with a spillover model and not with the pure price discrimination hypothesis.

Multinomial Logit Analysis

To examine the causes of this shift in brand quantity shares more formally, we estimate a multinomial logit model. We report the summary statistics for the variables in table 4 and the multinomial logit coefficient estimates in table 5. The dependent variables are the shares of the WIC contract winner, the WIC contract loser, and other brands (primarily the third major manufacturer) at each store at biweekly intervals. The base share is that for the other-brands group. The explanatory variables include a dummy equal to one after the contract changes to capture the instantaneous effect of a contract change; a time trend starting at the contract change to capture the gradual spillover effect; store-level liquid milk sales to reflect the size of a store and to serve as a proxy for the available shelf space; demographic store-level variables, and state-level control variables.

The zip code level demographic variables for each store include median age; share of the population under five years old; the fractions of the population that are white, black, Asian, and Hispanic; median household size; median household annual income in 1999; the fractions of those 25 years old and older who have finished at least high school and those who have at least a bachelor degree; and the fraction of families with incomes below the poverty level.

We have two types of variables for each state. The state birth growth rate is the ratio of total number of live births in the state in each year to that in the previous year. It is included to capture

state-specific trends affecting the demand for infant formula. A state dummy variable is used to capture other possible state-specific effects.

We do not include prices as explanatory variables for three reasons. First, the store-level brand shares reflect both WIC and non-WIC sales in an unknown proportions. WIC participants do not pay for the infant formula, and hence should not be sensitive to the listed retail price. Thus, the relationship between price and share is not clear. Second, the retail prices are potentially endogenous (though, as we showed, they hardly change when the contract changes). Third, because the prices are relatively constant over our time period, they provide little explanatory power.

Table 5 shows the estimated multinomial logit. Other than the coefficients relating to the WIC contract, relatively few of the coefficients on the control variables are statistically significantly different from zero at the 0.05 level. A few of the state dummy coefficients are statistically significant as is the birth growth rate in the winner's equation and the high school diploma variable in the loser's equation. Thus, we do not find strong evidence that the demographic composition of the store's customers plays a major role in market shares.

Our first hypothesis is that, after the WIC contract changes hands, virtually all the WIC customers shift immediately to the contract winner at the expense of the loser. Were these customers to continue to buy their original brand, they would have to pay the full retail price; whereas if they switch to the new brand, they receive the formula at no cost. To capture this change of brands by WIC customers, the multinomial logit equation includes a WIC dummy. For each of the three leading firms, the WIC dummy is one for the firm during the periods in which it holds the WIC contract. For example in Texas effective October 1, 1998, Mead became the WIC contract winner replacing Ross. Hence, for a store in Midland, Texas, the WIC dummy for Mead

is zero before October 1, 1998 and one thereafter. The coefficient on this dummy reflects the transfer of WIC sales from the loser to the winner. To allow different degrees of brand loyalty among consumers, we include in the analysis brand dummies indicating which of the three firms held the WIC contract at the time and in the state.

As table 5 shows, in the winner's share equation, the WIC dummy coefficient is positive and statistically significantly different from zero at the 0.05 level. Neither of the brand dummies is statistically significantly different from zero, indicating that the identity of the firm that wins the contract is irrelevant.

Panels a through d of figure 2 show for a typical store the simulated quantity shares of the winner, the loser, and the other firms for 37 biweekly periods after the contract change, which is the maximum time actually observed after a change. All four panels show a large increase in the share of the winner and a corresponding drop in the share of the loser in the period immediately after the contract changes hands after controlling for other factors. The magnitudes are comparable to those of the corresponding unconditional share plots in figure 1.

Our second hypothesis is that non-WIC sales by the WIC contract winner will gradually increase over time offsetting losses by the former contract holder. To capture nonlinear spillover effects, we use the natural log of the number of biweekly time periods since the contract changed plus one (to avoid taking the log of zero before the change). We experimented with other nonlinear functional forms, such as a polynomial, and found similar adjustment patterns.

The coefficients on the log of the time trend are statistically significantly positive for the winner's share and statistically significantly negative for the loser's share. Consequently, the share of the winner rises and that of the loser falls over time, as our theory predicts.

The four panels in figure 2 show that the winner's share grows gradually but substantially over time, and the loser's share falls by roughly the same degree. For example, Panel a shows a simulation of the shares in a typical store when Ross wins the WIC contract from Mead. Initially when Mead held the contract, Mead's estimated share was 72% and Ross had only 17%. In the first post-contract change biweekly period, Ross's share rose to 34% while Mead's falls to 54%. Four weeks after the change, Ross's share is 50% and Mead has a share of 38%. Then, gradually over time, Ross's share rises another 28 percentage points until it reaches 78% after about year, while Mead's share gradually drops to 12% after a year. In short, our predictions about a spillover effect are strongly confirmed by the data. We find that the adjustment is gradual and lasts up to a year and that the total spillover effect is large.

Consistent with our third hypothesis, the simulated share of the other brands—primarily Carnation—is essentially unaffected by the WIC brand contract change. The qualitative patterns are the same but spillover effects are larger in the other simulation figures.

Other Experiments

We conducted several robustness checks to determine if the manner in which we restricted the sample affected our conclusions. We also experimented with additional explanatory variables.

We restricted our sample to those states in which the firm that held the WIC contract changed during the sample period and to those stores that carried all three national brands for virtually the entire sample period. Did these restrictions cause biases?

First, we looked at firms' shares in stores in states without a WIC contract change and did not observe any substantial changes that occurred in those states at the time that the WIC contract was awarded. We conclude that restricting the sample to only those states that had such

changes is consistent with our objective in determining the spillover effects of contract changes. Moreover, the major share effects that we find in our multinomial logit analysis are not due to the reissuing of the contract per se, but are due to the change in the firm that holds the contract.

Next, we conducted two robustness checks to see if restricting the sample to only those stores that carried all three national brands throughout the sample period might cause a systematic bias by affecting the demographic composition of customers. We estimated a probit model where the dependent variable equals one if the store had no sales of one of the three national brands for more than three months in a row and one otherwise. The sample covered all 145 stores located in both the states where contract changes had occurred and in those where there were no changes in the firm holding the WIC contract from 1997 to 1999.

Out of the 145 stores only 1 store ever had a gap in sales of the WIC brand for more than three months at the time. That store is relatively small. Eleven other stores had a gap of no sales of a non-WIC brand exceeding three months.

The explanatory variables in our probit include our average weekly sales of liquid milk (our proxy for the size of the grocery store) and various zip code area demographics: median age; percent of population under five years of age; percent the population that is white, black, Asian, and Hispanic; median household size; median household annual income in 1999; fraction of families under poverty level; fractions of the those people at least 25 years old who have finished at least high school and those who have at least a bachelor degree. The only variable for which we can reject the null hypothesis that its coefficient is zero at the 0.05 level is the store size proxy. A 1,000 ounce increase in average weekly milk sales in a store decreases the probability by 0.3% that the store did not sell one of the major three national brands for more than three months. Thus, apparently only store size determines whether a store fails to carry a particular

brand. In another word, by restricting our sample to only those stores that carry all three brands virtually all of the time, we might have excluded a few very small grocery stores.

Next, we repeated the analyses using all stores in states whether a contract change occurred and found virtually identical results for the contract winners and losers: an initial large change in shares and then further, gradual adjustment over time. Based on the results from the entire sample, we conclude that, although we may have oversampled larger stores, the bias on the spillover effect, if any, is likely downward. Presumably becoming the WIC brand is likely to increase coveted shelf space more in small stores. For instance, one relatively small store that was not in our restricted sample did not carry Mead products until it became the WIC brand.

We also conducted several experiments concerning additional explanatory variables. The fraction of poor people may have a nonlinear spillover effect. The spillover effect is clearly zero if no one or everyone in an area is in WIC. As more WIC participants shop at a store, the WIC shelf space effect increases, but there are fewer non-WIC people available to buy the product. Thus it is possible that the spillover effect first increases and then decreases as the share of poor people rises. However, when we included a square term to capture this nonlinear effect, its t-statistic was close to zero. One possible reason that we cannot capture a nonlinear effect is the fraction of the population that is poor does not vary substantially enough over the sample (see Tables 1 and 2).

Finally, we included interactions between our time trend variable and the fraction the state birthrate relative to that in 1996 and with our grocery store size proxy. The first interaction term allowed for the possibility that the rate of adjustment in the contract winner's share might vary with an acceleration in birthrates since the 1996 base year. The second interaction term allows for the possibility that smaller stores allocate relatively large amounts of shelf space to the WIC

contract winner so that the spillover effect is relatively large in small stores. However, neither interaction term is statistically significant.

Conclusions

We examined the effects of the states' sole-source WIC infant formula rebate program on infant formula brand prices and quantity shares. Individual states or small group of states hold auctions for a WIC contract to be the exclusive provider of WIC infant formula for several years (typically three). All three major infant formula manufacturers then compete for non-WIC customers at grocery stores.

Most previous studies have tried to explain the behavior of the manufacturers using a standard price discrimination model. Instead, we hypothesize that the firms bid aggressively for WIC contracts because the winner benefits from a spillover effect in the non-WIC retail market. Grocery stores provide relatively large amounts of shelf space to the WIC contract winner. Non-WIC customers infer that the WIC brand is superior and are more likely to buy it, though this adjustment takes time as new families enter the market.

The data are more consistent with the spillover model than the price-discrimination model. The three major manufacturers set their wholesale prices (which determine both the retail level price and the size of the rebate that they provide to states) once a year at a national level. Thus, firms cannot be price discriminating on a state-by-state basis.

We are able to examine how the actual (not estimated) retail markup varies with the WIC contract. Our results show that retailer markups for any of the national brands do not change at the time of contract changes, so price changes are unlikely to explain shifts in shares. Furthermore, retailers do not charge a higher markup for WIC brands than for non-WIC brands.

Although retailers do not seem to charge higher markups for WIC brands, we find suggestive evidence that retailers are more likely to carry a WIC brand than a non-WIC brand when shelf space is limited. Therefore, increased shelf space allocation may be a potential mechanism for the spillover effect.

The pattern of market share adjustments over time is consistent with the spillover model and not with the price-discrimination model. Both models predict that the WIC participants should switch to the new WIC contract winner's brand immediately after the contract changes brands. However, only the spillover model predicts large increases in the contract winner's share over many months, which is what we observe. This additional growth in the winner's share reflects non-WIC customers switching to the WIC contract brand due to a spillover effect. This switch takes time because it only occurs when customers with new babies enter the market: current customers stick to their traditional brand, but new customers are more likely to buy the WIC contract winner brand, which has more shelf space in stores.

This pattern of adjustment is strongly shown by both simple plots and a formal statistical analysis. Immediately after a firm wins the WIC contract, its share jumps substantially (e.g., by a quarter of the total market). Then, a gradual adjustment period occurs that may last the better part of a year. Over this period, the WIC contract winner's share increases by more—often by much more than the initial jump. Because a typical WIC contract lasts three years, a contract winner could enjoy over two years of a dominant share among the non-WIC consumers.

Consequently, firms are willing to place very low bids to win the WIC contract according to the spillover model. The WIC price should be above the marginal cost according to the price-discrimination story, whereas the WIC price might be near or below marginal cost in the spillover model. We observe gigantic discounts to WIC agencies, averaging 94% less than the

wholesale price in one year and approaching 98% in some states. Thus, the observed extremely low WIC bids are consistent with the spillover model rather than the price discrimination model.

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Table 1. Demographics for the Zip Codes of the 39 Stores in the Sample

	<i>Mean</i>	<i>Std dev</i>	<i>Min</i>	<i>Max</i>	<i>U.S. average</i>
Median Age	35.8	2.7	29.9	42.3	35.3
Population under 5 Years (%)	7.0	0.9	5.4	9.8	6.8
White (%)	81.0	16.1	39.9	97.2	75.1
Black (%)	11.9	14.0	0.6	43.4	12.3
Asian (%)	1.9	1.2	0.4	5.8	3.6
Hispanic or Latino (%)	7.9	11.0	0.7	50.2	12.5
At Least High school Graduate* (%)	86.6	7.4	61.7	93.8	80.4
At Least Bachelor's Degree* (%)	27.8	10.7	10.4	49.9	24.4
Average Household Size	2.5	0.2	2.31	2.86	2.59
Median Household Income in 1999 (\$1,000)	47.5	9.4	27.4	67.6	42.0
Families Below Poverty Level (%)	5.5	4.1	1.7	19.7	9.2

* Of those at least 25 years old.

Table 2. Summary Statistics for Retailer Lerner Index Regressions

	original sample	collapsed sample	min	max
Retailer Lerner Index	0.074 (0.070)	0.084 (0.076)	0	0.298
contract change dummy	0.466 (0.499)	0.508 (0.501)	0	1
WIC brand dummy	0.364 (0.481)	0.339 (0.474)	0	1
Mead brand dummy	0.318 (0.466)	0.302 (0.460)	0	1
Ross brand dummy	0.363 (0.481)	0.341 (0.475)	0	1
# stores	70	70		
observation	24509	434		

Table 3. Retailer Lerner Index Regressions

Dep. Variable	original sample		collapsed sample	
Retailer Lerner Index		Std. error.		Std. error
	OLS	clustered at store	OLS	clustered at market
contract change dummy	-0.001 (0.001)	-0.001 (0.003)	0.002 (0.005)	0.002 (0.004)
WIC brand dummy	0.000 (0.001)	0.000 (0.005)	0.009 (0.006)	0.009 (0.013)
Contract change*WIC brand dummy	0.004*** (0.001)	0.004 (0.005)	0.000 (0.009)	0.000 (0.011)
Mead brand dummy	-0.121*** (0.001)	-0.121*** (0.007)	-0.131*** (0.005)	-0.131*** (0.024)
Ross brand dummy	-0.120*** (0.001)	-0.120*** (0.007)	-0.132*** (0.005)	-0.132*** (0.022)
Constant	0.152*** (0.006)	0.152*** (0.005)	0.165*** (0.004)	0.165*** (0.015)
store dummies	Y	Y		
week dummies	Y	Y		
Observations	24509	24509	443	443
R-squared	0.785	0.785	0.673	0.673

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4**Summary Statistics for Variables Used in the Multinomial Logit Analysis**

	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
Share of winner	0.410	0.315	0.000	0.991
Share of loser	0.474	0.309	0.000	1.000
Share of others	0.116	0.103	0.000	0.676
Log(1 + number of biweekly periods since contract awarded)	1.228	1.404	0.000	3.638
Contract Effective Dummy (1 if new firm has contract)	0.470	0.499	0.000	1.000
WIC brand is Mead in the store/biweek (dummy)	0.537	0.499	0.000	1.000
WIC brand is Ross in the store/biweek (dummy)	0.355	0.479	0.000	1.000
Average weekly liquid milk sales (1,000 ounces in 1999)	14.436	9.506	5.231	46.143
Georgia	0.130	0.336	0.000	1.000
Missouri	0.286	0.452	0.000	1.000
Pennsylvania	0.052	0.222	0.000	1.000
Texas	0.194	0.396	0.000	1.000
Minnesota	0.052	0.222	0.000	1.000
Iowa	0.234	0.423	0.000	1.000
Birth growth rate in the state	1.013	0.031	0.973	1.104
Median age in the zip code area	35.824	2.693	29.900	42.300
Population under 5 years old (%)	6.962	0.925	5.400	9.800
White (%)	81.209	15.947	39.900	97.200
Black (%)	11.839	13.931	0.600	43.400
Asian (%)	1.706	1.108	0.400	5.800
Hispanic, of any race (%)	7.805	10.905	0.700	50.200
At least high school graduate* (%)	86.568	7.364	61.700	93.800
At least bachelor degree* (%)	27.490	10.292	10.400	49.900
Median household size	2.504	0.160	2.310	2.860
Median household income in 1999 (\$1,000,000)	0.475	0.093	0.274	0.676
Families under poverty level (%)	5.468	4.082	1.700	19.700

Note: Number of observations = 3,001

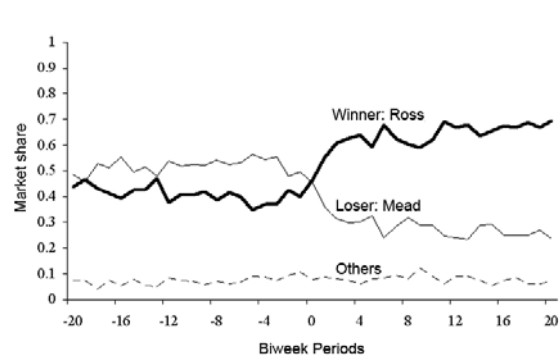
* Of those at least 25 years old.

Table 5. Multinomial Logit Estimation Results

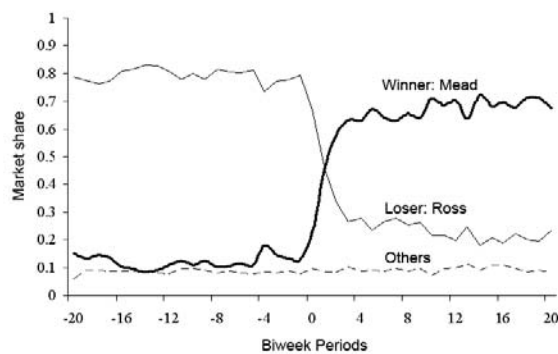
	<i>Winner's share</i>	<i>Loser's share</i>
Constant	-24.269 (44.518)	-44.826 (43.966)
Log(1 + number of biweekly periods since contract awarded)	0.369 (0.123)	-0.425 (0.135)
Contract Change Dummy (1 if new firm has contract)	0.855 (0.340)	-0.216 (0.354)
WIC brand is Mead in the store/biweek	-0.035 (0.214)	-0.197 (0.202)
WIC brand is Ross in the store/biweek	-0.548 (0.288)	-0.094 (0.285)
Average weekly liquid milk sales (in 1,000 ounces in 1999)	-0.031 (0.012)	-0.040 (0.011)
Missouri	0.843 (1.149)	0.303 (1.118)
Pennsylvania	2.995 (0.836)	3.083 (0.807)
Texas	0.032 (1.178)	-0.804 (1.150)
Minnesota	2.334 (1.322)	1.549 (1.275)
Iowa	1.335 (1.135)	0.257 (1.101)
Birth growth rate in the state	-23.101 (5.798)	7.493 (5.723)
Median age of population	0.114 (0.158)	0.112 (0.150)
Population under 5 (%)	0.362 (0.567)	0.559 (0.545)
White (%)	0.264 (0.406)	0.047 (0.400)
Black (%)	0.261 (0.405)	0.044 (0.399)
Asian (%)	0.597 (0.596)	0.064 (0.584)
Hispanic (of any race) (%)	0.240 (0.235)	0.085 (0.232)

High school diploma or more education for population 25 years and older (%)	0.221 (0.131)	0.337 (0.127)
Bachelor degree or above in the population 25 years and older (%)	-0.060 (0.036)	-0.038 (0.034)
Median number of household members	-0.555 (3.322)	1.626 (3.235)
Median household income in 1999 (in \$1,000,000)	-0.075 (0.088)	-0.146 (0.087)
Families under the poverty level (%)	0.083 (0.159)	0.202 (0.155)

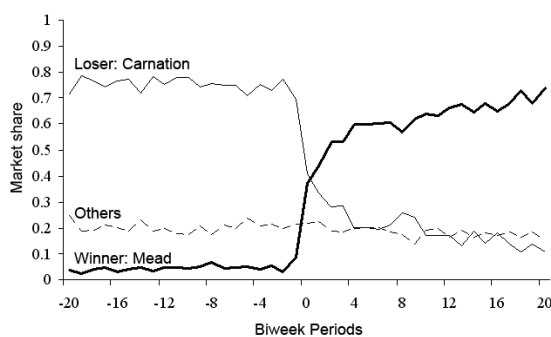
Notes: Numbers in parentheses are the asymptotic standard deviations. A bold font indicates that the null hypothesis that the coefficient is zero is rejected at the 0.05 significance level. There are 3,001 observations is 3,001. The log likelihood is -2,246. The χ^2 is 1,327 with 46 degrees of freedom.



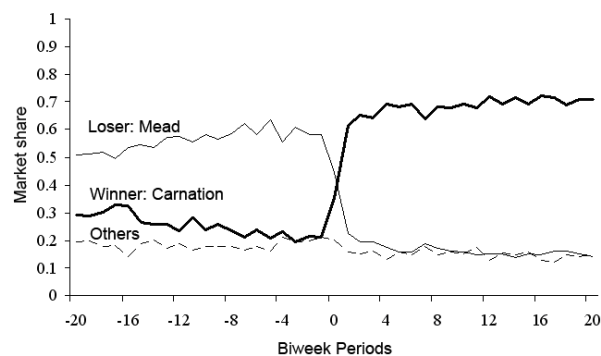
a. 7 Pennsylvania and Georgia Stores



b. 19 Texas, Minnesota, and Iowa Stores



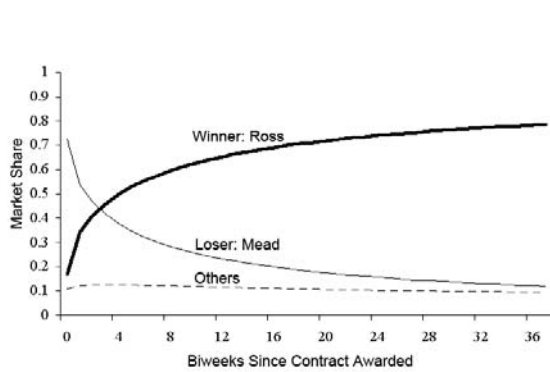
c. 11 Missouri Stores



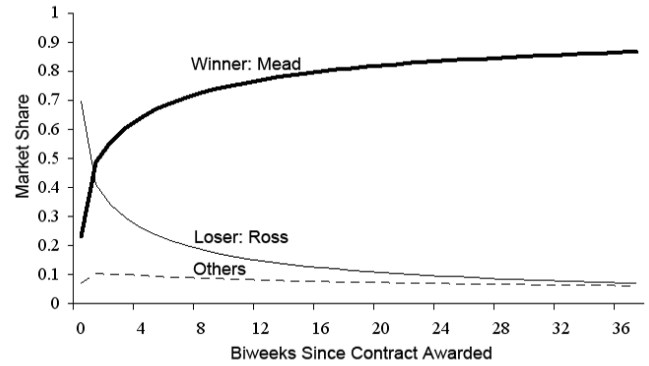
d. 13 Missouri and Florida Stores

Figure 1. Observed quantity shares

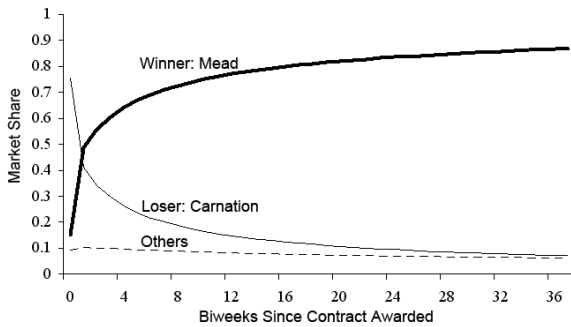
Note: Biweek zero is the biweek period when the contract change occurred. In biweek zero the contract loser still holds the contract, and the contract change occurs in biweek one. Biweek $-t$ is t biweekly periods ($2t$ weeks) before the contract change, while biweek t is t biweeks after the contract change.



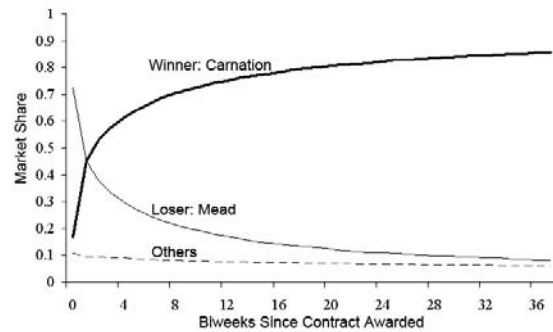
a. Ross Winner, Mead Loser



b. Mead Winner, Ross Loser



c. Mead Winner, Carnation Loser



d. Carnation Winner, Mead Loser

Figure 2. Simulation of quantity shares in a typical store

¹ For example, Hal Varian, www.wwnorton.com/mip/ime/varian/24a.htm, discusses a price-discrimination model where the removal of the low-income consumers from the out-of-the-pocket-market results in higher non-WIC price. Similarly, Post and Wubbenhorst (1989) argued that WIC vouchers make WIC consumers price insensitive so that the overall demand is much

less price sensitive hence profit-maximizing retailer raise their price. Oliveira et al. (2004, pp. 2-3) report this conclusion.

² The GAO report's logic was that, if the spillover effects were sufficiently large, then they would have resulted in enough increases in non-WIC wholesales prices so that the manufacturers' revenue would remain the same with or without rebates in effect. These researchers further assumed that, were there no rebates, the wholesales prices would have increased at the same rate as prices in pharmaceutical industries. The researchers used the observed rebates that the manufacturers offered, as well as WIC and non-WIC quantities, to compute the hypothetical wholesales prices that would have kept the revenue of the manufacturers equal to what would have been were there no rebates. The hypothetical wholesales prices thus calculated are much greater than the actual observed wholesales prices with rebates in effect. Consequently, the GAO report concluded that the spillover effects did not generate "adequate" increases in prices.

³ Conceivably, the manufacturers could divide the states in which they win the WIC contract in such a way that setting the wholesale price nationally to allow them to optimally price discriminate. They could do that by colluding, by using a mixed strategy in their bids such that they win an expected number of states, or by bidding in such a way that firms win in different types of states. Collusion is unlikely for three reasons. First, WIC contracts change regularly across firms, which is inconsistent with the usual freezing of shares in a cartel. For example, according to our fairly small samples for the late 1990s, the contract changed from Ross to Mead in states with relatively low retail prices and changed in the other direction in states with

relatively high retail prices, as we show later in the paper. Second, it is implausible that a cartel would charge the extremely low WIC prices. Third, Carnation charges much lower prices than the other two firms for a homogenous good, which is probably inconsistent with a cartel story.

⁴ Corts (1998) and others have solved for the oligopoly price-discrimination equilibria, which differ from the monopoly price-discrimination equilibrium. However, as this market is not properly described as one of price discrimination, we do not discuss these oligopoly price-discrimination models further.

⁵ Prell (2005) is the only formal analysis of WIC that incorporates a spillover effect. He considers the demand for a WIC brand and non-WIC brand carried by a representative retailer and solves for the equilibrium retail prices assuming the retailer takes wholesales prices as given. He provides some simulation results but does not estimate the spillover effect. In contrast, our model abstracts from the retailer's behavior and focuses on the manufacturer's decisions when there is a spillover effect.

⁶ In its suit against Gerber, Beechnut alleged that Gerber engaged in predatory pricing by bidding below cost for WIC contracts in California, Nevada, and Texas (Sally C. Pipes, "Fight Over Baby-food Vouchers," *Sacramento Bee*, March 18, 2004). It further asserted that the WIC monopolies generated so much demand for Gerber cereals that grocery chains dropped other brands or gave them inferior placement on shelves. As a consequence, Beechnut was essentially forced out of Texas and faced plummeting sales in Nevada and California.

⁷ Alternatively, suppose that there are two firms and the non-WIC demand curve facing Firm j is $Q_j = a_j - b_j p_j + d_j p_k$, where p_k is the price of the other firm. In addition, the winning brand sells N units for WIC participants. If the spillover effect causes a_j to rise or b_j to fall, then the Nash-Bertrand equilibrium price of both firms rise, but the contract brand's price will rise by more. If the increase in the contract winner's demand parameter is offset by a decrease in the loser's parameter, then the winner's price rises and the loser's falls.

⁸ See, for example, bottle-feeding-baby.com/what-baby-formula-milk-to-use.php and Rhode Island University's Cooperative Extension's nutritional education program site:

[www.uri.edu/ce/efnep/Infant percent20Feeding percent20p.10 percent20Choosing percent20A percent20Formula.htm](http://www.uri.edu/ce/efnep/Infant%20Feeding%20p.10%20Choosing%20A%20Formula.htm).

⁹ Both theories make the same prediction that the shares of the other firms remain constant. In the spillover model, the minor brands' shelf space is unaffected by the change involving the winner and loser of the WIC contract.

¹⁰ Our data set consists of grocery store sales of infant formula. In some states, WIC-only stores sell only WIC authorized products to WIC participants. Consequently, they cannot exhibit any spillover effect to non-WIC customers. Although WIC-only stores have been growing rapidly recently, during the period we examine, 1997 to 1999, WIC-only stores are believed to have accounted for at most a tiny share of the WIC products market. We do not have any numbers for our period, however, even by 2000, there were fewer than 15 WIC-only stores across all states

except California (303), Florida (78), and Texas (89). Texas and Florida are in our sample, but California is not.

¹¹ The seven states are Georgia, Missouri, Pennsylvania, Texas, Minnesota, Iowa, and Florida. In Georgia, Ross replaced Mead as the WIC supplier effective from August 1, 1998. Ross also replaced Mead in Pennsylvania two months later. Mead took over the contract with the alliance of Texas, Minnesota, and Iowa from Ross on October 1, 1998. In Florida, Carnation became the winner in February 1, 1999, replacing Mead. Two contract changes took place in Missouri, the WIC supplier changed from Mead to Carnation and to Mead again. The first change occurred on October 1, 1997, and the second on October 1, 1998.

¹² Atlanta; Cedar Rapids, Iowa; Houston; Kansas City, Missouri; Midland, Texas; Minneapolis/St. Paul; Philadelphia; Pittsburg; Rome, Georgia; St. Louis; Tampa/St. Petersburg.

¹³ Most states issue ready-to-use (RTU) infant formula only to WIC participants with specific conditions, such as unavailability of sanitary water supply or lack of the ability of the caretakers to dilute formula, or unavailability of comparable substitute in other format, so relatively few people are affected. We do not know which firm provides RTU infant formula through WIC in most states. Even if we had this information, we could not conduct an analysis similar to that for powder because most stores fail to carry at least one of the major brands for extensive periods.

¹⁴ Missouri went through two contract changes during the sample period. The first change became effective on Oct. 1, 1997, when Mead replaced Carnation. This contract was one year

long with two one-year renewal options, according to our conversation with Annie Siu-Norman, a veteran consultant at the WIC agency in Missouri. The WIC agency at Missouri chose not to renew the contract after one year and opened bids again in July 1998. Carnation won the contract back from Mead, and this change was effective on Oct. 1, 1998.

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Food Marketing Policy Center
1376 Storrs Road, Unit 4021
University of Connecticut
Storrs, CT 06269-4021

Tel: (860) 486-1927
FAX: (860) 486-2461
email: fmprc@uconn.edu
<http://www.fmprc.uconn.edu>