Buyer Alliances as Countervailing Power in WIC Infant-Formula Auctions

Abstract

State WIC agencies in infant-formula procurement auctions receive lower bids and final prices when they are in buyer's alliances than when they are unallied. The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) uses an auction to procure infant formula. Manufacturers bid on the right to be an agency's sole supplier by offering a rebate on formula sold through WIC. A theoretical model of rebates shows that bidders may shade their bids and extract surplus from agencies. An empirical estimation shows that bids are lower to alliances suggesting that alliances countervail the power of bidders to extract surplus.

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Introduction

State agencies in Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) infant-formula procurement auctions receive lower bids and final prices when they are in buyer's alliances than when they are unallied. There are several potential explanations for price discounts to large, allied, buyers. Fixed marketing or distribution costs may be spread over more units when buyers are large and prices may consequently be discounted. Davis (forthcoming) shows that suppliers experience large and profitable increases in sales to non-WIC customers when contemporaneously supplying WIC customers and large allied agencies may receive lower bids if fixed-marketing costs are important. Some research has shown that large-buyer discounts may result if there are economies of scale in production (Horn and Walinsky 1998, Chipty and Snyder 1999, and Chae and Heidhues 1999a, 1999b). Scale economies seem unlikely to affect bidding in infant-formula auctions because WIC contracts are relatively short and it seems doubtful that short-term contracts would elicit bids reliant on long-run increases in scale.[1] Relatedly, buyer's alliances may be a source of countervailing power. WIC agencies procure infant formula from a small number of suppliers and buyer alliances may better position small agencies when offering contracts to oligopolistic sellers. Some theoretical and empirical research suggests that buyers may receive price discounts if sellers compete more vigorously for large buyers (Snyder 1996, 1998; Ellison and Snyder 2010, DeGraba 2003).

To my knowledge, all previous empirical investigations of countervailing power have examined buyer-size effects when transactions are negotiated between buyer and seller. This paper extends that literature and contemplates buyer size effects in an auction setting. I estimate a reduced form equation for bids and control for buyer size. I find only weak evidence that bids

[1]WIC typically offers contracts for three year periods. Contracts can be extended only if both parties agree to an extension.

are inversely related to buyer size - consistent with the theory that fixed marketing costs spread over more units result in lower bids. Apart from this effect, I find that when buyers join an alliance, they receive lower bids than when unallied. I interpret this latter effect as a countervailing power effect resulting from enhanced competition among bidders.

Background

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a food assistance program administered through the US Department of Agriculture Food and Nutrition Service (FNS) that annually supplies grants to states to provide supplemental foods, and a variety of services to low-income women, infants, and children up to age five. Infant formula is a food item supplied to infants less than one year old and WIC purchases are over 50 percent of total US sales (Oliveira et al., 2011).

Infant formula is provided to participants in an unusual arrangement between state WIC agencies, retailers, and infant formula manufacturers. To control costs, agencies use an auction mechanism that grants a manufacturer the exclusive right to market to WIC customers. In exchange for the exclusive right to sell to WIC customers, the manufacturer pays WIC a rebate on each unit of its infant formula sold to WIC customers. Infant formula is dispensed through approved retailers where WIC participants purchase with vouchers. Manufacturers reimburse agencies based on the number of units bought with vouchers and the agreed rebate.

Manufactures compete for the right to be an agency’s sole supplier in infant formula rebate auctions. Agencies offer contracts for a period of about 3 years and manufactures submit sealed-bids in the form of rebates. The contract winner is the firm that submits the lowest weighted net-price bid, wholesale price minus rebate, where weights are the proportions of the various formula types typically bought by participants served by the agency.

A few states in the 1980s devised the current auction format and it has evolved to become the near universal method for agencies to procure infant formula. An important development in its evolution is the practice of some agencies joining together in an "alliance" to jointly offer contracts. Very little is known about agencies' motivations to form alliances, but likely candidates include the desire to garner more favorable bids by aggregating demand or reducing bidding costs.[2]

The infant formula market is highly concentrated, with three manufacturers (Mead Johnson, Ross, Carnation) producing about 98 percent of domestic sales (Oliveira, Frazao, and Smallwood 2010). In rebate auctions at most 4 manufacturers have bid for competitive contracts and in many auctions only 2 manufacturers bid.[3] The bidding environment seems less than ideal for rigorous competition and Davis (forthcoming) estimates that manufacturers shade their bids in WIC rebate auctions 24 to 50 percent. It seems alliances may form to provide agencies "countervailing power" when auctioning contracts to a small number of oligopolistic suppliers.

There is an extensive literature on countervailing power, but each paper investigates the commonly held proposition that large buyers receive lower prices than small buyers because large buyers are better able to counter the market power of large sellers. While the notion is intuitively appealing and taken for granted in some circles, the economics literature has sought to understand the conditions under which it might occur. Papers focusing on the supply side include DeGraba (2005) which shows that if sellers are risk averse then large buyers receive lower prices. Chipty and Snyder (1999) show that buyer size effects depend on the shape of the seller's gross surplus (profit) function. Buyers benefit when seller's surplus function is concave implying

[2] The Western States Contracting Alliance (WSCA) states, "The objective of this cooperative group is to obtain volume price discounts based on the collective volume of the numerous potential purchases by the individual WSCA States Agencies."
[3] Wyeth is a fourth firm that was active in WIC infant formula auctions until the mid-1990s.

that marginal costs are increasing. Chipty (1995) examines the marginal cost of large buyers of cable TV programming and finds them lower than marginal costs of small buyers owing to superior bargaining power rather than scale economies. Chae and Heidues (2004) use a two-person bargaining game to show that some risk-averse buyers will be bolder in negotiations when allied with other buyers. Snyder (1996; 1998) shows that sellers are likely to compete more aggressively for large buyers. In Snyder's models sellers tacitly collude and equilibrium prices are above marginal cost to the typical buyer. But sellers compete more vigorously for large buyers because the penalty from defecting is relatively small compared to the profit gained from the large buyer. Sellers will lower price to prevent undercutting.

Manufacturer's surplus and optimal bids

Infant-formula manufacturers potentially derive profit from selling to WIC customers and non-WIC customers. For brevity, I call infant-formula manufacturers firms and state agencies/alliances agencies. Firms sell in local markets that coincide with the state or states served by an agency. Firms' bidding decisions are based on potential WIC contracts with agencies.

I follow the model in Davis (forthcoming) that includes a potential spillover effect because prior research suggests that holding the WIC contract increases sales to non-WIC customers (GAO, 1998; Huang and Perloff 2007; Oliveira et al. 2011).[4] I represent firm m's share as $s_{m,i}^{*}$ when holding the WIC contract and $s_{m,i}$ when not holding the contract. Non-WIC demand to firm m is $Q_{m,i}^{N}$ which equals $s_{m,i}^{*}Q_{i}^{N}$ if the firm holds the WIC contract and $s_{m,i}\,Q_{i}^{N}$ otherwise, where Q_{i}^{N} is total non-WIC demand in market i. I let $\rho_{m,i}$represent the probability that

[4] A spillover is thought to occur because WIC represents 50 percent of sales and so the WIC brand is likely dominantly displayed on store shelves leading to increased sales to non-WIC customers relative to non-WIC brands. Doctors may also be more likely to recommend the WIC brand to non-WIC mothers.

firm m wins auction i, such that $\rho_{m,i} = Prob(j = m|\widehat{np})$ where $\widehat{np}$ is a vector of firm m's expected own-net price bid and the expected bids of rivals, which are a function of observable auction characteristics, $\widehat{np} = \widehat{np}(x)$. Expected non-WIC demand can be summarized as $Q_{m,i}^N = (s_m + \theta_m\rho_{m,i})Q_i^N$, where $\theta_m = (s_m^* - s_m)$ is a spillover effect. If Q_i^W represents demand from WIC customers, then total demand can be written $Q_{m,i}^N + Q_{m,i}^W = (s_m + \theta_m\rho_{m,i})Q_i^N + \rho_{m,i}Q_i^W$.

Firms chose a national wholesale price (p), but rebates are agency specific. I assume p is predetermined when firms determine rebates because wholesale prices and rebates are not determined simultaneously (Oliveira and Davis, 2006). Firms bid for profitable contracts if acquiring a contract does not extend production beyond capacity. Profit from agency i is

(1) $$E[\pi_i] = (p - c_i)(s + \theta\rho_i)Q_i^N + (p - r_i - c_i)\,\rho_i Q_i^W,$$

where c_i is the constant marginal cost of supplying agency i.[5] Let $np_i = (p - r_i)$ represent net price and since p is predetermined choosing np_i is equivalent to choosing r_i and the first-order condition is

(2) $$\frac{\partial E[\pi]}{\partial np_i} = \theta(p - c_i)Q_i^N\omega_i + \rho_i Q_i^W + (np_i - c_i)Q_i^W\omega_i = 0,$$

where $\omega_i = \frac{\partial\rho_i}{\partial np_i} < 0$ is the change in the probability of winning an auction from a change in bid. Rearrange 2 to get the optimal net price to bid to agency i,

(3) $$np_i = c_i + v_i - \theta(p - c_i)\frac{Q_i^N}{Q_i^W} = c_i + v_i - \theta\frac{pQ_i^N}{Q_i^W} + \theta c_i\frac{Q_i^N}{Q_i^W},$$

where $v_i = -\frac{\rho_i}{\omega_i}$.

The optimal net price equals the marginal cost of supplying agency i, adjusted higher by v_i, which measures the firms bid shade (Crespi and Sexton 2005; Davis forthcoming). Bids are adjusted lower by the additional profits earned from non-WIC customers per unit sold to WIC

[5]Constant marginal cost to agency i does not necessarily imply a constant marginal cost in production.

participants (i.e., $\theta(p - c_i)\frac{Q_i^N}{Q_i^W}$) which are earned only if firm m holds the WIC contract. Note that $\frac{pQ_i^N}{Q_i^W}$ is revenue, per-unit of WIC demand, earned as a consequence of holding the WIC contract. I expect firms to bid more aggressively for markets with larger per-unit revenues, ceteris paribus. In contrast, $\frac{Q_i^N}{Q_i^W}$ in equation 3 is correlated with the total cost of non-WC demand, per-unit of WIC demand, and I expect net price bids to increase with this variable, when holding revenues constant.

Equation 3 shows that bidders must estimate the competitiveness of auctions in order to formulate their bids to include the appropriate bid shade, $\boldsymbol{v_i} = \boldsymbol{v}(\widehat{\boldsymbol{np}}(\boldsymbol{x}))$. Allowing that fixed marketing or bidding costs may affect bids (denoted f_i), equation 3 can be rewritten in general form as

$$(4) \qquad np_i = np\left(c_i, f_i, x_i, \frac{pQ_i^N}{Q_i^W}, \frac{Q_i^N}{Q_i^W}\right).$$

I assume firms' production costs are a function of aggregate demand in all markets they serve, $c\big((s + \theta\Gamma)Q^N + \Gamma Q^W\big)$, where c(■) is twice differentiable and Γ is the proportion of all markets in which firm m holds the WIC contract. Furthermore, c(■)→∞ as $\big((s + \theta\Gamma)Q^N + \Gamma Q^W\big) \rightarrow Q'$, where Q' is a short-run capacity constraint. The firm will bid for a contract as long as the expected increase in output does not violate the capacity constraint, $\big((s + \theta\Gamma)Q^N + \Gamma Q^W\big) + \rho_i\left((\theta Q_i^N) + Q_i^W\right) < Q'$, and the expected profit from bidding is greater than not bidding, $\rho_i\left((p - c_i)\theta Q_i^N + (np_i - c_i)\, Q_i^W\right) > 0$.[6]

[6] I implicitly assume the firm is bidding for a market in which they do not currently hold the WIC contract. If the firm holds the contract in the market it seems unlikely that reacquiring the contract would exceed the capacity constraint.

Bid shading

In general, bid shading implies a bidder is willing to trade a decrease in winning probability in exchange for surplus when the bidder wins. In this model the bid shade relates to the firm's assessment of auction competitiveness. The numerator is the firm's assessment of the probability of winning and the denominator is the change in probability from a change in bid (Crespi and Sexton, 2005). To see that the numerator measures auction competitiveness, suppose hypothetically that bidders naively assess their winning probability according to a discrete uniform distribution. Then ρ declines as the number of bidders increases as the auction becomes more competitive. ρ is inversely related to bidders' assessment of auction competitiveness. In general, ρ is inversely related to each firm's estimate of auction competitiveness.

Likewise the denominator reflects competitiveness. If ω is large, a given change in bid is expected to lead to a large change in the probability of winning. The auction is assessed to be competitive since a decrease in bid will greatly increase the chance of winning and the firm will shade only slightly. In more competitive markets small price-changes lead to large (inverse) changes in quantity demanded. In more competitive auctions small bid-changes lead to large (inverse) changes in the expected probability of winning. If ω is small, then a large increase in bid only slightly decreases the probability of winning. The firm can shade a lot and decrease their expected probability of winning only slightly – the auction is not very competitive.

Buyers' incentives

Alliances are likely to form to share the cost of administering an auction or in anticipation of lower net-prices. Equation 3 suggests necessary conditions for alliances to form based on bids. If the subscript i+j denotes an alliance between agency i and j, then for an alliance to form between i and j, and for both to anticipate lower net prices post-alliance, then

(5) $$\left(c_{i+j} - c_i\right) + \left(v_i - v_{i+j}\right) + \theta\left[\left(\left(p - c_i\right)\frac{Q_i^N}{Q_i^W}\right) - \left(\left(p - c_{i+j}\right)\frac{Q_{i+j}^N}{Q_{i+j}^W}\right) + \right] < 0$$

and

(6) $$\left(c_{i+j} - c_j\right) + \left(v_i - v_{i+j}\right) + \theta\left[\left(\left(p - c_j\right)\frac{Q_j^N}{Q_j^W}\right) - \left(\left(p - c_{i+j}\right)\frac{Q_{i+j}^N}{Q_{i+j}^W}\right)\right] < 0.$$

Inequalities 5 and 6 suggest that agencies consider three elements when contemplating an alliance – post-alliance costs and profitability, and post-alliance bid shades. It seems reasonable that agencies expect bids to an alliance to be a weighted average of each agency's bid in absence of an alliance. So, if $c_{i+j} < c_i$ then $c_{i+j} > c_j$ All else constant, alliances should not form solely based on expected lower marginal costs since at least one agency expects the weighted average cost to increase and consequently expect a higher net price bid post-alliance. Similarly, if $\left(\left(p - c_i\right)\frac{Q_i^N}{Q_i^W}\right) < \left(\left(p - c_{i+j}\right)\frac{Q_{i+j}^N}{Q_{i+j}^W}\right)$ then $\left(\left(p - c_j\right)\frac{Q_i^N}{Q_i^W}\right) > \left(\left(p - c_{i+j}\right)\frac{Q_{i+j}^N}{Q_{i+j}^W}\right)$ and alliances should not form solely based on a change in profitability. However, it seems reasonable that $\left(v_i > v_{i+j}\right)$ and $\left(v_j > v_{i+j}\right)$ if agencies expect less bid shading to an alliance compared to each agency individually. In this sense, alliances form to acquire countervailing power.

Of course an agency might join an alliance expecting, for example, that the price increasing effect of higher marginal costs would be more than offset by the decreasing effect of higher profitability. Or, alliances may form simply to share the cost of administering a contract. The point is not to exhaust all possible explanations for alliances, but to note that countervailing power is a (perhaps compelling) motivation.

Empirical model

I assume a linear relationship between variables and rewrite equation 4 as

(7) $$np_i = c_i + f_{\boldsymbol{i}} + \beta_1\frac{pQ_i^N}{Q_i^W} + \beta_2\frac{Q_i^N}{Q_i^W} + \boldsymbol{\beta x},$$

where β_1, β_2, and vector $\boldsymbol{\beta}$ are parameters to estimate.

Estimating equation 7 requires data for WIC demand distinct from non-WIC demand. Data on infant formula demand are not available that distinguish sales to WIC customers from sales to non-WIC customers and so I suggest an approximation. Let h_j^N represent infant-formula demand by infant j in a non-WIC household. Some non-WIC households buy no infant formula because of price or personal preferences and denote their infant's demand $h_{j,1}^N = 0$. A second type of infant in a non-WIC household, $h_{j,2}^N$, consumes a positive amount of infant formula equal to a_j, where a_j is normally distributed with mean μ and standard deviation σ_h^2, or $h_{j,2}^N = a_j \sim N(\mu, \sigma_h^2)$. If H_i^N represents the total number of non-breastfeeding, non-WIC infants in market i, then total demand for formula from non-WIC infants is $Q_i^N(p_1 \ldots . p_M) = H_i^N * \mu$. Participating WIC infants are treated similarly. h_k^W is demand by arbitrary WIC infant k. There are two types of households and infants from type 1 demand no infant formula, but infants in type 2 households demand a positive amount equal to b_k, where $b_k \sim N(\mu, \sigma_b^2)$. Although mothers may supplement breastfeeding with formula-feeding, I assume WIC and non-WIC infants consume the same average amount of infant formula. Anecdotal evidence suggests that some WIC households purchase infant formula without vouchers, but Oliveira, Frazao, and Smallwood (2010) suggest the amount is likely very small. If H_i^W represents the total number of participating non-breastfeeding WIC infants in market I, then total WIC demand is $Q_i^W = H_i^W * \mu$.[7] Substituting and allowing for optimizing errors with a zero mean error-term (ε), equation 7 becomes

[7] If λ represents the proportion of infant formula that WIC households purchase with WIC vouchers, μ_V represents the average amount of infant formula purchased with WIC vouchers, and μ_{NV} represents the average amount purchased by WIC households without WIC vouchers, then $\mu = \lambda\mu_V + (1 - \lambda)\mu_{NV}$ and $\mu = \mu_V$ if λ =1.

(8) $$np_i = c_i + f_i + \beta_1 \frac{pH_i^N}{H_i^W} + \beta_2 \frac{H_i^N}{H_i^W} + \boldsymbol{\beta x} + \varepsilon.$$

I expect $\beta_1 < 0$ and $\beta_2 > 0$. From 3 $\frac{\partial np}{\partial\left(\frac{pQ^N}{Q^W}\right)} = \frac{\partial(v_i)}{\partial\left(\frac{pQ^N}{Q^W}\right)} - \theta < 0$ and $\frac{\partial np}{\partial\left(\frac{Q^N}{Q^W}\right)} = \frac{\partial(v_i)}{\partial\left(\frac{Q^N}{Q^W}\right)} + c_i\theta > 0$. I assume $\frac{\partial(v_i)}{\partial\left(\frac{pQ^N}{Q^W}\right)} = < 0$ and $\frac{\partial(v_i)}{\partial\left(\frac{Q^N}{Q^W}\right)} > 0$.

Data and Variables

The left-hand-side of equation 7 is the net price firms offer as bids for WIC contracts. I compiled data on rebates from a variety of sources including records kept by the FNS and the Center for Budget and Policy Priorities. To calculate net price I subtracted each firm's rebate bid from its wholesale price for a truckload size shipment of infant formula, the price agencies use when evaluating rebate bids. Rebates and wholesale prices are adjusted to constant 2007 dollars using the Consumer Price Index.

Variables on the right-hand-side include the number of participating WIC infants which are recorded by the FNS. Non-WIC infants are estimated by taking the number of births in a state and subtracting the number of participating WIC infants. Births data are from the National Centers for Disease Control and Prevention. The number of WIC and non-WIC infants is adjusted with breastfeeding rates from Ross's Mothers Survey.

The data are a time-series, cross-section of firms' winning and losing rebate bids for contract auctions from 1986 through 2007. Cross-sections are state WIC agencies which typically offer contracts for terms of about 3 years and so over the duration of the data agencies have a time-series of multiple contracts. Data were available for both milk- and soy-based formula in powder and 13-ounce cans of liquid concentrate. Bids for soy-based formula are only sporadically available, and bids for powder-based are available for only the years since 1998. However, a nearly complete data set of bids for 13-ounce cans of milk-based liquid concentrate are available from 1986 to 2007 documenting winning and losing bids for each contract auctioned by WIC agencies. I do not include bids for soy products since they do not provide a consistent time series, but do include all milk-based liquid concentrate and powder bids.

I expect firm's to adjust their bids according to auction characteristics. Several agencies have formed alliances to jointly offer contracts and alliances may affect bidding as there may be a fixed cost of preparing a rebate bid. An alliance allows a firm to prepare a single bid rather than several bids for each state in the alliance and net-price bids might be lower for larger alliances because the fixed cost is spread over more agencies. I include two variables to proxy for agency size, *Number in Alliance* and *Alliance Infants*. *Number in Alliance* counts the number of agencies in an alliance.[8] I expect a negative sign on its coefficient as fixed bidding costs are spread over more agencies. *Alliance Infants* is the number of non-breastfeeding infants in an agency or alliance of agencies. If there is a fixed cost of serving an agency, then bids may decline as that fixed cost is spread over more infants; I expect a negative coefficient.

I include an alliance dummy variable that takes a value of 1 for a state if it is a member of an alliance and 0 otherwise. Its coefficient is key and measures whether agencies in alliances receive lower net price bids than when they were unallied.

Equation 6 shows that alliance bids are determined by the cost of serving an agency, the additional profit earned from non-WIC sales as a consequence of holding the WIC contract, and the firm's bid shade. Profitability is a function of parameters and non-WIC demand relative to WIC demand which may change for each state and I include the ratio of non-WIC to WIC demand measured at the alliance level.[9] I control for the cost of serving a state with state fixed

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[8]The count of agencies includes Indian Tribal Organizations. If an agency is not in an alliance, the variable takes a value of 1.

[9] The ratio of non-WIC to WIC infants is calculated for each state until the state joins an alliance, then it is calculated for the alliance.

effects. The per-unit cost of serving a state is not affected when a state joins an alliance because firms market to each state identically, independent from whether the state is an alliance member. An exception might be that per-unit costs are related to transportation costs and an alliance might include states from distances far from a firm's production facility. Some states in alliances might receive higher bids reflecting that per-unit transportation costs to the alliance are higher than that state's individual per-unit transportation cost. In principle some distant states might receive lower bids reflecting lower per-unit costs to the alliance relative to the state's individual per unit cost. But the alliance might force firms to serve states through the alliance that they otherwise would not. If so, cost increases cannot be expected to be offset with cost decreases and an alliance dummy coefficient might capture uneven changes in transportation costs. I include a variable that measures the average distance from each firm's production facilities to each alliance state's largest city (*Average Distance*).[10]

I include a number of other controls. Firms likely have different production technologies and I include firm dummy variables to capture the effect of different marginal production costs for bidding (*Mead Johnson=1*; *Ross=1*; *Wyeth=1; Carnation* is the base). Recently manufacturers have supplemented formula with docosahexaenoic acid and arachidonic acid (DHA/ARA) that some studies have shown to influence infant health. Manufacturers now regularly use these formulas as the base product when offering rebate bids. I control for possibly higher costs associated with the production of DHA/ARA formula with a dummy variable (*DHA/ARA*).

Firms base their bids on their estimates of demand and other market characteristics. Firms that bid on an agency's contract may have more accurate estimates if they held the agency's most

[10]*Average distance* is calculated by taking the distance from each firm's plants to the largest city in each state. Plant locations for Mead Johnson, Ross, and Wyeth are noted in the *Handbook of American Business History* (Powell, 1997). Carnation's only infant formula plant in the US is in Eau Claire, WI.

previous contract. I include a dummy variable that equals 1 if the firm held the previous contract and zero otherwise (*Previous*). Some of the data are for bids based on the powder form of infant formula. Davis (forthcoming) finds that powder marginal costs are lower than liquid concentrate marginal costs. I include a dummy variable that equals 1 if a bid was based on powder formula and zero otherwise (*Powder*). Some agencies requested bids for milk based formulas separate from soy based formulas and I include a dummy variable (*Uncoupled*) for contracts requested separate, decoupled, bids.

When agencies began soliciting rebates from manufacturers, some agencies did not offer exclusive WIC selling rights. Instead, each manufacturer could sell to WIC customers and each manufacturer offered a rebate. These forms of WIC contracts were known as “open market” contracts. Other agencies offered contracts that requested sealed bids and that included the right to exclusively sell to WIC customers. These contracts were known as “competitive sole-source contracts” and have become the norm in WIC rebate auctions. While open market contracts are no longer used, it is interesting to consider whether there is evidence in these data that competitive contracts resulted in lower net-price bids. I include, in some specifications, a dummy variable that takes a value of 1 when bids were for a “competitive-sole source” contract (*Competitive*) and zero for open market contracts.

I include nonlinear controls for the number of bidders in each auction as suggested by Rezende (2008); I include a dummy variable for each level of the number of bidders (*One bidder*, *Two bidders*, *Three bidders*).[11] Table 1 presents the means and standard deviations for all variables.

[11] At most four bidders, Mead Johnson, Ross, Carnation, and Wyeth, bid for competitive sole-source contracts. In some open-market contracts, a small number of other small firms offered rebates to a small number of agencies. These bids are not included in the data set; the results below that include open-market contracts (columns 1 and 2 in table 3) should be cautiously interpreted.

Empirical Results

All firms did not bid in all auctions and I tested for selected sample bias when data are time-series/cross-section, and cross-sections are identified with fixed effects by following Wooldridge (pp. 581-82, 2002). Because the fixed-effects probit model is not consistent, Wooldridge suggests using a random-effects probit to estimate a first-stage selection equation.[12] The model suggests that the decision to bid is determined by capacity constraints and expected profits. I speculate that firms with larger shares of the WIC market are nearer their capacity constraint. I calculate each manufacture's share of the WIC market by adding up the WIC infants in the markets in which the firm holds the WIC contract and then dividing by the total number of participating WIC infants. I include the one-year lag of WIC share and its square to control for capacity constraints. I include WIC and non-WIC demand variables to proxy for profitability.[13] Other controls include the average distance variable and the previous dummy variable.

Table 2 presents results from a pooled probit, a random effects probit, and marginal effects from the random effects probit. Specification tests suggest that the random-effects model is the appropriate model and I focus attention on the marginal effects from that model.[14] Equation 8 suggests that bids are positively related to $\frac{pH_i^N}{H_i^W}$ and negatively related to $\frac{H_i^N}{H_i^W}$. I expect converse relationships in the selection equation since bidding decisions are likely to be positively related to revenues, but negatively related to costs.

[12] I estimate what Wooldridge calls "Chamberlain's random effects probit" and include time-averaged values for all right-hand-side variables (Wooldridge p. 487, 2002).

[13] I experimented with including an alliance dummy variable in the selection equation, but it was not statistically significant. I also experimented with treating the alliance dummy as an endogenous regressor, and estimating the selection equation with a bivariate probit. Results were similar to those reported and the alliance dummy was not statistically significant. Similarly, *Number in Alliance* and *Alliance Infants* coefficients were not significant in the selection equation.

[14] A chi-square test for the joint significance of the time-averaged variables rejected the null hypothesis that their coefficients were jointly zero.

Lagged WIC share and its square are significant suggesting that firms consider capacity constraints when bidding for WIC contracts. Figure 1 shows the relationship between the probability of submitting a bid and a firm's share of the WIC market. The probability of submitting a bid is positively related to WIC share until a firm's share is about 50 percent of the WIC market, beyond 50 percent the probability of submitting a bid declines.[15]

The coefficient on the previous dummy variable is positive and its marginal effect shows that holding an agency's most recent contract increases the probability of bidding in its current contract by .20. Firms are less likely to bid in auctions that are farther away from their plants as the coefficient on average distance is negative. This is consistent with the notion that transportation costs reduce the profitability of WIC contracts.

I use the selection equation to construct an inverse Mills ratio and include it as a regressor in several specifications of equation 10. The ratio's coefficient is never statistically significant and I conclude that sample selection bias is not a concern in these data.

Several variables in equation 10 may be simultaneously determined with net price bids biasing coefficients. I test whether *Alliance*, *Number in Alliance*, *DHA/ARA*, $\frac{pH_i^N}{H_i^W}$ and $\frac{H_i^N}{H_i^W}$ are endogenous using the augmented regression approach suggested by Davidson and McKinnon (1993, p.236).[16] I reject the null of no significant bias and estimate equation 8 using instrumental variables. I also present ordinary least squares results for comparison.

Table 3 shows IV and OLS results from estimating six specifications of equation 8. The first two columns of results are from a sample that includes bids under the open market format

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[15]The estimated WIC share effect is almost certainly determined by Mead Johnson's and Ross' bidding behaviors. Wyeth and Nestle are unlikely to have sufficient capacity to serve fifty percent of the WIC market, and their bids represent a relatively small number of the observations used to estimate the effect.

[16] I use a time trend and its square, the number of births in an alliance, state population, state population squared, a series of wholesale milk prices/indexes, and annual dummy variables as instruments.

and the competitive sole-source format. The competitive dummy variable is almost certainly endogenously determined with net-price bids. But, I could not find suitable instruments and so the results in these columns should not be causally interpreted. They do, however, show that competitive sole-source contracts on average received net-price bids \$.32 lower than open market contracts (\$.42 lower in the OLS results). This confirms what most agencies observed; competitive sole-source contracts resulted in lower net-price bids which ultimately lead all states to adopt sole-source contracts. The remainder of the analysis in table 3 includes observations from only sole-source contracts because open-market contracts are no longer used and because I cannot conclude that coefficients in a model that includes both open-market and competitive contracts are unbiased. Correspondingly, results should be interpreted conditional on the competitive sole-source auction format.

The third and fourth columns of results are from including winning and losing bids from competitive sole-source contracts. Coefficients on $\frac{pH_i^N}{H_i^W}$ and $\frac{H_i^N}{H_i^W}$ have the expected signs. The coefficient for *Average Distance* shows that each additional 1000 miles of distance increases net price bids by \$0.05. Firms appear to bid more aggressively for an agency's contract when they held the agency's current contract because the *Previous* dummy coefficient is negative. The *DHA/ARA* dummy coefficient suggests that all else constant, net price bids increased \$0.36 when firms started offering bids based on supplemented formulas.

Number in Alliance and *Alliance Infants* measure the size of an agency (or alliance). The *Number in Alliance* coefficient is negative and significant in only the (biased) OLS specification. *Alliance Infants'* coefficient is negative but not significant in either IV or OLS.

The *Alliance* dummy variable is negative and significant in both the IV and OLS specifications. When agencies band together in an alliance to jointly offer rebate contracts, they receive lower net-price bids than when they offer bids independently. I include state specific fixed effects, so the *Alliance* coefficient is identified by time series variation. The negative coefficient implies allied agencies receive lower net-price bids after they join the alliance.

There are three reasons joining an alliance might result in lower bids. First, an alliance may be more profitable than an individual state. But I control for profitability with $\frac{pH_i^N}{H_i^W}$ and $\frac{H_i^N}{H_i^W}$ which are aggregated to the alliance level. An agency in an alliance may receive a better bid because the alliance is more profitable, but the change in profitability is controlled in estimation. Second, an alliance may spread fixed costs over more infants or agencies. But, the average fixed cost should be negatively associated with the size of the alliance (measured by either infants or number of agencies), which is also controlled in estimation. The third possibility is that an alliance may shift bargaining power away from firms and toward state agencies giving agencies countervailing power. Firms may bid more aggressively and shade their bid less when bidding for larger contracts with alliances.

Most previous empirical countervailing power research has analyzed buyer size effects as a continuous variable. Although I include size variables and cannot definitively assert that their negative coefficients do not imply countervailing power, the theoretical model implies that countervailing power arises only through decreased bid shades. If size variables proxy for countervailing power firms decrease bids only because they expect lower rival bids, decreasing their assessed probability of winning the auction.

Because the alliance dummy variable is identified by time-series variation only, its coefficient implies that agencies receive lower bids after joining an alliance, even controlling for the size of the alliance.[17] Unlike a large agency, an alliance represents a decrease in the number of contract opportunities. Consider two agencies that form an alliance at time t. Before t firms may shade their bid aggressively, safe in the knowledge that the probability of winning neither auction is relatively low. After time t, firms must compete for a single contract instead of two. They are likely to anticipate lower bids from rivals and thus shade their own bids less. The size of the agency does not necessarily matter. But the reduction in the number of bidding opportunities and the increased competition does matter.

The result seems consistent with the predictions in Snyder's 1996 and 1998 papers that model countervailing power as a consequence of increased seller competition. Davis (forthcoming) shows that sellers bid above marginal cost for WIC contracts. In this article, it appears sellers compete more aggressively for contracts with an alliance of buyers and the surplus earned by manufactures declines.

So far, I have analyzed firms' bids regardless of whether they were winning or losing bids. The infant formula industry is very concentrated as three firms dominate the market. Indeed, firms in the infant formula industry have been targeted for investigations of anti-competitive behavior. The concentrated nature of the industry suggests firms may not bid competitively, but anti-competitive scrutiny may lead them to disguise their less than competitive bidding. For example, firms may offer courtesy bids that they expect to be too high to be accepted, but that are low enough to give the appearance of legitimacy to avoid regulatory scrutiny. While formally testing whether winning bids differ from non-winning bids is beyond the scope of this paper, I present results from estimating equation 8 using only data on winning bids and show results in the last two columns of table 3.

[17] Some state agencies have always been part of an alliance, while others joined or formed alliances over time. The alliance coefficient is identified distinct from each state-agency dummy variable only as individual agencies join alliances.

The results in the last two columns are usually consistent with those in the rest of the table. The *Alliance* coefficient is negative and significant confirming that agencies in alliances receive lower net prices. The *Previous* and *Uncoupled* coefficients are not significant in columns 5 and 6, but are significant in columns 3 and 4. In contrast, the *Two Bidder*s and *Three Bidders* dummy variables are not significant in columns 3 and 4, but are significant in columns 5 and 6. I suspect the results in columns 3 and 4 reflect firms individual shading strategies that are related to various auction characteristics. A firm may shade less when they previously held an agency's contract or when an auction requested uncoupled bids, but when the winning bid is determined these shading strategies do not matter. Instead, bids that win auctions are shaded only in accordance with the number of bidders (and whether the firm is bidding for an alliance). It is interesting that the *Two bidders* coefficient is smaller than the *Three bidders* coefficient, but this may be a consequence of the relatively small number of auctions that have 4 bidders.

Conclusion

This paper examines infant formula manufacturers' bidding practices in WIC rebate auctions and focuses on the role of agencies that form alliances. I develop a theoretical model of optimal rebates and use it to inform a reduced form equation for net price bids (wholesale price minus rebate). Results suggest that agencies that join with other agencies and conduct auctions jointly as an alliance receive lower bids in general and lower winning bids. This result is robust because the coefficient is identified only by time-series variation in the alliance dummy variable since the model includes state-agency dummy variables. States agencies receive lower bids only after they join an alliance. The coefficient can also be causally interpreted because I estimate it with instrumental variables. Joining an alliance causes a state agency to receive lower bids.

I interpret the result as an indication that joining an alliance provides state WIC agencies countervailing power when negotiating with an oligopoly of suppliers. So, this paper contributes to the literature on countervailing power in general, but also contributes to the literature on bidding in auctions.

Figure 1. WIC Share and the Probability of Submitting a Bid

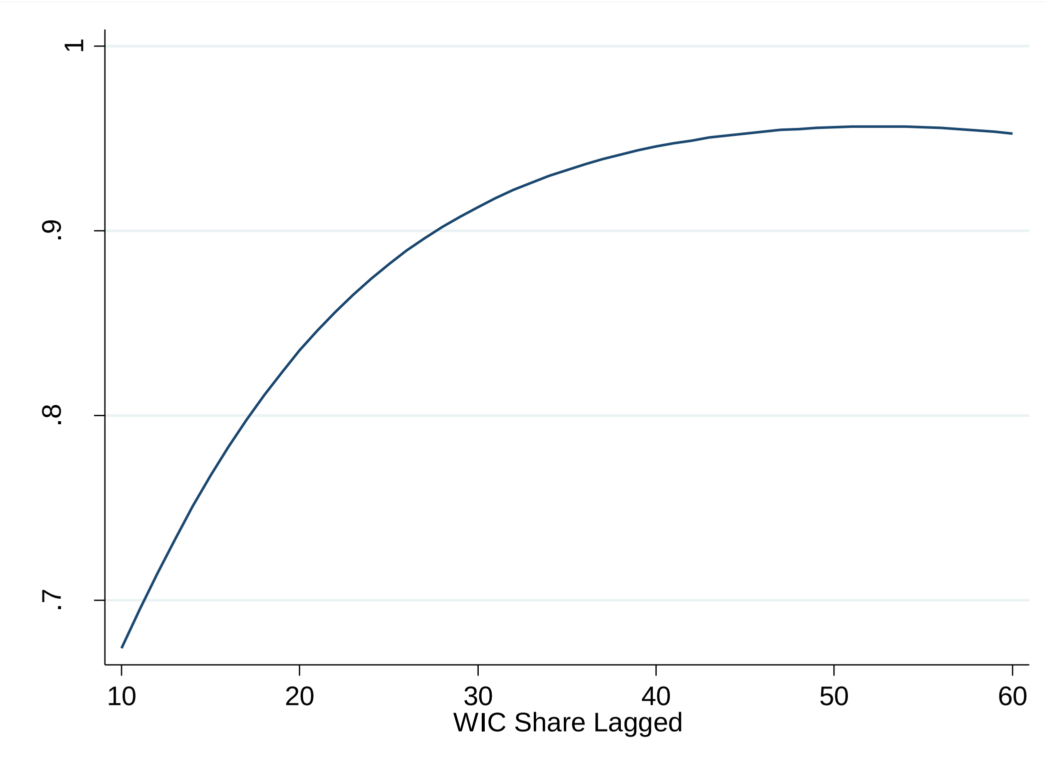

Table 1. Variable Means

Variable Names	
Select=1	0.761
Competitive	0.849
Alliance=1	0.449
Number in Alliance	4.996
Alliance Infants	9.385
DHA/ARA=1	0.220
Powder bid	0.239
Previous	0.220
Uncoupled	0.183
Average distance	4.958
$\frac{H_i^N}{H_i^W}$	4.054
$\frac{PH_i^N}{H_i^W}$	12.182
Carnation=1	0.243
Mead Johnson=1	0.313
Ross=1	0.313
Wyeth=1	0.131
One bidder=1	0.043
Two bidders=1	0.531
Three bidders=1	0.336
Four bidders=1	0.090

Table 2. First-Stage Selection Equation

Variables	Pooled Probit	Random Effects Probit (REP)	REP Marginal Effects
$\frac{H_i^N}{H_i^W}$	-0.203***	-0.254***	-0.0587***
	(0.0764)	(0.0928)	(0.0203)
$\frac{pH_i^N}{H_i^W}$	0.0779***	0.0970***	0.0224***
	(0.0278)	(0.0287)	(0.00642)
Average Distance	-0.0299***	-0.0464***	-0.0107***
	(0.00733)	(0.00969)	(0.00228)
Previous	1.190***	1.196***	0.195***
	(0.188)	(0.231)	(0.0222)
Uncoupled	0.364***	0.390***	0.0790***
	(0.134)	(0.138)	(0.0252)
WIC Share	0.0700***	0.0735***	0.0170***
	(0.00574)	(0.00578)	(0.00187)
$(\text{WIC Share})^2$	-0.000654***	-0.000701***	-0.000162***
	(6.42e-05)	(5.63e-05)	(1.84e-05)
Constant	-0.499***	3.747	
	(0.120)	(2.832)	
Observations	1450	1450	
Log liklihood	-570.8	-556.9	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Net Price Regressions

Variables	All Auctions IV	All Auctions OLS	Competitive Auctions IV	Competitive Auctions OLS	Winning Bids IV	Winning Bids OLS
Competitive Sole Source	-0.322***	-0.424***				
	(0.0534)	(0.0493)				
Alliance=1	-0.641***	-0.158***	-0.790***	-0.216**	-0.400**	-0.0501
	(0.144)	(0.0554)	(0.139)	(0.0847)	(0.158)	(0.0652)
Number in Alliance	0.0337*	-0.039***	0.0214	-0.0456***	-0.0419*	-0.0655***
	(0.0179)	(0.00933)	(0.0193)	(0.00782)	(0.0232)	(0.0130)
Alliance Infants	-0.0145**	-0.013***	-0.0133	-0.0134	-0.0122	-0.0128*
	(0.00738)	(0.0046)	(0.00847)	(0.00897)	(0.00965)	(0.00740)
DHA/ARA=1	0.436***	0.350***	0.405***	0.357***	0.282***	0.222***
	(0.0478)	(0.041)	(0.0483)	(0.0512)	(0.0494)	(0.0321)
Powder bid	-0.101**	0.0297	-0.0506	0.0394	-0.157***	-0.0691**
	(0.0481)	(0.0358)	(0.0505)	(0.0415)	(0.0475)	(0.0303)
Previous	-0.091***	-0.102***	-0.0865***	-0.0901***	0.00522	-0.00546
	(0.0304)	(0.0275)	(0.0306)	(0.0330)	(0.0289)	(0.0268)
Uncoupled	-0.175***	-0.161***	-0.160***	-0.156**	0.0220	0.0188
	(0.0536)	(0.0488)	(0.0546)	(0.0642)	(0.0444)	(0.0426)
Average distance	0.0139	0.0436***	0.0247**	0.0489***	0.0603***	0.0586***
	(0.0120)	(0.00850)	(0.0118)	(0.00721)	(0.0189)	(0.0131)
$\frac{H_i^N}{H_i^W}$	0.210***	0.122***	0.155***	0.128**	0.159***	0.116***
	(0.0488)	(0.0319)	(0.0531)	(0.0487)	(0.0532)	(0.0323)
$\frac{PH_i^N}{H_i^W}$	-0.127***	-0.040***	-0.102***	-0.0393**	-0.0870***	-0.0379***
	(0.0199)	(0.0119)	(0.0215)	(0.0162)	(0.0211)	(0.0114)
Mead Johnson=1	0.401***	0.298***	0.370***	0.297***	0.211***	0.184***
	(0.0631)	(0.0574)	(0.0643)	(0.0829)	(0.0624)	(0.0474)
Ross=1	0.435***	0.303***	0.410***	0.317***	0.161**	0.158***
	(0.0653)	(0.0598)	(0.0662)	(0.0857)	(0.0654)	(0.0534)
Wyeth=1	0.699***	0.610***	0.652***	0.596***	0.395***	0.463***
	(0.0664)	(0.0617)	(0.0673)	(0.0874)	(0.0744)	(0.0654)
One bidder=1	0.216**	0.00346	0.150	-0.00697	0.446***	0.307***
	(0.107)	(0.0957)	(0.116)	(0.0908)	(0.108)	(0.0960)
Two bidders=1	-0.0395	-0.174***	-0.0732	-0.186**	0.189**	0.0458
	(0.0724)	(0.0595)	(0.0737)	(0.0794)	(0.0898)	(0.0756)
Three bidders=1	0.102	-0.00953	0.108	0.00232	0.271***	0.142*
	(0.0716)	(0.0633)	(0.0746)	(0.0832)	(0.0862)	(0.0742)
Constant	0.966***	0.990***	0.594***	0.503***	0.408***	0.367***
	(0.119)	(0.107)	(0.108)	(0.0578)	(0.127)	(0.124)
Observations	1102	1102	965	967	369	371
R-squared	0.300	0.428	0.235	0.360	0.429	0.616

All specifications include state dummy variables, i.e., fixed effects. Robust standard errors in parentheses. Carnation is the base firm and four bidders is the base for the bidder dummy variables.
*** p<0.01, ** p<0.05, * p<0.1

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