Buyer Alliances as Countervailing Power in WIC Infant-Formula Auctions

Abstract

State WIC agencies in infant-formula procurement auctions receive lower bids 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. Agencies frequently join together in buyer alliances. An empirical estimation shows that bids are lower to alliances and that lower prices result because alliances are heterogeneous. Results suggest that when heterogeneity is not controlled, bids decline with alliance size which has policy implications because Congress recently limited alliance size.

May 2014

Key Words: auctions, food assistance, countervailing power, buyer concentration, oligopoly, WIC.

JEL codes: L13, D43, D44, Q18, I18

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Acknowledgements: Thanks to Victor Oliveira for providing helpful comments and Linda Clarke for providing assistance with compiling rebate data. Funding assistance for this research was provided by the Economic Research Service of USDA, Cooperative Research Agreement No. 58-5000-6-0063.

Introduction

State agencies in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) infant-formula procurement auctions receive lower net-prices when they are in buyer's alliances than when they are unallied. State WIC agencies provide exclusive selling rights to a single infant-formula manufacturer in exchange for a rebate on each can of the firm's brand sold to WIC participants. Firms bid for the right to be an agency's exclusive supplier by offering a net price, wholesale price minus rebate, in an auction format. Some agencies have banded together to form buyer's alliances. This paper investigates the effect of those alliances on net-prices received by agencies.

I estimate a reduced-form equation for WIC net-price bids. I find that agencies in alliances receive lower net-prices and that net-price decreases with the size of an alliance. In contrast, agencies outside alliances do not benefit from size increases. Some unallied agencies are as large as alliances and so it is not clear why size benefits agencies in alliances, and not equally-sized unallied agencies.

The countervailing-power literature investigates how buyer size can affect the bargaining relationship between buyers and sellers. A paper by Dana (2012) suggests that it is the heterogeneous makeup of buyer's alliances that provides buyers a bargaining advantage, and not necessarily buyer size. I test whether agency heterogeneity within an alliance affects net-price bids by including a heterogeneity index in estimated equations. Results indicate that more inequality in the distribution within an alliance decreases net prices.

Agency size and heterogeneity are linked and limiting size also limits the ability of agencies to construct heterogeneous alliances. In 2004, Congress limited the size of new alliances to 100,000 participating infants and limited the ability of alliances with over 100,000 participating infants to expand.[1] I find a cost reducing effect of alliance size that extends beyond 100,000 participating infants. The estimates in this paper suggest that costs decline until an agency serves nearly 200,000 infants.

Background

The WIC program 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 other services to low-income women, infants, and children. 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, Frazao, Smallwood, 2011).

The WIC program is not an entitlement program. Instead, it relies on annual budget appropriations to fund its services. WIC agencies have sought to efficiently provide services with available appropriations by enacting cost-containment practices. One such cost-control effort is an auction mechanism that grants a manufacturer the exclusive right to market to an agency's WIC participants. 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 through WIC. WIC infant formula is dispensed through approved retailers where WIC participants purchase with vouchers. WIC agencies reimburse retailers the full-retail price, but manufacturers reimburse agencies the agreed rebate based on vouchers redeemed.[2]

Manufactures compete for the right to be an agency's sole infant-formula supplier by submitting sealed bids in the form of rebates. The contract winner is the firm that submits the lowest

[1] Limiting alliance size was intended to promote competition for contracts. Quoting the Federal Register "…an unintended consequence of large alliances is that competition is diminished because not all infant formula manufactures may be able to compete for larger State alliance contracts due to production capacity. The Department believes that limiting the size of State alliances will help to maintain competition among infant formula manufacturers by ensuring all manufacturers can compete for rebate contracts" (Federal Register, 3/3/2008).

[2] The total per-unit cost to WIC is the net price plus the retail markup over wholesale price.

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 (Oliveira, et al., 2001).[3] Federal regulations stipulate that net-price bids must be evaluated using the "lowest national wholesale price for a full truckload of infant formula" (S.2507, 2004). Infant-formula manufactures publish wholesale-price catalogs and agencies require bidders to provide their lowest, published, national wholesale price with their rebates bids, in order that agencies may accurately assess net-price bids.[4]

An important development in the evolution of the rebate system is the practice of some agencies joining together in a multi-state "alliance" to jointly request a single bid from suppliers that would apply to all state agencies in the alliance. 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 costs. For example, the Western States Contracting Alliance (WSCA) stated goal is, "… to obtain volume price discounts based on the collective volume of the numerous potential purchases by the individual WSCA States Agencies." The average alliance includes about five agencies, but alliances can have as few as two, or as many as 22 agencies (WSCA included 22 agencies in 2007).[5]

The rebate system has been successful at reducing program costs. Several government reports have examined rebates and noted that winning rebates are typically about 85-90 percent of wholesale price and rebates total about $1.5 billion annually (Oliveira et al., 2004; Oliveira and Davis, 2006; Oliveira, Frazao, and Smallwood, 2010). The data in this paper include rebates offered

[3] See Oliveira, et al., (2001) for a more complete discussion of the history of the WIC infant formula rebate system.
[4] There is no provision in Federal regulations for monitoring wholesale prices, but agencies are required to monitor retail prices. The wholesale price is a useful benchmark to compare rebate bids, but actual wholesale prices charged retailers may vary. Manufacturers offer volume discounts, ordering a truckload size volume offers the largest discount, and different retailers may order different volumes.
[5] See Davis (2008) for a complete description of WIC infant-formula alliances and their member agencies.

by firms between 1987 and 2007. The average winning rebate (in 2007 dollars) was $2.79 for 26 ounces of reconstituted formula, while the average wholesale price was $3.21, for a discount of 87 percent.

The infant-formula market is very concentrated, with three manufacturers (Mead Johnson, Ross, Carnation) producing about 98 percent of domestic sales (Oliveira, Frazao, and Smallwood 2010).[6] Some have speculated that firms sell below cost in the WIC market, compensating for losses by selling at a premium above cost to non-WIC customers. Davis (2012) investigates the issue and provides evidence that firms infrequently sell below cost to WIC. A GAO (1998) report also finds that firms appear to be covering production costs when selling to WIC customers.

Others have speculated that there may be a “spillover effect” from holding the WIC contract. The spillover effect occurs if sales of the WIC brand of infant formula increase to non-WIC customers as a result of holding the WIC contract. If sales to non-WIC customers are profitable, a spillover effect would increase the value of the WIC contract to firms providing them an incentive to bid aggressively for the WIC contract.

The spillover effect may result from three related mechanisms (Huang and Perloff, 2013). Oliveira, Frazao, and Smallwood (2010) estimates that WIC purchases represent between 57 and 68 percent of all infant-formula sales in the US and it is likely the WIC contract-brand receives a predominant share of store shelf-space, making it a natural choice for non-WIC customers. Similarly, non-WIC customers may view the WIC contract as an implicit government endorsement of a particular brand. Finally, doctors may be more likely to endorse the WIC contract brand to non-WIC mothers (GAO, 1998; Oliveira, Frazao, Smallwood, 2010, and 2011).

[6] In rebate auctions at most 4 manufacturers have bid for the sole-source contracts and in many auctions only 2 manufacturers bid. Wyeth is a fourth firm that was active in WIC infant formula auctions until the mid-1990s.

Huang and Perloff (2013) were the first to investigate the spillover effect. Using infant-formula purchase data, they demonstrate that sales of a brand of infant formula increased once the brand acquired the WIC contract in a region. Contemporaneously, sales of the brand that relinquished the contract fell. The increase in sales were large. A brand's market share increased from less than 20 percent to over 70 percent when the brand transitioned from the non-contract brand to the WIC contract brand. Subsequent to Huang and Perloff, Oliveira, Frazao, Smallwood, (2011) and Davis (2012) find spillover effects similar in magnitude to those found in Huang and Perloff.

Government reports have examined the effectiveness of some WIC cost containment practices (Kirlin, Cole, and Logan, 2003; Davis and Leibtag, 2005; GAO, 1998). Other research has examined the effect that WIC exclusive selling contracts have on sales to non-WIC customers (Huang and Perloff, 2013; Davis, 2012; Oliveira, Frazao, and Smallwood, 2010). Still others have attempted to identify the effect of WIC infant formula sales on infant-formula retail prices (Oliveira et al. 2004). However, no previous research has examined whether agencies banding together to form buyers alliances decreases program costs.

Model and Variables

I assume infant-formula manufacturers, m, bid a net price, wholesale price (wp) minus rebate (r), to be the sole-supplier to WIC agency i, $np_{i,m} = wp_m - r_{i,m}$. I estimate a reduced-from equation in which net-price bids are a function of agency and auction characteristics.[7]

I test whether agencies in alliances receive lower net-price bids than unallied agencies by including a dummy variable (*Alliance)* that takes a value of one if a state agency is a member of an

[7] I call the equation a reduced form to distinguish it from a structural model of bids. The equation is not a true reduced form since it includes endogenous variables as regressors.

alliance and zero otherwise. As an alternative measure, I calculate the number of agencies allied to together, *Alliance Number*, and include this variable as a regressor in place of the dummy variable.

I test whether agency size affects bids. Size may be an important determinant for two reasons. Large agencies may allow firms to produce more efficiently at a lower cost and firms may pass cost savings to agencies in the form of lower net prices. Alternatively, size may be a proxy for bargaining power.

I include the number of non-breastfeeding WIC infants in an alliance (*WIC Infants*) as a regressor. The effect of WIC infants on net-price is uncertain. I assume firms bid more aggressively if they earn profits from WIC infants. Net-prices are historically very low relative to wholesale prices. If net price is below average cost firms earn negative profits from sales to WIC infants and I expect a positive relationship between net price and *WIC Infants*. Alternatively, sales to WIC infants may be profitable if net price is above average cost, in which case I expect a negative relationship. If net price is equal to average cost, I expect a negative sign if larger agencies are supplied at lower average-costs.

The cost of supplying an agency is likely affected by the cost of manufacturing infant formula and the cost of supplying it to a specific state agency. I control for manufacturing costs with firm-specific dummy variables and each firm's wholesale price (*Wholesale Price*). The dummy variables control for firm cost differences that are constant over time, while the wholesale price controls for time-varying production costs.

Time invariant state/agency specific costs are controlled with state-specific dummy variables. I also assume costs vary with an agency's distance from a firms' production facilities (*Alliance Distance*). Manufacturers typically have multiple plants and *Alliance Distance* is measured as the distance from a firm's nearest plant to an agency's largest city.[8] If an agency is in an alliance, *Alliance Distance* is the sum of the weighted distances of all agencies in the alliance, where weights are each agency's proportion of WIC infants in the alliance.[9]

I allow that firms may behave strategically and bid more or less aggressively based on their rivals' locations. I include a variable, *Rival Distance*, which is the distance from a rivals' plant to an agency's largest city, for the rival that is closest to the largest city.[10]

I include a number of other controls likely to affect net-price bids. Recently manufacturers have supplemented formula with docosahexaenoic acid and arachidonic acid (DHA/ARA) that some studies have shown to influence infant health. I control for possibly higher costs associated with the production of DHA/ARA formula with a dummy variable (*DHA/ARA*) that takes a value of one when firms based their bids on these products.

Firms that bid on an agency's contract may have more accurate sales estimates if they held the agency's most previous contract. I include a dummy variable that equals 1 if the firm held the previous contract and zero otherwise (*Previous*).

Production and transportation costs may be lower for powder products than for liquid concentrate products as powdered products require the product to be mixed with water in the correct proportions leaving some of the production process to the purchaser. I include a dummy variable that equals 1 if a bid was based on powder formula and zero otherwise (*Powder*). Some agencies

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[8] Plant locations for Mead Johnson (Evansville, IN, Zealand, MI, and Springfield, MO), Ross (Casa Grande, AZ, Columbus, OH, Sturgis, MI, and Alta Vista, VA), and Wyeth (Mason, MI and Georgia, VT) 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.

[9]The weight for agency i is $WIC\ Infants_i + .5NonWICInfants_i \big/ \sum_{i \in A}(WIC\ Infants_i + .5NonWICInfants_i$, where the sum is over all agencies in an alliance. I use a 0.5 weight for nonWIC infants to capture the spillover effect. I also experimented with weights of 0 and 0.7; the choice of weights did not meaningfully affect regression results.

[10]Firms do not know which of their rivals will bid in an auction. So *Rival Distance* is always the distance of a firm's rival closest to the agency. I assume firms bid as if they always expect their rival nearest the agency to bid.

requested bids for milk-based formulas separate from soy based formulas and I include a dummy variable (*Uncoupled*) for contracts that requested separate, decoupled, bids.

I control for auction competitiveness with the number of bidders in each auction. The number of bidders ranges from 1 to 4 and experiments with various specifications suggested a nonlinear relationship between bidders and net price. I include dummy variables for each level of number of bidders, *two bidders*, *three bidders*, and *four bidders*. Auctions that had only 1 bidder serve as the base.

Data

The dependent variable is the net-price firms offered 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.[11] Net prices and wholesale prices are adjusted to constant 2007 dollars using the Consumer Price Index.

Variables on the right-hand-side include the number of non-breastfeeding WIC infants. Participating WIC infants is recorded by the FNS. I adjust the number of participating infants with one minus each state's breastfeeding rate from Ross Laboratories Mothers Survey to get the number of non-breastfeeding participating infants (*WIC Infants*).

The data are a time-series, cross-section of firms' net-price bids for contract auctions from 1986 through 2007. Cross-sections are state WIC agencies. Over the duration of the data agencies have a time-series of contracts.

[11] Infant-formula manufacturers provide their customers with price catalogs of all their various products. The wholesale prices in these data are taken from those catalogs.

The data include a nearly complete set of bids for 13-ounce cans of milk-based liquid concentrate from 1986 to 2007. Bids based on powdered products are available from 1998 to 2007.[12] The sample includes 371 observations of winning net-price bids. Table 1 provides summary statistics.

Empirical Results

There are two related econometric issues that must be addressed when estimating the model. The data are from a non-random sample of observations because all firms did not bid in all auctions, and some regressors may be endogenously determined. I address each of these issues.

Sample Selection

I test for sample-section 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.[13]

I use the selection equation to construct an inverse Mills ratio and include it as a regressor in the empirical models. The Mills ratio's coefficient is not statistically significant and I conclude that sample-selection bias is not significant.[14]

Endogeneity Bias

[12] Powdered bids are adjusted to equal the amount of reconstituted formula (26 fluid ounces) produced by a 13 ounce can of liquid concentrate.

[13] 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). Specification tests suggest that the random-effects model is the appropriate model. A chi-square test for the joint significance of the time-averaged variables rejected the null hypothesis that their coefficients were jointly zero at the 5 percent level.

[14] I follow the procedure suggested by Wooldridge, 2002 pages 567-68, to test for sample-selection bias using two-stage least squares.

I consider *Alliance*, *WIC Infants*, *DHA/ARA*, *Two Bidders*, *Three Bidders,* and *Four Bidders* potentially to be simultaneously determined. I test for bias using the augmented regression approach suggested by Davidson and McKinnon (1993, p.236).

Joining an alliance is likely related to the size of the agency. Large agencies tend to negotiate alone while smaller states tend to join alliances. I use a state's population and population squared as instruments for each of the alliance variables.[15]

The number of infants using WIC is unlikely to be exogenous because the number of infants served by WIC is arguably determined by net price. I use the total number of births in an alliance as an instrument for *WIC Infants*. Births data are from the National Centers for Disease Control and Prevention.

Wholesale price is also likely endogenously determined. I use a non-fat dry milk price, a condensed milk producer-price-index, the dry whole-milk price, the dry-whey price, and a dairy producer-price-index as instruments for wholesale price.

I use each firm's annual share of the WIC market as instruments for *Two Bidders, Three Bidders,* and *Four Bidders*. I calculate each firm's annual number of WIC infants served in the US. I then divide that figure by the total number of WIC infants in the US each year. Each firm has limited capacity and as they serve more WIC infants they are likely nearer that limit, and the less likely they are to bid for a contract. I lag each firm's share one year in the event contemporaneous WIC shares are simultaneously determined with net prices. The development of DHA/ARA formulas are the result of technological advance. I capture technological change with a time trend and its square that serve as instruments for the *DHA/ARA* dummy variable.

[15]Below, I consider the number of agencies in an alliance (*Number in Alliance)* as an alternative variable to measure alliance effects. The count of agencies includes Indian Tribal Organizations. If an agency is not in an alliance, the variable takes a value of 1.

The F-statistic for each of the first stage regressions exceeds 10, suggesting strong instruments (Staiger and Stock, 1997). I also examine the partial effect of each instrument. Instruments are either individually or jointly statistically significant at the 5 percent level in the appropriate first-stage regression. I cannot reject the null of no significant endogeneity bias in the augmented regression version of a Hausman test and so present instrumental variable (IV) estimates.

Estimation Results

Table 2 provides evidence that agencies in alliances receive lower bids. Table 2 shows IV estimates from estimating specifications with the *Alliance* dummy variable or the *Alliance Number* variable.[16] The first specification includes the *Alliance* dummy and its coefficient is negative and statistically significant in each case. Similarly, the coefficient on *Number in Alliance* is negative and statistically significant in the other specification.

Table 2 suggests that agencies in alliances receive lower bids. But the specifications in table 2 do not include variables that measure the size of an agency/alliance. When an agency joins an alliance the number of WIC infants that will be served under its contract increases. Likewise, in the presence of a spillover effect, the number of non-WIC infants a manufacturer gains from the contract increases. So, the number of WIC and non-WIC infants served by a single contract is affected when agencies join alliances. Because *Alliance* and *Number in Alliance* are correlated with agency size, their coefficients may reflect only that large agencies receive lower bids. I explore this possibility and present results from alternative specifications in table 3.

[16]Some auctions include bids for both liquid-concentrate and powder. While the bids are based on the same 26 reconstituted ounces, including them both in a regression may bias standard errors since errors are likely correlated across observations (Moulton 1986, 1990). I adjust for arbitrary correlation within agencies by using cluster-robust standard errors. Because the powder/liquid concentrate level of clustering is nested within the higher agency level, it is necessary to only adjust standard errors at the higher-level cluster (Cameron, Gelback, and Miller, 2012).

Other coefficients in table 2 are usually consistent with *a priori* expectations. The coefficient on *Alliance Distance* is statistically significant and suggests that each additional 1000 miles of distance increases net-price bid by about $0.11 in 2007 dollars. The *DHA/ARA* dummy coefficient suggests that all else constant, net prices are about $0.35 - $0.37 higher when firms offer bids based on supplemented formulas, perhaps capturing the higher cost of producing these formulas. Net-price bids for powdered products are $0.10 lower than bids for liquid-concentrate products.

The coefficient on *Wholesale Price* is negative likely because infant formula wholesale-prices have been increasing faster that the rate of inflation, while net prices are lower in recent years than they were in earlier years (Oliveira and Davis, 2006). There is some evidence that soliciting bids for milk-based products uncoupled from soy-based products results in lower prices; the coefficient on *Uncoupled* is negative and significant. Holding an agency's previous contract does appear to have a marginally-significant influence on net price.

The coefficients for *Two Bidders* and *Four Bidders* are negative, statistically significant, and approximately the same magnitude (each is within the other's 95% confidence interval). Although the coefficient on *Three Bidders* is not statistically different from zero, it is negative and is within a 95% confidence interval of both *Two Bidders* and *Four Bidders*.[17]

Table 3 shows the effect when *WIC Infants* are included as a measure of agency size. The first two results columns include the *Alliance* dummy or *Alliance Number*, while the third column deletes both. The coefficient on *Alliance* is not individually significant, but the *Alliance* and *WIC*

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[17] Initially the bidder dummies do not seem to suggest lower bids when there are more bidders. But the coefficients are imprecisely estimated and because the coefficients are estimates the best we can conclude is that the true value is within its 95 percent confidence interval. For example, from column (1) the true effects could be, for two bidders -0.85, three bidders -1.0, and four bidders -1.2. All these values are within the 95 percent confidence interval of the estimated. The imprecision is likely due to the small sample, and the small number of auctions that have more than two bidders.

Infants coefficients are jointly significant at the 1 percent level. The *Alliance Number* and *WIC Infants* coefficients are also jointly significant at the 1 percent level in the next column. When *Alliance* and *Alliance Number* are deleted, the *WIC Infants* coefficient is negative and statistically significant.

Alliance, Alliance Number, and *WIC Infants* are to some degree proxies for agency size, and including multiple proxies may tax the ability of the regression to individually identify their parameters. But, the results do suggest that the size of an alliance matters. When alliance size is measured with *Alliance Number,* its coefficient is negative and significant, even when *WIC Infants* is included. When *WIC Infants* is included alone, its coefficient is negative and significant.

In the final column of table 3 I interact the alliance dummy with the number of WIC infants, *Alliance x WIC Infants.* The interaction term's coefficient is negative and significant. Now, the coefficient on *WIC Infants* is not statistically significant, suggesting that *WIC Infants* is not a significant determinant of net price for unallied agencies This evidence suggests that growing large benefits agencies in alliances, but does not benefit unallied agencies. There are unallied agencies that are as large as the largest alliance so it appears there is something unique about being in an alliance that gives agencies an advantage.

I turn to the countervailing-power literature to explore this result. This literature considers how large buyers can extract price discounts from sellers. Buyer size effects arise in a variety of environments, but most pertinent for my problem are models that include multiple-buyers. Several papers show there is an incentive for buyers to grow larger by forming groups. Forming groups increases buyer size and provides the group a benefit unattainable by the individual group members (Horn and Wolinsky, 1988; Chae and Heidhues, 1999; Inderst and Wey, 1999; Chipty and Snyder, 1999). The beneficial effects of size are also apparent in multiple buyer, multiple seller models as in Snyder (1996, 1998).

An alternative explanation considers alliance *formation* (rather than alliance size) as a tool to enhance seller competition. Economists have long studied the benefit to imperfectly competitive firms from bundling goods when buyers have heterogeneous preferences (see for example Adams and Yellen, 1976; McAfee, McMillan, and Whinston, 2003; Palfrey 1983).

Dana (2012) applies bundling to the formation of buyer alliances. Dana shows that when buyers' valuations are heterogeneous, joining together in an alliance can increase the intensity of competition among sellers. The essence of Dana's argument can be captured with a simple example.

Suppose there are two sellers (A, B) with a marginal cost, c, and multiple buyers each with a unit of demand. The buyers have different preferences/values for the goods offered by the sellers. Some buyers prefer A ($v_A > v_B$) and some buyers prefer B ($v_A < v_B$). Dana shows that in equilibrium Firm A will sell to buyers with $v_A > v_B$ at $p_A = c + (v_A - v_B)$, and firm B will sell to buyers with $v_A < v_B$ at $p_B = c + (v_B - v_A)$. However, if buyers were indifferent, $v_A = v_B$, they would mix between A and B and sellers would price at marginal cost, $p = c$.

Sellers can extract surplus from buyers who prefer their product, but if buyers are indifferent firms earn zero profits. The insight in Dana is that buyers can strategically form groups so that the average valuation for each group member is equal across groups, $\bar{v}_A = \bar{v}_B$. If buyer groups no longer exhibit a preference for either seller and jointly commit to buying from one seller, then the seller is no longer able to extract rents and sellers price at marginal cost. In effect, products are homogeneous to buyer groups and the game reduces to Bertrand competition.

In this model, the formation of groups is key. Groups must form in a way to make the group indifferent between sellers. If the group is indifferent, they will buy on price alone, ignoring any individual member's preference. The strategic formulation of groups eliminates the ability of sellers to segment buyers and increases competition. Dana shows that even without transfer payments within groups, it is rational for groups to form.

It seems logical that the insights in Dana's paper apply to the formation of WIC alliances and it is easy to construct scenarios consistent with Dana. While agencies are almost certainly indifferent between infant-formula manufacturers, manufacturers are unlikely to be indifferent between agencies. Suppose manufacturers' valuations of contracts differ. For simplicity, assume there are two manufacturers (i=1,2) that are competing for contracts with two agencies (j=*A*,*B*). Contract values differ and $v_{1,A} > v_{2,A}$ and $v_{1,B} < v_{2,B}$. The agencies have one contract and sell it to the lowest bidder. Firm surplus is the firm's bid minus it's value, $np_{i,j} - v_{i,j}$. Like Dana, this is a model of perfect information.

The equilibrium is for each firm to offer a bid equal to its rival's value and for the agencies to accept the bids. Firm 1 offers *B* $np_{1,B} = v_{2,B} - \epsilon$ and Firm 1 wins the auction and earns surplus greater than zero. Firm 2 could not offer *B* $np_{2,B} < v_{2,B}$ since they would earn profit/surplus less than zero. Firm 2 offers *A*, $np_{2,A} = v_{1,A} - \epsilon$ wins the auction and earns surplus greater than zero. Firm 1 cannot offer *A* $np_{1,A} < v_{1,A}$since they would earn surplus/profit less than zero.

As in Dana, there is an incentive for *A* and *B* to form an alliance and offer their contracts jointly if $\max\{v_{i,AB}\} = \frac{v_{i,A}+v_{i,B}}{2}$ is less than or equal to the minimum winning bid when agencies are unallied. The firm with $\min\{\frac{v_{i,A}+v_{iB}}{2}\}$ wins the joint contract by offering $np_{i,AB} = \max\{\frac{v_{i,A}+v_{iB}}{2}\}$ and earns profit $np_{i,AB} - \min\left\{\frac{v_{i,A}+v_{iB}}{2}\right\} > 0$. The firm with $\max\{\frac{v_{i,A}+v_{iB}}{2}\}$ cannot bid less than that amount or profit will be negative. So, the firm with $\min\left\{\frac{v_{i,A}+v_{iB}}{2}\right\}$ needs to bid $np_{i,AB} = \max\left\{\frac{v_{i,A}+v_{iB}}{2}\right\} - \epsilon$ to win the auction. Since $\max\{\frac{v_{i,A}+v_{iB}}{2}\}$ is less than both winning bids when agencies are unallied, agencies are better off. There is an incentive for agencies to strategically form alliances to receive better bids.

The example above is stylized, but shows that there is an interest for heterogeneous agencies to form alliances. The heterogeneity in net-price bids across agencies has been well documented elsewhere (see for example, Oliveira et al., 2004; Oliveira and Davis, 2006). This heterogeneity in net prices suggests that firms place different values on contracts with different agencies.

The theory suggests the incentive to form alliances is based on member heterogeneity and not size or any other alliance characteristic.[18] WIC alliances are composed of very heterogeneous member agencies. For example, WSCA is the largest alliance and is made of state agencies that are geographically dispersed, including Alaska and Hawaii and Washington DC, Maryland, Washington, and Kansas. WSCA member agencies also range in size from small (Washington DC with about 4500 participating infants) to large (Washington state with about 39,000 participating infants).[19] Other alliances seem similarly heterogeneous, as Texas is in an alliance with Iowa and Minnesota. The New England and Tribal Organizations alliance includes several northeast states and tribal organizations in Oklahoma.

The empirical results establish that joining an alliance decreases net price to an agency. The theory presented above suggests that alliances receive lower net prices when they are composed of agencies with heterogeneous values to firms. If the incentive to form alliances is based on agency heterogeneity, then the heterogeneous composition of an alliance should affect the net price member agencies receive. I test this hypothesis.

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[18] Of course alliance size might still matter if costs decrease with size.

[19] Note that infant counts are for all participating infants and is not restricted to non-breastfeeding infants, the measure of infants used in regressions.

The value of a WIC contract to a supplier is the profit earned from the contract. I assume the contract profit is positively related to the number of non-breastfeeding WIC infants, and because of the spill-over effect, a share of non-breastfeeding non-WIC infants. The value of a contract is measured as (*WIC Infants* + .5**non-WIC Infants*), where infant counts are adjusted for breastfeeding rates.[20]

To measure the degree of heterogeneity in an alliance, I create a Gini index based on each member agency's value. The Gini index measures the degree that a variable is unequally distributed across subgroups. In this case, the Gini index measures how unequally contract values are distributed among the members of an alliance where contract value is assumed correlated with *WIC Infants* + .5**non-WIC Infants*. Smaller Gini values indicate more equality, and for example, a single unallied agency would have a Gini index of 0. The more unequal the distribution of value, the larger the Gini index.

I include the Gini index as a regressor in net price regressions. It seems likely agencies would recognize the benefit of heterogeneity and construct alliances accordingly. If so, then the Gini index is endogenous. When Congress reauthorized the WIC program in 2004, the language of the law effectively limited new alliances to less than 100,000 participating infants. The law likely also affected agencies' ability to construct heterogeneous alliances. I create a dummy variable that takes a value of 1 for years after 2004 and use it as an instrument for the Gini index.

Table 4 shows the results when Gini is included as a regressor. The first column includes Gini, but no size measures. The Gini coefficient is negative and significant providing evidence that more heterogeneous alliances receive lower net-price bids. The next column includes *WIC Infants* as a size measure. The Gini coefficient is negative and significant, but in contrast to earlier results,

[20] The results reported are not sensitive to the choice of weight placed on non-WIC infants. I experimented with weights of 0 and 0.7 and regression results were largely unaffected.

the coefficient on *WIC Infants* is no longer negative and significant. Finally, in the last column I include the *Alliance x WIC Infants* interaction variable. The *Alliance x WIC Infants* coefficient is not significant, while the Gini index is negative and significant.[21]

These results suggest that member agency heterogeneity is an important determinant of the net-prices that alliances receive. Strictly interpreted the results suggest that once heterogeneity is controlled, agency size does not affect net price. However, multicollinearity is likely a consequence of including *Alliance* and *Gini* in the same regression. Table 6 shows the simple correlation coefficients of the variables in tables 3-5. As expected the correlation between *Alliance* and *Gini* is high at 0.913. So even though the *Alliance* coefficient is not statistically significant, the high degree of collinearity with *Gini* likely inflates its standard error.

When heterogeneity is not controlled larger alliances receive lower net-prices. Yet when Congress reauthorized WIC in 2004, alliance size was limited. As a final investigation, I attempt to determine whether limiting alliances to no more than 100,000 participating infants is likely to have effects on net prices. It is possible that net price declines are not linear and that there is a limit to the net price reducing effect of alliance size.

I include the square of *WIC Infants* (*WIC Infants Sq.)* and its interaction with the *Alliance* dummy variable (*Alliance x WIC Infants Sq.*) as regressors. The results are in table 5. In the first column only the coefficients on the interaction terms individually significant, and the coefficients for WIC Infants and WIC Infants Sq. are not significant, individually or jointly.[22]

[21] As robustness checks I experimented with other heterogeneity measures. I used an Atkinson Index in place of the Gini, and conclusions were unchanged. I also created a measure similar to a Hefindahl-Hirschman Index. I found each agency's share of an alliances as ($\frac{WIC\ Infants_i + .5*(nonWIC\ Infants_i)}{\sum_{i\in A}(WIC\ Infants_i)+0.5*\sum_{i\in A}(nonWIC\ Infants_i)}$, then squared each share and summed the squared shares. Results were similar to those reported using the Gini index, but the Gini results were more consistently statistically significant.

[22]I ran all models in table 5 including Gini as a regressor; the coefficients on *WIC Infants, WIC Infants Sq., AlliancexWIC Infants,* and *AlliancexWIC Infants Sq.* were not statistically significant, jointly or individually.

In the second column, I drop the *WIC Infants Sq.* variable because it is not significant and to mitigate multicollinearity. The coefficients on *Alliance x WIC Infants* and *Alliance x WIC Infants Sq.* are statistically significant. Using these results and holding all other variables constant, the marginal effect of *Alliance WIC Infants* is -0.264 + (2 x .015 x *Alliance x WIC Infants)*. Setting the marginal effect equal to zero and solving gives the value for *Alliance x WIC Infants* at which net price is minimized, 8.6363 (when all other variables are held constant). The variable is denominated in 10,000s of infants, and so net price declines until the number of non-breastfeeding WIC infants in an agency reaches about 86,363. Given that the average in-hospital breastfeeding rate for WIC infants is about 54.85 percent, 86,363 non-breastfeeding infants implies about 191,280 participating WIC infants. The corresponding calculation using the results from the first column implies net price declines until an agency reaches 161,834 infants. That is, the estimates here suggest that winning net-price bids decline until an agency serves well over 100,000 participating WIC infants.[23]

Conclusion

This paper examines infant-formula manufacturers' bidding practices in WIC rebate auctions and focuses on the role of agencies that form alliances. I estimate an equation of 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 net prices. This result is robust in that the coefficient is identified only by time-series variation in an alliance dummy variable, since the model includes state-agency dummy variables. State agencies receive lower net prices 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 net prices.

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[23]The alliance with the largest number of participating WIC infants was the Texas, Minnesota, Iowa alliance with about 279,000 infants in 2007.

Net-price bids are found to be negatively related to the number of infants in an alliance. But the size effect accrues only to agencies in alliances, which suggests that alliances provide agencies a bargaining advantage. I speculate that alliance size is correlated with alliance heterogeneity, and that heterogeneity is the true source of bargaining advantage as suggested in Dana (2012). I test the hypothesis by including a Gini index to measure the degree of inequality among alliance members. The results indicate that agencies in more heterogeneous alliances receive lower net prices, and that size is a much weaker net-price determinant once heterogeneity is controlled.

The evidence suggests that alliances can reduce costs by increasing the heterogeneity of their member agencies, while holding size constant. In practice this might be difficult as an alliance cannot become more heterogeneous without increasing in size, unless it changes the mix of member agencies. Asking agencies to leave an alliance might be politically impractical.

Because heterogeneity and size seem inextricably linked, I investigate the negative relationship between size and net price. Estimates suggest that net prices decline with size until an alliance serves over 190,000 participating infants. However, in 2004 Congress limited alliance size. If an alliance had more than 100,000 participating infants it could not add more state agencies to increase its size. Alliances that had not reached 100,000 participating infants were prevented from growing beyond 100,000. The results here suggest the WIC program could benefit from reconsidering this restriction and allowing alliances to increase in size beyond 100,000 participating infants.

Table 1. Summary statistics

Variable	N	Mean	Std. Dev.	Min.	Max
Net price (2007 US dollars)	371	0.41	0.26	0.08	1.58
Alliance Distance (thousands of miles)	371	0.637	0.477	0	4.407
Rival Distance (thousands of miles)	371	0.777	0.463	0.092	4.115
Uncoupled	371	0.194	0.396	0	1.00
Previous	371	0.426	0.495	0	1.00
DHA/ARA	371	0.30	0.46	0	1.00
Alliance	371	0.53	0.50	0	1.00
Alliance Number	371	5.96	7.49	1.00	22.00
WIC Infants (ten thousands)	371	3.87	3.05	0.09	16.83
Wholesale Price (2007 US dollars)	371	3.21	.357	2.38	4.01
Powder	371	0.31	.464	0	1.00
Two Bidders	371	0.53	0.50	0	1.00
Three Bidders	371	0.37	0.48	0	1.00
Four Bidders	371	0.07	0.26	0	1.00
Gini Index	371	.215	0.22	0	0.54

Table 2. Net Price Regressions without Size Variables

Variable Name	(1)	(2)
Alliance	-0.413***	
	(0.094)	
Alliance Number		-0.021***
		(0.005)
Wholesale Price	-0.326***	-0.359***
	(0.078)	(0.07)
Two Bidders	-0.852***	-0.754**
	(0.3186)	(0.301)
Three Bidders.	-0.502	-0.443
	(0.3118)	(0.294)
Four Bidders	-0.680**	-0.836***
	(0.3232)	(0.303)
Alliance Distance	0.106**	0.112***
	(0.0439)	(0.0413)
Rival Distance	-0.025	0.046
	(0.0583)	(0.0572)
DHA/ARA	0.353***	0.373***
	(0.0612)	(0.0595)
Powder	-0.093**	-0.116***
	(0.0461)	(0.0419)
Previous	0.062*	0.057*
	(0.034)	(0.0318)
Uncoupled	0.054	0.076
	(0.081)	(0.0845)
Constant	2.288***	2.273***
	(0.4028)	(0.3714)
N	371	371

* p<0.10, ** p<0.05, *** p<0.01 Specifications include firm and state dummy variables. Standard errors in () corrected for arbitrary correlation (clustering) within agencies.

Table 3. Net Price Regressions with Size Variables

	(1)	(2)	(3)	(4)
Alliance	-0.248			0.307
	(0.20)			(0.344)
Alliance Number		-0.022***		
		(0.008)		
WIC Infants	-0.017	0.003	-0.042***	0.016
	(0.021)	(0.018)	(0.012)	(0.026)
Alliance x WIC Infants				-0.087**
				(0.044)
N	371	371	371	371

* p<0.10, ** p<0.05, *** p<0.01. Specifications include firm and state dummy variables and all other variables included in table 2. Standard errors in () corrected for arbitrary correlation (clustering) within agencies.

Table 4. Net Price Regressions with Measures of Alliance Heterogeneity

Variable Name	(1)	(2)	(3)
Alliance	1.373**	1.376**	1.333**
	(0.613)	(0.616)	(0.641)
Gini Index	-3.332***	-3.671***	-3.809**
	(1.166)	(1.280)	(1.555)
WIC Infants		0.018	0.016
		(0.025)	(0.030)
Alliance x WIC Infants			0.016
			(0.088)
N	371	371	371

* p<.10, ** p<0.05, *** p<0.01 Specifications include firm and state dummy variables and all other variables included in table 2. Standard errors in () corrected for arbitrary correlation (clustering) within agencies.

Table 5. Net Price Regressions with Nonlinear Size Effects without Heterogeneity

	(1)	(2)
Alliance	1.112	0.908*
	(0.712)	(0.479)
WIC Infants	0.272	0.011
	(0.170)	(0.027)
WIC Infants Sq.	-0.012	
	(0.008)	
Alliance x WIC Infants	-0.643**	-0.264***
	(0.321)	(0.092)
Alliance x WIC Infants Sq.	0.044*	0.015**
	(0.023)	(0.006)
N	371	371

p<.10, ** p<0.05, *** p<0.01 Specifications include firm and state dummy variables and all other variables included in table 2. Standard errors in () corrected for arbitrary correlation (clustering) within agencies.

Table 6. Simple Correlation Coefficients

	Alliance	*Alliance Number*	*WIC Infants*	*WIC Infants Sq.*	*Alliance x WIC Infants*	*Alliance x WIC Infants Sq.*	*Gini Index*
Alliance	1.000						
Alliance Number	0.626	1.000					
WIC Infants	0.390	0.361	1.000				
WIC Infants Sq.	0.238	0.156	0.936	1.000			
Alliance x WIC Infants	0.765	0.587	0.743	0.602	1.000		
Alliance x WIC Infants Sq.	0.520	0.334	0.767	0.704	0.925	1.000	
Gini Index	0.913	0.706	0.516	0.350	0.847	0.642	1.000

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