Demand Spillover and Inequality in the WIC Program*

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Abstract

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a large U.S. government program that provides infant formula to low income households. States procure infant formula through auctions of sole-sourced exclusive supply contracts and in total, purchases infant formula for about 50% of all U.S. infants. This paper studies the impact of the WIC program on consumer behavior and equilibrium infant formula prices with a focus on the spillover effect of the WIC program on households who are not eligible for the program. Using household-level data and the timing of WIC contract changes across states, we estimate large spillover effects on market shares among non-WIC households but only small changes in retail prices. However, these estimates do not take into account possible equilibrium effects on optimal pricing behavior from introducing a competing WIC-branded product in the market. To account for equilibrium effects on prices, we estimate a structural demand and equilibrium pricing model where we allow for heterogeneous preference for the WIC brand. Preference for the WIC brand may stem from consumer misperception of the WIC brand as a higher quality product hence creating artificial vertical differentiation in the market. We show that the estimated distribution of preference for the WIC brand leads to significantly higher equilibrium spillover effects on retail prices for all infant formula products. Finally, we find that lower income, non-college educated and minority non-WIC households tend to prefer the more expensive premium and WIC-branded products and thus are disproportionally affected by the increase in retail prices.

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The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

1 Introduction

Government programs intended to provide goods and services to a specific population can have impacts on the rest of the market. For example, Medicare fee schedules are intended for providers of Medicare-insured patients, but a $1 increase in Medicare's fees can increase private payments by more than $1 (Clemens and Gottlieb, 2017). As another example, Low-Income Housing Tax Credits intended for low-income households can either depreciate or appreciate neighboring housing values depending on income heterogeneity in these neighborhoods (Woo, Joh, and Van Zandt, 2016).

In this paper, we study a large government nutrition program whose implementation dramatically changes market shares and may impact prices. The Special Supplemental Nutrition Program for Women, Infants and Children (WIC) distributes essential foods such as infant formula to low income households, and serves as much as 50% of US infants[1]. To curb the high cost of infant formula for the WIC program, federal regulations require states to procure infant formula through competitive auctions. In each state, the winning manufacturer receives an exclusive contract to supply all the infant formula for WIC participants over several years. Participating households receive vouchers for the WIC supplier's formula that are redeemed at retail stores, and the government then reimburses the retailer for the retail price. A manufacturer that receives this exclusive contract can experience an increase in market share from 10% to 90% (Oliveira, Frazao, and Smallwood, 2011). While some of this increase is due to the 50% of US infants mechanically purchasing the WIC supplier's product because they participate in WIC, the remaining increase must be due to non participants purchasing the WIC supplier's product even though they obtain no benefit from the government for doing so.

We measure the impact of the WIC program on infant formula market shares and prices, focusing on the effect on households that do not participate in the program. Using household-level data on infant formula purchases and demographics, we analyze the purchasing behavior of households that do not qualify for WIC based on income and therefore directly quantify the WIC "demand spillover effect". To analyze the WIC spillover effect on prices, we estimate a structural model of demand with heterogeneity in brand preferences and combine it with a simple firm pricing model to account for important equilibrium price effects due to WIC. Finally, because our demand model allows us to estimate how brand preferences vary based on observed demographics, we can identify the segment of the non-WIC household population that is most affected by the spillover effect.

[1] https://www.ers.usda.gov/topics/food-nutrition-assistance/wic-program/

The demand spillover effect suggests that the WIC program changes the perceived quality of the WIC supplier relative to the quality of the non-WIC manufacturers. One possible explanation for the demand spillover is that since WIC serves half of US infants and the government reimburses retailers for participating households' purchases, retailers compete for WIC participants by prominently displaying the WIC product and allocating better or more shelf space. Because non-WIC households shop in the same stores, the WIC product is then also more salient for non-WIC households. A second explanation is that hospitals are more likely to recommend or carry samples for formula supplied by the WIC supplier, so new mothers exposed to such "advertising" perceive the WIC product as higher quality. Peer effects offer a third explanation; new mothers may observe their friends using the WIC supplier without knowing that the product was obtained for free. All these mechanisms for the demand spillover can be considered changes in perceived quality. These changes in perceived quality then has the potential to also dramatically change infant formula prices.

Existing work has primarily relied on comparing prices between WIC and non-WIC suppliers (Oliveira, Prell, Smallwood, and Frazao (2004)) or comparing prices of manufacturers before and after the winning manufacturer replaces the incumbent WIC supplier (Oliveira, Frazao, and Smallwood (2011); Rojas and Wei (2019)) using plausibly exogenous variation in the timing of the contract change. Although the literature has documented a dramatic impact on market shares using this identification strategy, the general consensus is that prices increased only modestly. For example, Oliveira, Frazao, and Smallwood (2011) find that the price of the new WIC brand relative to the former WIC brand on average increases by less than 2%, and only increases in half the states.

In this paper we argue that comparing the prices of winners and losers is inadequate to capture the true equilibrium price effects of the WIC program. If the WIC program changes the perceived quality of the WIC supplier relative to other manufacturers, then this creates vertical differentiation across the infant formula brands. When their is sufficient variation in how much consumers care about quality, vertical differentiation in turn can segment the market and soften price competition. Analyses that do not account for manufacturer equilibrium responses to vertical differentiation may therefore underestimate WIC's impact on prices.

To quantify equilibrium effects of WIC on infant formula prices, we first develop a stylized conceptual model of horizontally and vertically differentiated duopoly model with consumers that have heterogeneous taste for quality. In this model, the WIC brand is viewed as the higher quality product while non-WIC brand is of lower quality. We show that if consumers are sufficiently

heterogeneous in their taste for quality, then prices of both the WIC and non-WIC brand are above the price without vertical differentiation. We also show that ignoring the equilibrium price effect of vertical differentiation may understate the spillover price effect on the WIC brand's price.

Motivated by the results from our conceptual model, we estimate a discrete choice demand model that allows for heterogeneous taste for the WIC brand, for premium brands, and for size. We find that lower income (but over WIC's income eligibility criterion), non-college educated, and minority households tend to have strong preference for WIC and are more likely to purchase the more expensive premium branded and regular-sized infant formula. We then use the estimated demand model to simulate equilibrium prices under two scenarios. The first scenario is the status quo where we calibrate marginal cost to match observed prices assuming differentiated Bertrand competition. Using the calibrated marginal cost, we then simulate equilibrium prices in a second scenario where we shut down the taste for the WIC brand. In this scenario, there is no vertical differentiation beyond what is already captured by premium brand effects.

We find substantially larger increases in prices due to the WIC spillover effect when we account for the equilibrium effects of vertical differentiation. In our price regressions that essentially compare the prices of winners and losers of the WIC contract, we estimate price effects to be an increase of at most 1% (less than a cent per oz). In contrast, we find price effects to range from 10% (an increase from \$1.18 to \$1.30 per oz) to as large as 40% (an increase from 65 cents to 91 cents per oz) when accounting for equilibrium effects. The equilibrium price effect varies by manufacturer and by product size. Moreover, all infant formula products, even those that are not from the WIC brand, experience price increases. For example, even the store brand which is never a WIC product raises its price from 62 cents per oz to 67 cents per oz when there is a WIC product in the market.

This paper contributes to the existing body of literature that documents the substantial effect of the WIC infant formula procurement program on market shares. Using scanner data on infant formula retail sales at the state-level, Oliveira, Frazao, and Smallwood (2011) document that the market share of a manufacturer increases by 74 percentage points after winning the WIC contract. Choi, Ludwig, Andreyeva, and Harris (2020) and Rojas and Wei (2019) quantify the increase in market share using variation in the shares of eligible and non eligible products as states' WIC suppliers change over time. Huang and Perloff (2014) infer the spillover effect using scanner data by assuming that WIC participants respond to contract changes immediately while non-participants respond with a lag. We contribute to this body of work by directly quantifying the impact of becoming the WIC supplier on non-participating households' purchasing behavior using individual-

level panel data. Using individual-level data allows us to identify non-participating households and show that purchases of the WIC brand by non-participants also increase dramatically even as early as the first month of a contract change. Furthermore, we find that our estimated effect is driven mainly by first time purchases as opposed to existing non-WIC households switching to the new WIC contract winner. Indeed, we find evidence of very strong brand loyalty and some evidence that brand loyalty is even stronger when it is the WIC brand. Finally, because we can tie purchases to specific demographic variables, we also provide novel insights on the distributional impacts of the WIC spillover effect.

This paper also contributes to the literature studying the impact of WIC on retail prices in general. Meckel (2020) studies the price effects of a reform in the Texas WIC program that prevents retailers from charging different prices to participating and non-participating households. She finds that smaller vendors increase prices by 6.4% and that government savings come at a cost to non-participating households. McLaughlin, Saitone, and Sexton (2019) studies the impact of authorizing stores that earn above 50% of their food revenue through WIC ("A50" stores). They find that given the restriction that A50 stores cannot charge more than the average charged by other WIC vendors for the same product, A50 stores decreased program costs relative to a world in which A50 stores are not authorized. We contribute to this literature by providing evidence of a significant price increase driven by the WIC infant formula procurement program. Our paper is the first to estimate the substantial equilibrium price effect of WIC sole-source contracting and to show the importance of consumer heterogeneity in determining equilibrium effects.[2]

Finally, our work is also related to the literature that investigates the effect of consumer misperception about product attributes on market outcomes. Bronnenberg, Dubé, Gentzkow, and Shapiro (2015) for example show that misinformation and consumer mistakes explain the high willingness to pay for branded health products relative to the corresponding store brand. Abito and Salant (2019) examine the extended warranty market and provide observational and experimental evidence that overestimation of product failure rates drive the high willingness to pay for extended warranties on TVs. They show that providing information about product failure rates is more effective in improving consumer welfare as opposed to introducing more competition in this market. We contribute to this literature by studying the potential role of a large and important government program in actually driving consumers' quality perception about products. Moreover,

[2] An, Davis, Huang, Liu, and Xiao (2017) also study the equilibrium effects of sole source contracting in the context of WIC and infant formula but does not explicitly take into account consumer-level heterogeneity. The currently available version of their paper (2007 IIOC) does not provide the estimates of the price effects yet.

we show that the effect on pricing depends on heterogeneity in preferences for product attributes and explore its distributional implications.

The paper proceeds as follows. Section 2 provides a background on the infant formula market and the auction procurement process. Section 3 presents the data. Section 4 presents reduced-form analyses on the effect of winning the WIC auction on market shares and retail prices. Section 5 estimates the equilibrium effects. The final section concludes.

2 Background

2.1 Infant formula market

Infant formula is an essential product with limited substitutability. Although the American Academy of Pediatricians recommends exclusively breastfeeding infants for the first year of life[3], many women do not produce enough milk or lack the support needed to breastfeed. 6 month breastfeeding rates are 59% for Asian, 45% for white and Hispanic, and 28% for black mothers[4]. Thus, a household that is considering purchasing infant formula likely does not have breastfeeding as an outside option if infant formula prices increase. Additionally, if breast milk is not available, infant formula cannot be produced at home because a baby's nutritional needs are very specific and any contamination or imbalance in vitamins and minerals can cause serious health consequences [5].

The infant formula market is heavily regulated. Infant formula falls under section 412 of the Federal Food, Drug and Cosmetic Act. The act lays out minimum standards for the nutrient content, quantity and quality of infant formula, along with requirements for recordkeeping and recall practices. The act also requires all infant formula manufacturers to register with the US Food and Drug Administration (FDA). The act also gives the FDA the authority to set and adjust requirements for nutrient quality control standards, submission requirements, labeling and nutrient specifications[6]. All formula sold legally in the US is reviewed by the FDA, which regularly inspects formula products and the manufacturing facilities where they are made[7]. Heavy regulations that differ from those in other counties and import tariffs have together limited imports of formula into the US. 4 companies together produce 90% of infant formula sold in the US, and only 2% is

[3]https://www.cdc.gov/nutrition/infantandtoddlernutrition/breastfeeding/recommendations-benefits.html
[4]https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4410446/
[5]https://www.cdc.gov/nutrition/infantandtoddlernutrition/formula-feeding/choosing-an-infant-formula.html
[6]https://www.ibisworld.com/united-states/market-research-reports/infant-formula-manufacturing-industry/
[7]https://www.cdc.gov/nutrition/infantandtoddlernutrition/formula-feeding/choosing-an-infant-formula.html

imported[8].

2.2 The WIC program and auctions

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a federal assistance program of the Food and Nutrition Service (FNS) of the United States Department of Agriculture (USDA) that aims to supplement the health of at-risk low-income pregnant, postpartum, and breastfeeding women, infants, and children up to age five[9]. It is the third largest food and nutrition assistance program and served about 6.2 million participants per month in fiscal year 2020, including almost half of all infants born in the United States[10]. The WIC program provides certain foods to eligible participants, including powdered infant formula, infant cereal, and other dietary supplements for children and mothers. Based on the estimates by USDA, in 2017, 2.2 million infants (56 percent of all infants in the United States) were eligible for WIC and 79% of eligible infants participated in the program[11]. This paper focuses on milk-based powder formula, which accounts for 72% of all infant formula in dollar sales to WIC and non-WIC consumers[12].

WIC is an expensive program, with annual costs totalling about $6 billion[13]. Since the late 1980s, WIC State agencies have attempted to control costs by holding auctions in which infant formula manufacturers offer discounts in return for the exclusive right to supply the state's WIC program. WIC participants are then given vouchers for a specific brand and quantity of the winner's product to redeem at retail stores, who then bill the federal government at their retail price for each redeemed voucher.

To determine the brand that supplies WIC, the federal government holds auctions where manufacturers bid a rebate paid to the government for each redeemed voucher, and a wholesale price that puts the rebate into context. The lowest net price (wholesale price - rebate) wins the auction. Demand for a manufacturer's produce increases when a manufacturer becomes the WIC supplier not only because WIC participants purchase their products, but because non-participants also shift consumption to the winner's products. The manufacturer therefore trades off losses from providing rebates with gains from increased demand from retailers for their product. In particular, non-

[8] https://www.theguardian.com/us-news/2022/may/18/baby-formula-shortage-why-is-there-none-what-to-do-causes-explained

[9] https://www.fns.usda.gov/wic/about-wic

[10] https://www.ers.usda.gov/topics/food-nutrition-assistance/wic-program/

[11] https://www.fns.usda.gov/wic-2017-eligibility-and-coverage-rates

[12] https://www.ers.usda.gov/amber-waves/2011/september/infant-formula-market/

[13] https://www.cbpp.org/research/food-assistance/wics-competitive-bidding-process-for-infant-formula-is-highly-cost

participating households' dramatic shift to the winner's product may incentivize manufacturers to bid high rebates that are close to or even *above* their wholesale price.

Increasing demand for the WIC supplier's product also allows retailers to increase prices. In particular, since WIC participants receive formula for free, price increases only decrease sales to non-participating households. The limited responsiveness of sales to prices potentially allow retails to increase prices dramatically with little decrease in unit sales. Retail price regulations have therefore been put into place to curb retailer pricing power.

Sole source contracts were not always the preferred method of saving costs. In the 1980s, infant formula prices increased more than the rate of inflation, leading states to investigate ways to limit formula costs. The states that were successful in providing formula at reduced cost used methods that favored the provision of a single brand of formula. Some states provided exclusive selling rights and solicited sealed rebate bids ("competitive sole source system"), while other states negotiated rebate amounts with manufacturers, usually did not use sealed bids, and did not provide exclusive selling rights ("open market system"). The method that would provide the greatest cost savings was in doubt during the early years of adoption, which some states requesting bids under both systems, which usually led to the adoption of a sole source competitive bidding system. In 1989, federal law required all state agencies to adopt a competitive bidding process or another process that provided equal or greater savings, and defined competitive bidding as a procurement process in which the State WIC agency selects the single source offering the lowest price for the infant formula, as determined by the submission of sealed bids[14].

3 Data

We combine individual panel data on purchases with WIC auction bids, and collect several disjoint datasets on program regulation and contracts from the USDA and individual states.

Individual purchases. Our primary data come from Nielsen Homescan for 2006-2019, which include rich demographic information including race, income, education, household size, and voluntary reporting of program participation. Of the 12,000 households who purchased powdered infant formula during this period, we focus on the 9,000 households who did not report receipt of WIC benefits *and* did not qualify for WIC benefits because their reported income was above 185% of the federal poverty level for their household size.

[14] https://ideas.repec.org/p/sda/workpa/12008.html

Prices. We supplement individual purchase data with retail scanner data to construct the set of products and prices that each individual faced but did not purchase. Store-week level prices and quantities come from Nielsen Retail Measurement Services.[15]

WIC auction records. To examine non-participating households' purchases in states in which a new winner replaces the incumbent manufacturer, we combine data on WIC auction bids of rebates and wholesale prices, winners, and contract start and end dates between 1988 and 2019 provided by Professor David Davis[16]. We have also collected supplemental contract and bid data directly from the USDA.

We plan to use several other datasets to supplement our purchase and auction data.

- **Price and advertising regulations.** States implement retail price caps and restrictions on advertising and hospital discharge pack provision to limit the influence of the WIC supplier on consumer behavior. We will collect data on retail price caps, advertising, and discharge pack regulations from the USDA and individual states to model manufacturers' pricing decisions and consumer purchase response to advertising.

- **Contract details.** Auction bids consist of a rebate off the manufacturer's wholesale price bid, and the manufacturer with the lowest net price (wholesale price - rebate) wins the auction. The USDA notes that manufacturers may offer rebates above wholesale prices if increased sales from non-WIC consumers offset losses from WIC consumers (Oliveira, Frazao, and Smallwood, 2011). While we corroborate the existence of negative net prices in our data, it is unclear how manufacturers are bound by the wholesale price bid in sales to retailers. We will collect data on how these wholesale prices are used from the USDA and individual states to model manufacturers' supply of infant formula.

3.1 Summary Statistics

We first examine Homescan panelists who do not participate in WIC and make at least two separate trips between 2006-2016. Table 1 shows that these households make on average 10 trip-upc purchases over 13 months. They purchase 16 cans of formula containing 365 ounces of powder, of which 139 ounces are purchased from the WIC supplier for that state and month. On average, they pay $330 for formula over the period of study. The average number of manufacturers purchased is

[15]Nielsen Homescan, Retail Measurement Services, and Ad Intel are provided by the Kilts Center for Marketing at the University of Chicago Booth School of Business.

[16]https://econpapers.repec.org/paper/sdaworkpa/12008.htm

1.6.

Table 1: Non-WIC household characteristics conditional on at least 1 month in data

	N	mean	sd	min	p25	median	p75	max
trips	4,860	9.8	9.7	2.0	3.0	7.0	12.0	103
brands purchased	4,860	1.6	0.7	1.0	1.0	1.0	2.0	4
cans	4,860	16.1	18.2	2.0	5.0	10.0	21.0	244
oz	4,860	365.3	400.7	24.0	102.2	231.3	490.1	4,284
WIC oz	4,860	138.7	270.2	0.0	0.0	25.8	153.3	4,113
total price paid	4,844	331.0	381.2	8.3	90.4	203.9	431.7	7,012
duration	4,860	13.5	17.8	2.0	4.0	7.0	12.0	131

Note: Table shows the number of trips taken by each household from 2006-2016, as well as cans of formula, ounces of formula, ounces of formula purchased from the WIC supplier, price paid, and the duration from the first purchase to the last purchase. Households with a duration of at least one month are represented.
Source: Nielsen Homescan Data.

We now examine manufacturers' market shares across all households in the Homescan data. The infant formula industry is dominated by three firms, Abbott, Mead Johnson, and Nestle, with stores also offering their own brands. Table 2 displays market shares within two different size categories. Since powdered infant formula provided by the WIC program come in containers containing between 12-16 ounces of powder, we refer to these containers as "regular" sizes and larger containers as "bulk" sizes. Abbott and Mead Johnson together capture 75% (62%) of households' purchases of regular (bulk) sized formula. Since Homescan panelists purchase 12-16 oz cans almost exclusively from the 3 premium brands, we omit store brand purchases in regular sizes beginning in the descriptive analysis in Section 3.

Figure 1 displays price paid by households in our sample by manufacturer, size, and whether the manufacturer was the WIC supplier. Abbott and Mead Johnson set the highest prices, with Nestle priced lower. Store brands are half the price of the 3 premium brands. The Abbott and Mead Johnson products are priced lower and Nestle products are priced higher when the manufacturer wins the WIC contract. This is consistent with retailers increasing Nestle prices due to increased demand and inelastic demand from WIC participants when Nestle wins the contract, and with retail price caps curbing prices when the most expensive premium brands win the WIC contract. Prices for bulk products are similar regardless of whether manufacturer wins the WIC contract.

Table 2: Manufacturer share of powdered milk containers

manufacturer	Regular cans	Regular share	Bulk cans	Bulk share
ABBOTT	27,367	0.37	20,473	0.30
MEAD JOHNSON	27,161	0.37	21,513	0.32
NESTLE	18,883	0.25	7,698	0.11
STORE	723	0.01	18,367	0.27

Note: Table shows the number and share of cans that Homescan households purchase from each manufacturer in regular and bulk size containers. Regular size refers to12-16 oz and bulk size refers to containers larger than 16 oz.
Source: Nielsen Homescan Data 2006-2016.

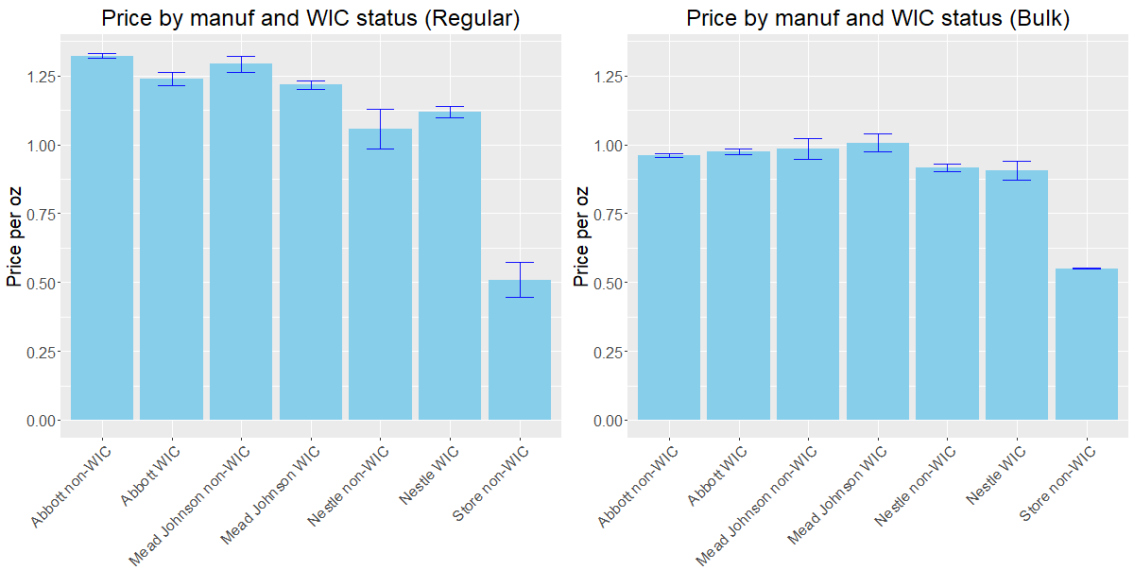


Figure 1: Price by Manufacturer and WIC Status

Note: Panels show price per oz for each manufacturer, for periods where the manufacturer is or is not the WIC supplier. The left panel shows prices for 12-16 oz containers (regular size) and the right panel shows prices for containers above 16 oz (bulk size). 95% confidence intervals are shown.
Source: Nielsen Retail Scanner Data, auction data provided by David Davis. Years 2006-2016 are represented.

Table 3 describes the wholesale and rebate bids at auction conditional on winning contracts for powdered milk from 2006 to 2017, and the retail prices of regular sized products for comparison. Contracts generally last between 3-4 years. Winning bids offer rebates between \$.9 and \$.95 per ounce, given wholesale prices of \$1 per ounce. Retailers then charge prices between \$1.1 to \$1.25 per ounce. This suggests that manufacturers are willing to offer rebates around 90% of the wholesale price. One one hand, we observe that the government receives rebates of 70-80% off the retail price, suggesting that offering a single manufacturer the exclusive right to supply WIC participants may allow the government to save on costs. On the other hand, this may also suggest the presence of

Table 3: Auction bids conditional on win

varname	manuf	n	mean	sd	min	q25	q50	q75	max
Contract Length		64	1,269.52	332.55	364	1,095	1,095	1,460	1,829
Rebate	Abbott	58	0.95	0.18	0.55	0.81	1.01	1.03	1.31
Rebate	Mead Johnson	38	0.90	0.15	0.67	0.79	0.90	0.99	1.32
Rebate	Nestle	28	0.91	0.16	0.72	0.77	0.84	1.03	1.17
Wholesale	Abbott	58	1.02	0.12	0.86	0.90	1.06	1.14	1.23
Wholesale	Mead Johnson	38	1.02	0.10	0.86	0.91	1.01	1.11	1.23
Wholesale	Nestle	28	1.00	0.10	0.86	0.94	0.95	1.05	1.17
Retail price	Abbott	55	1.25	0.12	1.05	1.13	1.30	1.34	1.49
Retail price	Mead Johnson	40	1.23	0.14	1.00	1.12	1.22	1.33	1.50
Retail price	Nestle	28	1.13	0.15	0.90	1.01	1.09	1.21	1.44
Rebate to wholesale ratio	Abbott	58	0.92	0.09	0.47	0.90	0.95	0.97	1.06
Rebate to wholesale ratio	Mead Johnson	38	0.88	0.07	0.75	0.81	0.87	0.91	1.07
Rebate to wholesale ratio	Nestle	28	0.90	0.08	0.77	0.86	0.89	0.97	1.05
Rebate to retail ratio	Abbott	54	0.76	0.10	0.40	0.71	0.75	0.81	0.98
Rebate to retail ratio	Mead Johnson	38	0.73	0.06	0.62	0.70	0.73	0.76	0.88
Rebate to retail ratio	Nestle	28	0.80	0.07	0.69	0.74	0.81	0.84	0.99
Wholesale to retail ratio	Abbott	54	0.82	0.03	0.76	0.79	0.81	0.85	0.92
Wholesale to retail ratio	Mead Johnson	38	0.83	0.03	0.74	0.82	0.83	0.85	0.90
Wholesale to retail ratio	Nestle	28	0.89	0.04	0.76	0.87	0.89	0.91	0.96

Note: Table presents contract length in days, rebate bids, wholesale bids, and retail price in dollars per oz, and ratios of rebate to wholesale bids, rebate bid to retail price, and wholesale bid to retail price. Wholesale bids represent a listed national wholesale price and need not correspond to actual prices paid by retailers.

Source: Contract length, rebate bids, and wholesale bids come from auction data provided by David Davis. Retail price comes from Nielsen Retail Scanner data. Years 2006-2017 are represented.

low marginal costs and high markups.

Table 4 shows the transition matrix between households' first purchase and last purchase, categorized by the 5 types of products. We see sticky preferences for premium vs store brands, sizes, and WIC manufacturers, with deviations from sticky size preferences explainable by the growth of the infant.

Households that purchase bulk products overwhelmingly stay with their category of purchases. 38% of premium regular purchasers continue to purchase premium regular, with 35% switching to premium bulk. Such behavior could be driven by the growth of the infant. 56% of premium regular WIC purchaser stay with this purchase, with 22% switching to premium bulk WIC, which again could be driven by infant growth and a continued preference for the WIC manufacturer's product.

We show evidence of strong brand loyalty, illustrating a dynamic benefit of capturing market share today. We examine the interaction of brand loyalty and purchasing from a WIC supplier

Table 4: Dynamic product choice

	Last Purchase										
	Prem bulk		**Prem bulk wic**		**Prem reg**		**Prem reg wic**		**Store bulk**		**Total**
First Purchase	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Premium bulk	937	69	129	9	107	8	39	3	155	11	1,367
Premium bulk wic	111	10	731	66	17	2	140	13	113	10	1,112
Premium regular	193	35	50	9	210	38	47	8	59	11	559
Premium regular wic	59	7	201	22	49	5	500	56	85	10	894
Store brand bulk	50	7	41	6	12	2	23	3	588	82	714

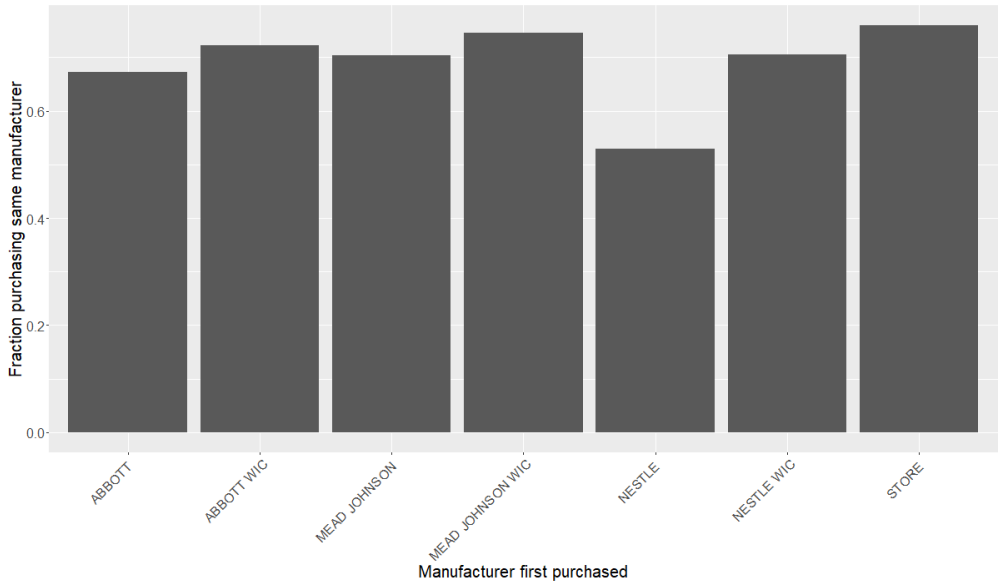
Note: Table examines the first and last purchases of Homescan panelists who do not participate in WIC and whose first and last purchases are at least 1 month apart. Purchases are characterized by the manufacturer type (premium vs store brand), size (regular vs bulk), and whether the manufacturer was the WIC supplier in the state and month of purchase. Premium brands are Abbott, Mead Johnson, and Nestle. Regular size refers to 12-16 oz containers and bulk size refers to containers larger than 16 oz.

Source: Nielsen Homescan Data 2006-2016. WIC status come from auction data provided by David Davis.

in table 2, which shows the probability that non-participating households purchase from the same manufacturer in their last purchase as their first purchase. We examine whether this probability differs when the manufacturer of the first purchase is the WIC supplier or not, and find that when the manufacturer of the first was a WIC supplier, the probability of staying with the same manufacturer is slightly greater. However, amongst households who first purchase from one of the 3 premium manufacturers, the probability of staying with the same manufacturer is 70% regardless of whether the manufacturer was the WIC supplier. This suggests that while households that experience a WIC contract change may be only slightly more likely to switch to the new WIC supplier, the market share that the a manufacturer gains by becoming the WIC supplier will include many new parents who are exposed to the brand and will continue to be brand loyal.

Because winning the WIC contract in a given state dramatically increases market share within that state, we provide evidence that manufacturers are careful not to win when they don't have enough capacity. Figure 3 plots manufacturers' national share of ounces sold for each year in 2006-2016. The upper left panel considers a manufacturer as holding a state's contract if the manufacturer held the contract at any point during the year. The upper left panel shows that manufacturers' shares are stable even when holding different numbers of state contracts, suggesting that manufacturers trade off winning many states with less demand with winning few states with

Figure 2: Brand loyalty



Note: Figure examines the first and last purchases of Homescan panelists who do not participate in WIC. The household's first purchase in 2006-2016 is characterized by the manufacturer and whether the manufacturer was the WIC supplier in the state and month of purchase. The y axis shows the probability that the last purchase is from the same manufacturer.

Source: Nielsen Homescan Data 2006-2016. WIC status come from auction data provided by David Davis.

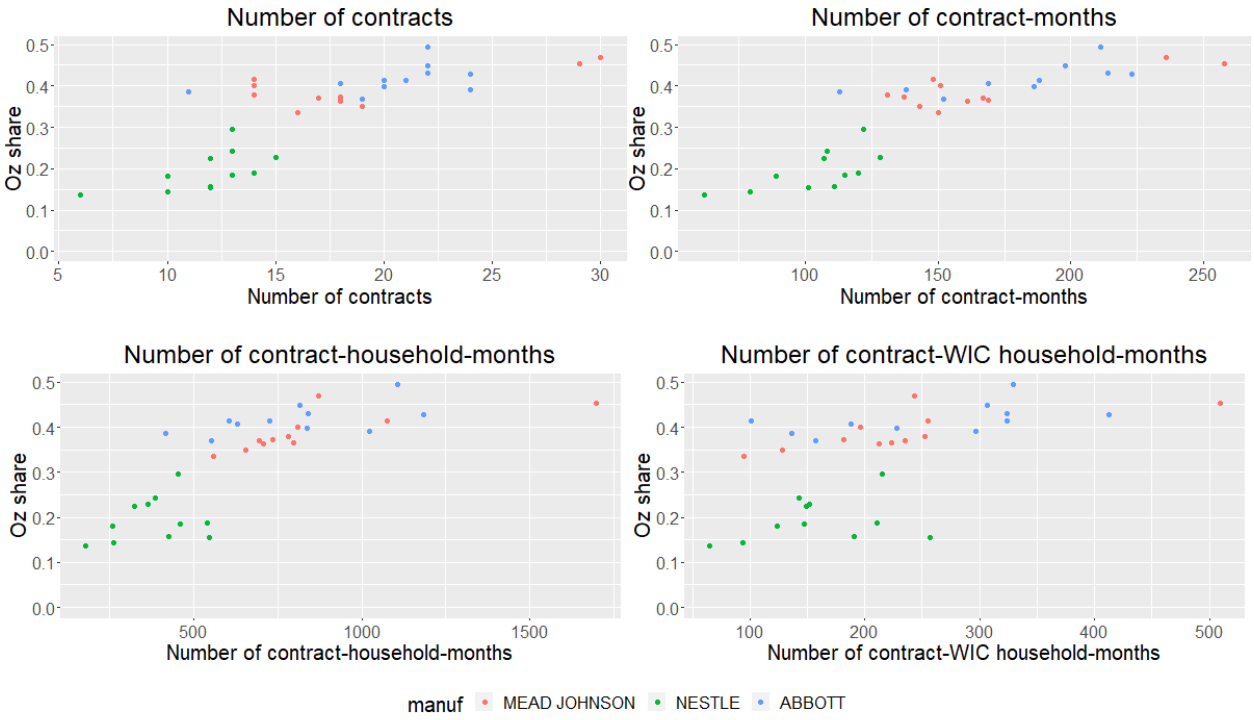
more demand. However, how long a manufacturer holds a contract within the year will affect her annual share. The upper right panel accounts for the number of months that a state's contract is held by showing that manufacturers' annual national shares remain stable as the number of contract-months increase. Similarly, since manufacturer's share depend on the demand in each state, the bottom two panels show that shares remain stable when accounting for the number of Homescan households and Homescan households who report WIC participation or meet income eligibility criteria. This suggests that manufacturers are not building new factories in order to supply a WIC contract and abandoning factories upon termination of a contract, but rather only bidding aggressively when capacity is available.

4 Reduced-form analysis

4.1 Effect on market shares

We first provide reduced form evidence that a manufacturer who wins the auction captures a substantial portion of *non-participating* households' purchases.

Figure 3: National oz share of regular sized containers by number of WIC contracts held



Note: Figure plots manufacturers' national share of ounces sold in each year from 2006-2016 against measures of their obligations to the WIC program. The upper left panel considers a manufacturer as holding a state's contract in a year if she held the contract at any point in the year. The upper right panel accounts for the number of months in each year that states' contracts are held. The bottom left panel accounts for the number of Homescan households who purchase powdered infant formula in the state in which each contract is held. The bottom right panel accounts for the number of Homscan households who report WIC participation or meet income eligibility criteria. Regular size refers to 12-16 oz containers.

Source: Nielsen Homescan Data 2006-2016, David Davis' auction data.

Table 5 examines the shares of non-participating households' purchases of formula in ounces that are captured by each manufacturer in each state and month. Column 1 focuses on regular sized products and shows that a manufacturer's share increases by 31 percentage points after becoming the WIC supplier. For Abbott, the reference manufacturer, shares increase from 44% to 75% after becoming the WIC manufacturer, while Nestle (Mead Johnson) start with slightly lower (higher) shares when not supplying WIC. Column 2 allows the effect of supplying WIC to differ across manufacturers, and estimates that becoming the WIC manufacturer increases Abbott and Mead Johnson's shares by 29 percentage points from baselines of 46% and 51%, while Nestle's shares increase by 35 percentage points from a baseline of 40%. All specifications include state, year, and month fixed effects.

Table 5: Market share regression

	Manufacturer share							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WIC	0.308***	0.291***	0.283***	0.266***	0.057***	0.038***	0.052***	0.033***
	(0.008)	(0.015)	(0.008)	(0.015)	(0.005)	(0.010)	(0.005)	(0.010)
WIC*MEADJ		0.005		−0.002		0.014		0.014
		(0.021)		(0.022)		(0.014)		(0.014)
WIC*NESTLE		0.058**		0.065***		0.060***		0.062***
		(0.024)		(0.025)		(0.016)		(0.017)
STORE BRAND	−0.065	−0.083*	−0.048	−0.067	−0.016	−0.023	−0.006	−0.014
	(0.048)	(0.048)	(0.057)	(0.058)	(0.016)	(0.017)	(0.017)	(0.017)
MEADJ	0.051***	0.048***	0.048***	0.049***	−0.010	−0.015*	−0.013**	−0.019**
	(0.009)	(0.013)	(0.009)	(0.014)	(0.006)	(0.008)	(0.006)	(0.009)
NESTLE	−0.038***	−0.066***	−0.041***	−0.073***	−0.144***	−0.165***	−0.135***	−0.157***
	(0.011)	(0.016)	(0.012)	(0.017)	(0.007)	(0.009)	(0.008)	(0.010)
PRICE	0.018	0.008	0.014	0.002	−0.130***	−0.130***	−0.114***	−0.114***
	(0.026)	(0.026)	(0.027)	(0.027)	(0.035)	(0.035)	(0.036)	(0.036)
Constant	0.440***	0.464***	0.470***	0.495***	0.582***	0.593***	0.602***	0.613***
	(0.040)	(0.042)	(0.042)	(0.044)	(0.036)	(0.036)	(0.037)	(0.037)
Included sizes	Regular	Regular	Regular	Regular	Bulk	Bulk	Bulk	Bulk
Included stores	All	All	Big	Big	All	All	Big	Big
State FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Month FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	5,581	5,581	5,199	5,199	11,812	11,812	11,374	11,374
Adjusted R^2	0.393	0.393	0.374	0.375	0.309	0.310	0.307	0.308

Notes: Dependent variable is a brand's non-WIC market share in a particular state and month. Additional regressors include state, year, and month dummies. Abbott is the excluded category. Regular size refers to 12-16 oz and bulk size refers to containers larger than 16 oz. Big stores are retailers where all three branded infant formula were sold.
*p<0.1; **p<0.05; ***p<0.01

One may be concerned that the gain in market share is driven not by consumers' preferences for the WIC supplier's products but by changes in choice sets induced by stores carrying a manufacturer's products only when are the WIC supplier. Columns 3 and 4 address this concern by limiting the set of stores to "big stores" that sell all 3 premium brands. We find roughly the same spillover effect, suggesting that the spillover effect is not purely driven by unavailability of non-WIC products.

The spillover effect is smaller but still present for bulk sized products. Columns 5 and 6 show that supplying WIC increases a manufacturer's share of bulk sized products by 4-10 percentage points. The effect is particularly strong for Nestle, which experiences an increase of 10 percentage points from a baseline of 44%. Although changes in choice set are less of a concern here because bulk products are not eligible for WIC vouchers, for completeness, in columns 7 and 8, we limit

analyses to stores carrying all three brands to again confirm that the gain in market share is not driven by the unavailability of a manufacturer's products when they are not the WIC supplier.

4.2 Effect on retail prices

Given the large effect of winning or losing a WIC contract on state-level market shares, an obvious question is what happens to prices. As we do not observe the actual wholesale prices that manufacturers charge, we focus on retail prices. In particular, we examine the effect of WIC contract changes on average retail prices using the Retail Scanner data.

Table 6 presents the same 8 models with average retail price per ounce rather than market share as the dependent variable. All specifications control for state, year, and month fixed effects.

Table 6: Price regression

	Price per oz							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WIC	−0.066***	−0.093***	−0.067***	−0.100***	0.002*	0.007***	0.001	0.005**
	(0.004)	(0.008)	(0.004)	(0.008)	(0.001)	(0.003)	(0.001)	(0.003)
WIC*MEADJ		−0.003		0.006		−0.011***		−0.009**
		(0.011)		(0.011)		(0.004)		(0.004)
WIC*NESTLE		0.117***		0.124***		−0.003		−0.004
		(0.013)		(0.013)		(0.004)		(0.004)
STORE BRAND	−0.773***	−0.792***	−0.725***	−0.746***	−0.427***	−0.425***	−0.427***	−0.425***
	(0.023)	(0.023)	(0.028)	(0.028)	(0.002)	(0.002)	(0.002)	(0.002)
MEADJ	−0.013***	−0.012*	−0.024***	−0.028***	0.045***	0.050***	0.046***	0.050***
	(0.005)	(0.007)	(0.005)	(0.007)	(0.002)	(0.002)	(0.002)	(0.002)
NESTLE	−0.181***	−0.234***	−0.190***	−0.246***	−0.061***	−0.060***	−0.060***	−0.058***
	(0.005)	(0.008)	(0.006)	(0.008)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	1.042***	1.066***	1.045***	1.072***	0.873***	0.869***	0.869***	0.866***
	(0.015)	(0.016)	(0.016)	(0.017)	(0.005)	(0.005)	(0.005)	(0.005)
Included sizes	Regular	Regular	Regular	Regular	Bulk	Bulk	Bulk	Bulk
Included stores	All	All	Big	Big	All	All	Big	Big
Observations	5,581	5,581	5,199	5,199	11,812	11,812	11,374	11,374
Adjusted R^2	0.556	0.565	0.544	0.553	0.918	0.918	0.918	0.918

Notes: Dependent variable is a brand's price (per oz) in a particular state and month. Additional regressors include state, year, and month dummies. Abbott is the excluded category. Regular size refers to 12-16 oz and bulk size refers to containers larger than 16 oz. Big stores are retailers where all three branded infant formula were sold. Significance levels: * p<0.1; ** p<0.05; *** p<0.01

Consider the regressions pertaining to regular sizes. When we do not allow the WIC spillover effect on price to vary by manufacturer, the estimated effect on price is negative. When we allow for the spillover effect on price to vary by manufacturer, we find that Nestle's price goes up by

about 2 cents per oz or about 2% of Nestle's price in the sample. In contrast, Abbott and Mead Johnson's price goes down by about 10 cents per oz when either wins the contract. This brings their price closer to Nestle's.

Moving to the regressions with bulk sizes, the spillover effect on bulk retail prices is much smaller. Without allowing for brand specific effects, we do find a positive effect though this is small—about a tenth or two tenths of a cent—and barely statistically significant. When we allow for heterogeneous effects, we find about a half cent per oz increase in Abbott's bulk retail price, and almost no effect for Mead Johnson and Nestle.

Our finding that the effect on retail prices differs by manufacturer may partially explain why the previous literature has only found very modest price effects from winning the WIC contract. More fundamentally, using contract changes to identify the effect of WIC on prices ignores equilibrium pricing. The ideal experiment would have been to compare prices in markets where there is no WIC brand with prices where there is a WIC brand. However, this is not possible. Instead, we estimate a structural model of demand and firm pricing to simulate equilibrium prices in a counterfactual world where consumers are not affected by WIC demand spillovers.

5 Equilibrium effects

This section estimates the equilibrium effects of the WIC program. In particular, we focus on the equilibrium effects of the WIC program on retail prices. We start with a conceptual model that microfounds the increase in demand for the WIC product as an increase in perceived quality of the WIC contract holder's brand relative to the other brands. We then discuss our demand and supply models that we estimate. Finally, using our estimated demand and supply models, we simulate equilibrium prices in a setting where consumers do not see the WIC brand as a higher quality product. We compare this scenario with the (simulated) status quo and this will be our proxy measure for the spillover effect of WIC.

5.1 Conceptual model

Consider two profit-maximizing infant formula manufacturers who have zero production costs and compete directly for a continuum of consumers by setting prices.[17] Although the consumers are

[17] We abstract from two things in terms of the manufacturer's profit maximization problem in our conceptual model. First, we do not model the strategic bidding decision in the procurement auction. Instead, we take the winner of the auction as given and think about the pricing problem. Second, we abstract from the retailer-manufacturer vertical

households that do not participate in WIC, we assume that they may have preference for the WIC brand. In particular, let a consumer i's indirect utility from consuming product k be equal to

$$u_{ik} = -\alpha p_k + \beta_i WIC_k + \epsilon_{ik}$$

where $WIC_k = 1$ if product k is the WIC brand and zero otherwise, and ϵ_{ik} is an idiosyncratic Type I extreme value shock. For our conceptual model, we assume that all consumers have the same $\alpha = 2$ but allow consumers to differ in how much they care about quality, i.e. β_i can differ across i. In particular, we assume that β_i is a draw from a normal distribution with mean of 0.1 and standard deviation of $\rho \in [0.01, 1]$.

Given consumer demand, we solve for the equilibrium prices in two scenarios. The first scenario involves $\beta_i = 0$ for all i. In the second scenario, we solve for equilibrium prices for each ρ from 0.01 to 1 in 0.01 increments.

Figure 4: Equilibrium prices

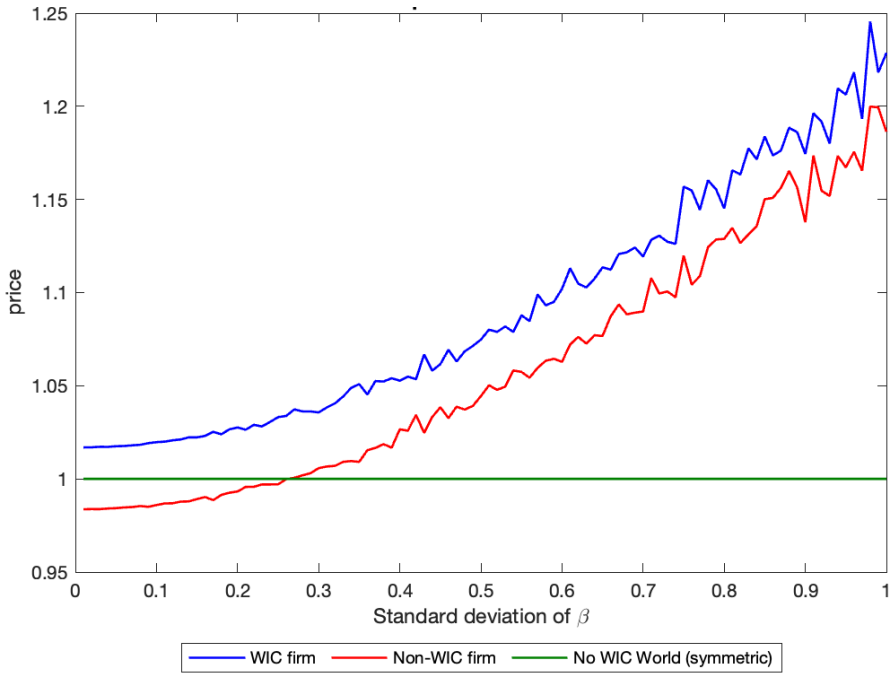


Figure 4 plots the equilibrium prices for the two sets of scenarios. The green line corresponds to the scenario where $\beta_i = 0$ for all i. In this scenario, the products of the two firms are ex-ante identical (up to the ϵ shock), and therefore both firms charge the same price. Because of horizontal differentiation, both firms price above marginal cost. This scenario will serve as our benchmark to

relationship and assume that manufacturers sets retail prices directly.

measure the equilibrium WIC spillover effect on prices.

The blue and red lines correspond to the scenarios where some consumers may value the WIC brand more than the non-WIC brand. For this scenario, the blue line corresponds to the WIC product's price, i.e. the high quality product, while the red line corresponds to the non-WIC product, i.e. the low quality product. When there is no or little variation in β_i, the non-WIC brand sets a prics below the benchmark symmetric price in green. This has the same intuition as the textbook model of vertical differentiation (e.g. Tirole (1988)). When there is a single consumer type, firms cannot segment the market into those who care a lot about higher quality and those than do not. In this case, it would be harder for the low quality product to compete against the high quality product for the same type of consumer, which drives the low quality product's price to marginal cost. When there is sufficient variation in β_i, the two firms can segment the market. The high quality firm will tailor its price to the group that cares a lot about quality while the low quality firm will tailor to the other. With sufficient variation in preference for quality, these tailored prices would be sufficiently far apart such that the high quality firm would not want to lower its price to attract the low quality product's consumers.

In contrast to the textbook vertical differentiation model, the non-WIC brand (low quality product) sets a price above marginal cost because of horizontal differentiation. For low levels of ρ, the non-WIC brand's price may actually be below the benchmark symmetric price. As variation in β_i increases, both high and low quality prices go up and latter may eventually exceed the benchmark symmetric price.

Our conceptual model has two main takeaways. First, ignoring equilibrium price effects hides the fact that the price of the non-WIC brand may actually go up relative to the equilibrium price in the benchmark symmetric case. Second, given that the non-WIC brand's price may actually be above the benchmark symmetric price, one may understate the spillover price effect on the WIC brand's price. The identification strategy that uses WIC contract changes, which essentially compares the price of a particular brand when it is a WIC contract holder and when it is not, identifies the WIC spillover effect as the difference between the blue and red lines. However, this is not the true spillover effect of WIC. Instead, one should be comparing the blue and green lines which gives a much larger spillover effect when there is significant variation in β_i.

5.2 Demand model

The preceding conceptual model shows how heterogeneity in the preference for the WIC brand affects equilibrium prices and thus the WIC program's spillover effect. Motivated by this observation, we estimate a random coefficients logit demand model where we allow heterogeneous taste for price, whether the produce is a premium or store brand, whether the product is sold in bulk or regular size, whether the formula is a special formula, and finally whether the product is the WIC product or not at the time of purchase. Specifically, we assume the the indirect utility for product k is given by

$$u_{ik} = -\alpha p_k + \beta_i WIC_k + \gamma_i BULK_k + \delta_i BRAND_k + \zeta_i SPECIAL_k + \epsilon_{ik}$$

where again, ϵ_{ik} is a Type I extreme value taste shock. Except for the coefficient on $SPECIAL_k$, we allow the preference weights $(\alpha_i, \beta_i, \gamma_i, \delta_i)$ to vary with household level observables including consumer i's income, education (college versus no college), and race. Finally we include an unobserved component for all preference weights (including ζ_i) these can be correlated across product characteristics.

Table 7 contains the coefficient estimates for our demand model. The coefficient estimate on the interaction between income and price implies that households with higher income are less price sensitive. Interestingly households with a college education are actually more price sensitive after controlling for income. Compared to White households, Black households and households that are non-White, non-Asian and non-Black are less price sensitive.

The coefficient on WIC is positive which is consistent with households perceiving the formula from the WIC brand as higher quality. However there is considerable heterogeneity across households. In particular, lower income, non-college educated and Black households tend to have stronger preference for the WIC brand. On the other hand, the coefficient on WIC for households in the highest income categories is close to zero.

Product characteristics that are highly correlated with price are the product's size and whether the product is a premium brand or store brand. In fact, not including $BULK_k$ and $BRAND_k$ in the demand model leads to estimates that imply that higher income households are *more* price sensitive. This is because higher income households tend to purchase the bulk version and also tend to purchase the much cheaper store brand.

To summarize, we find that lower income, non-college educated minorities tend to have a strong

preference for premium and regular-sized products and that this same group of households tend to prefer the WIC brand. As we will see in our counterfactual exercise, this same group of households will be disproportionally affected by the increase in prices due to the WIC spillover.

Table 7: Random coefficients logit estimates

	choice
price	16.04*** (4.21)
lincome * price	−1.28*** (0.38)
college * price	0.71** (0.36)
black * price	−0.06 (0.50)
asian * price	1.03 (0.72)
other * price	−1.47** (0.58)
wic	3.38** (1.47)
lincome * wic	−0.26* (0.13)
college * wic	−0.02 (0.12)
black * wic	0.57*** (0.19)
asian * wic	−0.23 (0.28)
other * wic	0.39 (0.25)
bulk	−10.56*** (1.59)
lincome * bulk	0.98*** (0.14)
college * bulk	0.08 (0.13)
black * bulk	−0.64*** (0.19)
asian * bulk	0.14 (0.30)
other * bulk	0.37 (0.24)
special	−0.93** (0.37)
abbott	2.15 (2.72)
lincome * abbott	−0.16 (0.24)
college * abbott	0.26 (0.22)
black * abbott	0.36 (0.37)
asian * abbott	0.79* (0.46)
other * abbott	−0.39 (0.43)
mj	1.58 (2.88)
lincome * mj	−0.10 (0.26)
college * mj	0.16 (0.23)
black * mj	0.55 (0.38)
asian * mj	0.96* (0.49)
other * mj	0.03 (0.44)
nestle	1.81 (2.85)
lincome * nestle	−0.18 (0.26)
college * nestle	0.04 (0.22)
black * nestle	0.61 (0.37)
asian * nestle	0.82* (0.45)
other * nestle	−0.34 (0.48)
Random coefficient correlation	0.91
Observations	2,400
Log Likelihood	-4,225.33

Note: *p<0.1; **p<0.05; ***p<0.01

To have a better understanding of the substitution patterns in the data, Table 5 contains estimates of own price and cross-price elasticities for the different brands and product sizes. For each brand-size, we also include own and cross price elasticities when the brand is the WIC contract holder.

Figure 5: Estimated price elasticities

	Abbott	MJ	Nestle	Abbott (Bulk)	MJ (Bulk)	Nestlé (Bulk)	Store brand
Abbott	-2.44	0.41	0.15	0.14	0.19	0.06	0.02
Abbott (WIC)	-2.41	0.22	0.08	0.34	0.11	0.04	0.01
MJ	0.36	-2.33	0.14	0.14	0.19	0.06	0.01
MJ (WIC)	0.16	-2.44	0.06	0.07	0.28	0.03	0.01
Nestlé	0.34	0.39	-2.28	0.13	0.18	0.06	0.01
Nestlé (WIC)	0.31	0.36	-2.43	0.11	0.15	0.25	0.01
Store Brand	0.07	0.07	0.03	0.03	0.04	0.00	-0.26

Focusing on the last column, we see that there is basically no substitution towards the store brand for a 1% price change in any of the premium brands. Symmetrically, the last row shows that a 1% price increase in the store brand leads to almost zero substitution towards any of the premium brands.

Next, among the premium brands, we find greater substitution between Abbott and Mead Johnson. For example for regular-sized, non-WIC products, a 1% increase in Abbott's price leads to a 0.41% increase in Mead Johnson's sales but only to a 0.15% increase for Nestlé.

Finally, when a premium brand becomes the WIC product, there is less substitution towards other premium brands. Instead, households would tend to buy more of the less expensive (per oz) bulk version of the WIC brand.

5.3 Supply model

For our supply model, we currently assume manufacturers compete in differentiated Bertrand fashion by choosing prices for their product lines to maximize profits from the non-WIC households in our data. We allow marginal cost to vary by geography (by state or by alliance, which is a collection of states based on the auction data if the state-level data on retail prices is thin), by product size (regular versus bulk) and by manufacturer. We estimate a manufacturer's marginal cost from its first order conditions for profit maximization given the set of products it sells. In estimating

marginal cost, we take the demand estimates as given. In ongoing work, we will estimate demand and supply jointly.

Our current estimates for (per oz) marginal cost for bulk sized products are significantly lower than for regular-sized products. In fact, in some instances, marginal cost for the bulk product is negative. Given our demand estimates (specifically that the coefficient on the bulk dummy tends to be positive for less elastic high income households) and the assumption of differentiated Bertrand competition, the model rationalizes the much lower bulk price (per oz) through a much lower marginal cost relative to the marginal cost of the regular-sized product. Although marginal cost for bulk products may be lower than for regular-sized products, e.g. plastic tubs are cheaper than aluminum cans, we do not believe that the difference is as drastic as what we see in our estimates. We will explore whether accounting for potential second degree price discrimination (quantity discounts) may fix the potential downward bias in the bulk size marginal cost estimates.

5.4 Counterfactual analysis [preliminary]

For now, we calibrate marginal cost for bulk and regular sized products to be \$0.1 and \$0.5 per oz, respectively, for each manufacturer including the store brand. We solve for equilibrium prices under two scenarios. First we solve for equilibrium prices under the status quo where we use our demand estimates. We find that the calibrated marginal costs matches well the observed retail prices across brands and product sizes. Second, we solve for equilibrium prices under the assumption that $\beta_i = 0$ for all households but nonetheless keeping all other demand estimates fixed. The goal of the second scenario is to compute equilibrium prices when there is no WIC product in the market. The way we model this scenario can be interpreted as either households learning that the WIC designation for a given brand does not contain any information about product quality, or the government directly distributes infant formula to WIC participants instead of distributing through retail stores or hospitals.

Tables 6, 7 and 8 contain the simulated equilibrium prices under different WIC contract holders. The results confirm our two takeaways in the conceptual model. The change in price for the WIC contract holder is positive and much larger than the change in price that we estimated using the timing of contract changes. Relative to the scenario when consumers do not see additional value from being designated as the WIC brand, retail prices increase from 10% to 13% for the regular size, and 23% to 40% for the bulk size.

Second, we also see that prices of formula produced by the non-WIC manufacturers also increase.

The increase ranges from 6% to as high as 23%.

A result that we were not able to see with the simple conceptual model nor in the price regressions using the timing of contract changes is the substantial increase in the price of bulk size products. This result is possibly driven by the significant softening of the much tougher interbrand competition in the bulk segment when a WIC product is introduced in the market. In the bulk segment, the premium brands face an additional competitor in the form of the store brand which sets much lower prices since it lacks the positive brand effect that the premium brands have.

Figure 6: Simulated prices: Nestle is WIC

Manufacturer	Size	Status quo Price ($/oz)	No WIC ($/oz)	Price increase due to WIC spillover (%)
Nestlé (WIC)	Regular	1.15	1.03	12%
Nestlé (WIC)	Bulk	0.91	0.65	40%
Abbott	Regular	1.20	1.12	7%
Abbott	Bulk	0.89	0.82	9%
Mead Johnson	Regular	1.26	1.18	7%
Mead Johnson	Bulk	1.11	0.90	23%
Store Brand	Bulk	0.66	0.62	6%

Figure 7: Simulated prices: Abbott is WIC

Manufacturer	Size	Status quo Price ($/oz)	No WIC ($/oz)	Price increase due to WIC spillover (%)
Abbott (WIC)	Regular	1.27	1.12	13%
Abbott (WIC)	Bulk	1.06	0.82	29%
Mead Johnson	Regular	1.43	1.18	21%
Mead Johnson	Bulk	1.04	0.90	16%
Nestlé	Regular	1.10	1.03	7%
Nestlé	Bulk	0.70	0.65	8%
Store Brand	Bulk	0.67	0.62	6%

Figure 8: Simulated prices: Mead Johnson is WIC

Manufacturer	Size	Status quo Price ($/oz)	No WIC ($/oz)	Price increase due to WIC spillover (%)
MJ (WIC)	Regular	1.30	1.18	10%
MJ (WIC)	Bulk	1.11	0.90	23%
Abbott	Regular	1.27	1.12	13%
Abbott	Bulk	0.94	0.82	15%
Nestlé	Regular	1.11	1.03	8%
Nestlé	Bulk	0.70	0.65	8%
Store Brand	Bulk	0.66	0.62	6%

6 Conclusion

In this paper, we quantify the WIC spillover effect on market shares and prices. We emphasize the importance of accounting for equilibrium effects in our analysis. Not accounting for equilibrium effects noty only understates the size of the price increase from being the WIC product, it also hides the possibility that all infant formula prices actually go up, especially in previously more competitive segments.

Capturing heterogeneity in preferences especially with respect to how consumers view a brand being designated as the WIC brand is essential in reaching the correct conclusion regarding the size and direction of the WIC spillover effect on equilibrium prices. Moreover, having a model that is able to explain purchasing patterns as a function of consumer demographics allow us to talk about distributional implications of the price increase due to WIC. Our demand estimates suggest that in general lower income, non-college educated, and minority non-WIC households spend much more on infant formula since they tend to (1) prefer premium brands, (2) buy less of the store brand and most importantly (3) have stronger preference for the WIC brand. Given the strong preference for the WIC brand, this same group of households experience are thus disproportionally hurt by the resulting equilibrium price increases driven by the WIC spillover effect.

Our results should not be taken as a direct criticism of the infant formula rebate program for WIC. The program confers huge savings to the government since the government pays only about 25% of the retail price after the rebate. Unless competition drives prices close to marginal cost, we doubt that we can see an equivalent price decrease in the overall infant formula market as that conferred by the rebate program. Instead, our results point to the importance of providing sufficient

information and education about what it means to be the WIC manufacturer and more generally, the true differences, or lack of, between the infant formula brands.

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