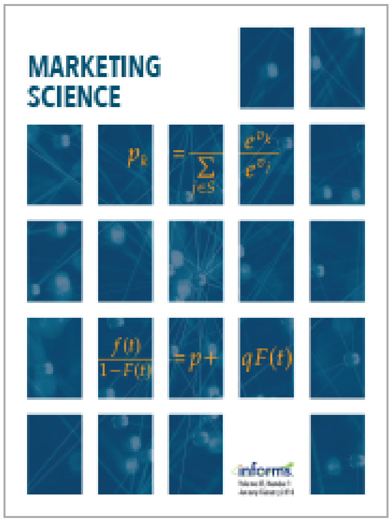

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Comment

Cross-Brand Pass-Through: Fact or Artifact?

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Cross-brand pass-through implies that a retailer responds to wholesale promotional support from a target brand by changing the retail prices of competitive brands. Besanko et al. (2005) model a target brand's retail price as a function of its own and other brands' wholesale prices using 780 observations (15 price zones × 52 weeks) and take the many significant coefficients for other brands' wholesale prices that they find as evidence of cross-brand pass-through. Because price zones do not react independently to wholesale prices when they set a brand's retail price, Besanko et al.'s (2005) estimation overstates the number of independent observations by a factor of 15. When we correct for this overstatement of independent observations, we find that the number of stable, significant coefficients for other brands' wholesale prices is lower than one would expect by chance. We conclude that there is no evidence of cross-brand pass-through in the 11 categories analyzed by Besanko et al. (2005).

Key words: pricing; promotion; retailing and wholesaling; channels of distribution; econometric models; Dominick's; packaged goods; laundry detergent; price zones
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1. Introduction

Cross-brand pass-through implies that a retailer responds to wholesale promotional support from a target brand by changing the retail prices of competitive brands. Most empirical studies assume that cross-brand pass-through is rarely practiced in the grocery industry.

In their paper "Own-Brand and Cross-Brand Retail Pass-Through," Besanko et al. (2005) analyze 78 products across 11 large categories using 1992 retail and wholesale pricing data from Dominick's Finer Foods (DFF). They show evidence of own-brand pass-through to the extent that DFF's wholesale price data allows. They also estimated a large number of coefficients that they interpret as indicators that DFF practiced cross-brand pass-through.

Figure 1, reporting the retail and wholesale prices of both brand B_1 and brand B_2, presents a hypothetical illustration of positive and negative cross-brand pass-through. In this and all figures in this paper, wholesale prices are represented with thick lines (solid, dashed, or dotted) and retail prices are represented with thin lines (solid, dashed, or dotted). Figure 1 shows the impact on retail prices of a promotional wholesale price reduction by B_1 in week 7 and the impact on retail prices of a promotional wholesale price reduction by B_2 in week 15. In week 7, we see positive cross-brand pass-through of B_1's wholesale price reduction to B_2's retail price. In week 15, we see negative cross-brand pass-through of B_2's wholesale price reduction to B_1's retail price.

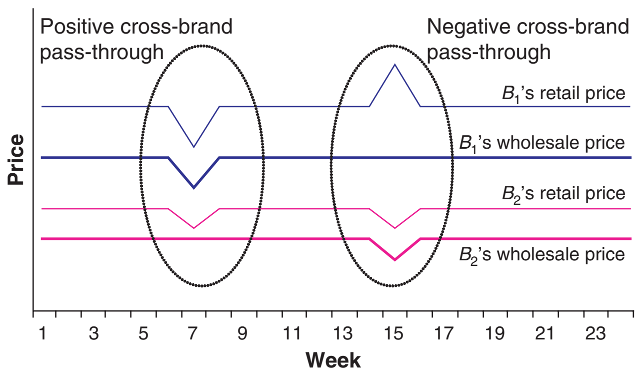
Besanko et al. (2005) (BDG in the rest of this paper) estimate the following model of a target brand's retail price that includes terms with which they hope to capture cross-brand pass-through:

$$\ln(P_{\text{target},z,t}) = \alpha_{\text{target},z} + \gamma_{\text{target},z}\ln(C_{\text{target},t}) + \sum_{j\neq\text{target}} \beta_{\text{target},j}\ln(C_{j,t}) + \text{holiday terms} + \varepsilon_{\text{target},z,t}, \quad (1)$$

where $P_{\text{target},z,t}$ is the target brand's retail price in price zone z, in week t, $C_{\text{target},t}$ is the target brand's wholesale price in week t, and $C_{j,t}$ is the wholesale price of brand j (a competitor to the target brand) in week t (equation adapted[1] from BDG Equation 7, p. 130). BDG interpret coefficients of the target brand's own wholesale price ($\gamma_{\text{target},z}$) as indicators of own-brand pass-through. They interpret coefficients of other brands' wholesale prices ($\beta_{\text{target},j}$) as being

[1] BDG denote wholesale prices using three subscripts: one for brand, one for week, and one for price zone. However, on p. 129 of their paper, BDG tell us that a brand's wholesale price does not differ across price zones. Hence, we suppress the zone subscript here for simplicity of exposition.

Figure 1 **Hypothetical Illustration of Cross-Brand Pass-Through**



indicators of cross-brand pass-through. In part, BDG conclude that "…as many as two-thirds of the estimated cross-brand pass-through rates are statistically significant. This implies that the retailer responds to a trade promotion for one brand by changing retail prices of multiple products in the category" (p. 125). In fact, with so many significant coefficients for other brands' wholesale prices, BDG's findings imply that, on average, when the wholesale price changes for one brand in a category, the retailer changes retail prices for two-thirds of the other brands in that category.

In this paper, we argue that BDG find so many significant coefficients for other brands' wholesale prices because they inadvertently inflated the number of independent observations by a factor of 15. This inflation in the number of independent observations results from BDG's implicit assumption that each of DFF's 15 price zones reacted independently to wholesale prices when they set retail prices. After adjusting for inflation in the number of independent observations, we conclude that there is no stable, significant evidence of cross-brand pass-through.

In what follows we provide, in §2, a description based on information from published papers of the process DFF used to set retail prices. In §3 we explain why, given this pricing process, BDG's use of 780 observations (52 weeks × 15 price zones) to estimate each brand's model overstates the number of independent observations by a factor of 15. In §4 we show how BDG's overstatement of the number of independent observations can magnify pricing "coincidences" into significant coefficients for other brands' wholesale prices. In §5 and Appendix F, we show that after adjusting for the number of independent observations, there is no statistically significant and stable evidence that DFF practiced cross-brand pass-through in any of the 11 categories studied by BDG. We end with a summary and discussion of the implications of this work for future research.

2. How DFF Sets Prices

Consider what we know about DFF's pricing policy from earlier published research using DFF data. Montgomery (1997, p. 330) tells us that DFF originally grouped its stores into three price zones based on the intensity of competition each store faced. Relative to prices in DFF stores facing typical competition, prices in DFF stores close to warehouse competitors were lowered by 10 percent, and prices in DFF stores in urban locations were increased by 10 percent.

The point of Hoch et al.'s (1995) paper was that DFF should base its price zones on grocery shoppers' price sensitivities rather than on the fierceness of retail competition around a store. Hoch and Purk (1993) report the results of pricing experiments done by DFF and the University of Chicago, Graduate School of Business (GSB), which confirm the short-run profitability of exploiting differences in grocery shoppers' price sensitivities in different stores. Montgomery (1997) developed a model that recommends different "regular" (i.e., unpromoted) retail prices for refrigerated orange juice brands in different stores based in part on differences in grocery shoppers' price sensitivities in those stores.

Presumably, DFF took the advice of these researchers because, as noted by BDG (Footnote 8, p. 129), DFF appears to have moved from its original three price zones in 1989 to 15 price zones in 1992, the year of BDG's data. Chintagunta et al. (2003, p. 114) speculate that the 15 price zones detected by BDG reflect DFF's reconfiguration of price zones to exploit differences in grocery shoppers' price sensitivities. To simplify exposition, in the remainder of this paper we will refer to DFF's price zones as having been defined to exploit grocery shoppers' price sensitivities. It is not critical to our argument that we know whether DFF designed price zones in reaction to differences in competitive intensity or in reaction to differences in grocery shoppers' price sensitivities. What is critical to our argument is that differences in a brand's regular retail price across price zones *are not* reactions to wholesale prices.

Hoch et al. (1995) tell us that, though DFF set different "regular" (i.e., unpromoted) retail prices for a brand in different price zones, it set the same promotional retail price for the brand in all price zones. Montgomery (1997) explains that DFF did this in order to maintain its overall image and positioning. (Grocery shoppers are not typically aware of differences in a brand's "regular" retail price in distant DFF stores, but they are typically aware of the promotional retail price that is advertised in DFF's weekly promotional supplement that reaches all price zones.) Chintagunta et al. (2003, p. 122) report that DFF's decision to promote a particular brand at a particular retail promotional price in a particular week is driven by manufacturers' wholesale promotional offers. According to Chintagunta et al.'s (2003) interviews with DFF managers, DFF responds to wholesale promotional offers by building a chainwide calendar of retail promotions for the coming weeks. That calendar specifies the brands to be promoted and the nature of each retail promotional offer for each week. (See Appendix A for a laundry detergent promotional calendar we inferred using BDG's laundry detergent data.)

In summary, DFF is motivated by one factor when it sets a brand's "regular" retail price in different price zones and it is motivated by another factor when it sets a brand's promotional retail price. The desire to exploit differences in grocery shoppers' price sensitivities causes DFF to set *different* levels for a brand's "regular" retail price in different price zones. The desire to maintain its image and positioning causes DFF to respond to manufacturers' wholesale promotional offers by setting the *same* promotional retail price for a brand in all price zones.

A brand's "regular" wholesale price does have an impact on its "regular" retail price. As suggested in by Blattberg and Neslin (1990), Levy and Weitz (1996), and Besanko et al. (1998), retailers with many prices to set (a typical grocery retailer carries, and therefore has to price, more than 30,000 different items) simplify their complicated pricing problem by setting a brand's "regular" retail price as a fixed mark-up of its "regular" wholesale price. Based on Montgomery's (1997, p. 330) description of DFF's original zone pricing policy cited earlier, for stores facing typical competition DFF probably set a brand's "regular" retail price as a fixed mark-up of its "regular" wholesale price. Zone pricing was then achieved by subtracting 10% from that fixed mark-up price for stores near warehouse competitors and by adding 10% to that fixed mark-up price for stores in urban locations. As DFF's pricing experiments revealed differences in grocery shoppers' price sensitivities, DFF seems to have continued this policy of adjusting a brand's "regular" retail price relative to that fixed mark-up price. DFF stores whose grocery shoppers were more price sensitive were assigned "regular" retail prices below the fixed mark-up price and DFF stores whose grocery shoppers were less price sensitive were assigned "regular" retail prices above the fixed mark-up price.

In summary, a brand's "regular" wholesale price influences its fixed mark-up "regular" retail price. Across-price-zone differences in a brand's "regular" retail price represent adjustments that DFF makes to that fixed mark-up price in order to exploit differences in grocery shoppers' price sensitivities in different price zones. A brand's promotional retail price, which does not differ across price zones, is influenced by wholesale promotional offers.

3. BDG Overstate the Number of Independent Observations by a Factor of 15

3.1. Only One Independent Observation of the Impact of Wholesale Prices on a Brand's Retail Price Each Week

BDG inadvertently overstated the number of independent observations when they estimated their model of a target brand's retail price as a function of brands' wholesale prices using 780 observations (52 weeks × 15 price zones). Consistent with what one would expect, BDG tell us that a brand's wholesale price does not differ across price zones (BDG, p. 129). Hence, BDG's use of 15 observations each week implicitly assumes that the 15 price zones reacted to wholesale prices independently when setting a brand's retail price, and that is not the case. Recall that a brand's promotional retail price does not differ across price zones. Recall further that differences across price zones in a brand's regular (i.e., unpromoted) retail price are *not* driven by wholesale prices.

To understand what might have led BDG to implicitly assume that price zones react independently to wholesale prices when setting a brand's retail price, consider BDG's model in Equation (1). In that model of the retail price of a target brand, it is only the price-zone-specific constants and price-zone-specific coefficients for the target brand's own wholesale price that differ across price zones. The price-zone-specific constants capture differences in the target brand's regular retail price in different price zones. Recall that those differences are driven by DFF's desire to exploit differences in grocery shoppers' price sensitivities, not by wholesale prices. Importantly, differences across price zones in coefficients for a target brand's own wholesale price do *not* represent "differences in response" across price zones. Rather, like differences in price-zone-specific constants, differences across price zones in coefficients for a target brand's own wholesale price are merely another reflection of the differences in the target brand's regular retail price across price zones. As Figure 2 illustrates, in response to hypothetical brand B_1's wholesale price reduction in week 3, B_1's retail price is dropped to \$3.99 in both hypothetical price zones X and Y. This \$3.99 promotional retail price for B_1 represents a \$0.70 retail price reduction in high priced zone X, but it only represents a \$0.30 retail price reduction in lower priced zone Y. Since B_1's promotional retail price is identical across price zones, BDG's model would estimate a larger coefficient for B_1's own wholesale price in zone X than in zone Y.

BDG may have interpreted the across-price-zone differences in coefficients for a target brand's own wholesale price as evidence that different price zones

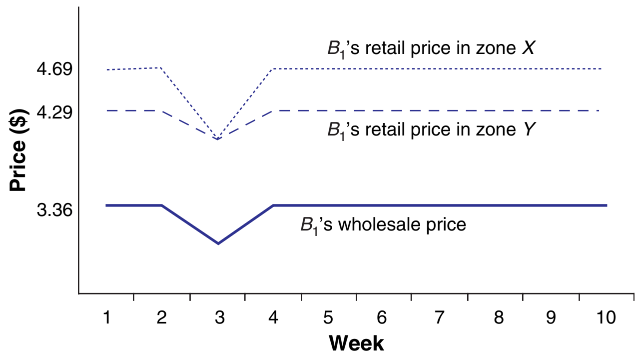


Figure 2 Across Price Zone Differences in Coefficients for a B_1's Own Wholesale Price Reflect Differences in Price-Zone-Specific Regular Retail Prices, *Not* Differences in Price-Zone-Specific Response to a Change in Wholesale Prices

"react differently" to changes in the target brand's own wholesale price. In fact, differences in those coefficients are merely artifacts of DFF's zone pricing.

In summary, given that wholesale promotions yield simultaneous and identical retail promotions across all price zones, and given that differences in a brand's regular retail price across price zones are driven by differences in grocery shoppers' price sensitivities rather than by wholesale prices, price zones are not reacting independently to wholesale prices when they set retail prices and there are not 15 independent observations of the impact of wholesale prices on a brand's retail price each week—there is only 1.

If there is only one independent observation of the retailer's response to the brands' wholesale prices in a given week, BDG have only 52—not 780—independent observations with which to estimate their model.

3.2. Illustration of Zone Pricing and of Simultaneous and Identical Retail Price Promotions

To enhance confidence that across-price-zone differences in a brand's regular retail price are not being driven by wholesale prices, consider Figure 3 that reports the retail price for Wisk 128 oz. in BDG's 15 price zones for the period of observation. The topmost solid line in Figure 3 represents the retail price of Wisk 128 oz. in 4 BDG price zones that priced Wisk 128 oz. identically. The bottommost solid line represents the retail price of Wisk 128 oz. in 9 BDG price zones that priced Wisk 128 oz. identically. The dashed and dotted lines represent the retail price of Wisk 128 oz. in two additional BDG price zones.

To see zone pricing, notice that across the 15 price zones there are 3 levels of regular retail price for Wisk 128 oz. ($9.07, $8.68, and $8.29). Further, note that in each of the BDG price zones there are extended periods of time during which Wisk 128 oz. has a stable, "regular" (i.e., unpromoted) price. To see evidence

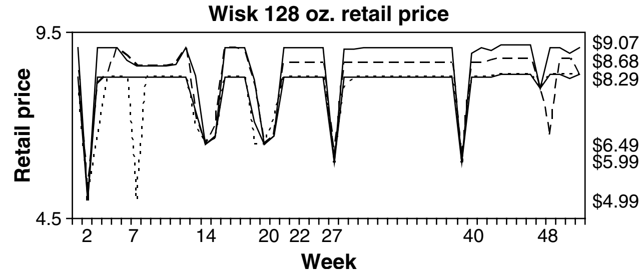


Figure 3 Illustration of Zone Pricing and of Simultaneous and Identical Retail Price Promotions: Wisk 128 oz. Retail Price in All 15 BDG Price Zones

of identical retail promotions across price zones, consider weeks 2, 14–15, 20–21, 27, 40, and 48 in which Wisk 128 oz. experiences retail price promotions. Those promotions happen simultaneously in all price zones and for each promotion the retail promotional price point is the same in all price zones.

3.3. Across-Price-Zone Idiosyncrasies in Wisk 128 oz. Retail Price Are Not Driven by Wholesale Prices

In addition to price-zone-specific, stable regular retail prices driven by DFF's desire to exploit differences in grocer shoppers' price sensitivities, Figure 3 shows additional instances of retail price differences for Wisk 128 oz. across price zones. In this section, we argue that those across-price-zone pricing idiosyncrasies are not instances of price-zone-specific reactions to wholesale prices. Rather, we suggest that those idiosyncracies are probably driven by DFF and University of Chicago GSB pricing experiments, by DFF's adaptation of retail prices in response to the results of those experiments, and by mismatches between promotional periods and data observation weeks. None of these phenomena (pricing experiments, reactions to those experiments, promotion period/data collection week mismatches) is driven by wholesale prices in a given week.

Across Zone Retail Price Differences Driven by DFF and University of Chicago GSB Price Experimentation. The website[2] on which the DFF data are available reports that DFF and the University of Chicago GSB ran pricing experiments in DFF's stores from 1989 to 1994, a timespan that includes BDG's period of observation. (See Dreze et al. 1994, Hoch et al. 1994, Hoch and Purk 1993, and Hoch 1996 for examples of research papers based on DFF and University of Chicago GSB experimentation.) Looking back at Figure 3, it is likely that the reduction of Wisk 128 oz. regular price to $8.59 during weeks 7–11 in price zones with a $9.07 regular retail price,

[2] http://gsbwww.uchicago.edu/kilts/research/db/dominicks/.

the $4.99 promotion in week 7 for the dotted line price zone, and the extension of the week 48 promotion through week 49 for the dashed line price zone are all instances of DFF and University of Chicago GSB price experiments. Consistent with the weeks 7–11 price reduction for the $9.07 regular price zones being a part of a price experiment, we see that it is one of those $9.07 zones (the zone represented by the dashed line) that permanently lowered its regular retail price to $8.68 in week 22. Such experimentation and adaptation reinforce the notion that DFF set zone prices to exploit differences in grocery shoppers' price sensitivities and that DFF changed those zone prices when they got new information about shoppers' price sensitivities.

Across Zone Retail Price Differences Driven by a Promotion that Doesn't Begin and End at the Beginning and End of a Data Collection Week. Most of the other observations which show unexplained differences in Wisk 128 oz. retail prices across price zones occur at the beginning or end of the retail price promotions in weeks 15–16 and 20–21. The recorded retail prices that fall between the regular and the promoted price for a zone probably indicate that the promotion did not begin at the beginning of a data collection week and did not end at the end of a data collection week. In such a case, the retail price recorded for the first week of the promotion will be a weighted combination of the brand's regular and promoted retail prices where weights are determined by the mix of regular price and promoted units sold in that data collection week. The retail price recorded for the last week of the promotion will be a similarly constructed weighted combination of the brand's regular and promoted retail prices. Such a mismatch between the promotion period and the data collection week will result in different recorded retail prices for a brand across price zones because it is unlikely that each price zone will sell exactly the same proportion of regular priced and promoted units in those data collection weeks that mix promoted and unpromoted prices.

In summary, brands' wholesale promotions impact Wisk 128 oz. retail price through a centrally managed process that imposes simultaneous and identical retail price promotions in all price zones. Most differences in Wisk 128 oz. regular retail price across price zones are driven by DFF's desire to exploit differences in grocery shoppers' price sensitivities—not by wholesale prices in a given week. Across-price-zone differences in Wisk 128 oz. retail price that are not attributable to zone pricing can be attributed to DFF and University of Chicago GSB price experiments, DFF's pricing adaptation in response to those experiments, and mismatch between promotion period and data collection week.

3.4. For Each Laundry Detergent Brand, There is Only One Independent Observation Each Week of the Impact of Wholesale Prices on the Brand's Retail Price

Support for the contention that there is, each week, only one independent observation of the impact of wholesale prices on Wisk 128 oz. retail price rests on the fact that each of Wisk 128 oz. retail price promotions occurs simultaneously and identically across all price zones. In this subsection, we report a statistic that indicates the extent to which each of a brand's retail price promotions occurs simultaneously and identically across all price zones. That statistic is the average across all 105 pairs of BDG price zones of the correlation of the brand's retail price in each pair of BDG price zones. As reported in Table 1, that statistic takes on the value of 0.93 for Wisk 128 oz. Looking at Figure 2 as a whole, we can see that this high average across-price-zone correlation for Wisk 128 oz. retail price is driven by the deep promotional price cuts that occur simultaneously and identically in all price zones. The generally high level of this statistic for all of the laundry detergent brands (ranging from 0.82 to 0.95) is consistent with each of these brands experiencing a series of deep retail promotional price cuts and with each promotional price cut occurring simultaneously and identically in all price zones.

In Appendix B, we present and discuss the retail price plots for the laundry detergent brand with the lowest average across-price-zone correlation (All 64 oz.) and for the brand with the lowest minimum across-price-zone correlation (Cheer 64 oz.). Examination of the price plots for even these brands with the most pronounced idiosyncrasies in retail price across price zones again confirms the assertion that brands experience a series of deep retail

Table 1 Average Across-Price-Zone Correlation of a Brand's Retail Price for Laundry Detergent Brands

Brand	Size (oz.)	Average correlation of brand's retail price in each of the 105 pairs of BDG price zones	Minimum correlation of brand's retail price in a pair of BDG price zones	Maximum correlation of brand's retail price in a pair of BDG price zones
Wisk	128	0.93	0.69	1.00
Wisk	64	0.94	0.77	1.00
All	128	0.95	0.88	1.00
All	64	0.82	0.59	1.00
Surf	64	0.87	0.73	0.99
Cheer	64	0.86	0.47	1.00
Cheer	128	0.86	0.61	0.99
Tide	128	0.86	0.59	1.00
Tide with bleach	128	0.90	0.73	1.00
Tide	96	0.95	0.79	1.00
Tide	64	0.95	0.81	1.00
Tide with bleach	64	0.95	0.81	1.00

promotional price cuts and that each promotional price cut occurs simultaneously and identically in all zones. Further, examination of these plots confirms the assertion that across-price-zone idiosyncrasies in a brand's retail price are not driven by brands' wholesale prices. These plots provide additional examples of DFF's price experimentation and adaptation as sources of across-price-zone idiosyncrasies in retail price. Appendix B also shows that data recording errors can cause across-price-zone idiosyncrasies in retail prices. Hence, we infer that the forces which cause these across-price-zone average correlations to be less than one are not associated with wholesale prices. BDG implicitly acknowledge the existence of such wholesale-price-independent sources of noise in scanner data when they elect to aggregate SKUs into a brand if the correlation of the SKUs' retail prices is above 0.8 (BDG, p. 128). Table 1 tells us that the average across-price-zone correlation of the retail prices of the laundry detergent brands ranges from 0.82 to 0.95.

3.5. Summary

In this section, we argue that (1) differences in a brand's regular retail price across price zones are driven by grocery shoppers' price sensitivities rather than by wholesale prices, (2) a brand's promoted retail price, which *is* driven by wholesale prices, does not differ across price zones, and (3) points 1 and 2 combine to imply that price zones do not react independently to wholesale prices when they set retail prices. Because price zones do not react independently to wholesale prices, BDG, using 780 observations (52 weeks $\times$ 15 price zones), overstate the number of independent observations by a factor of 15. We looked closely at Wisk 128 oz. retail price in all 15 BDG price zones and concluded that there are no across-price-zone differences in Wisk 128 oz. retail price that should be interpreted as being a reaction to wholesale prices. This across-price-zone lack of independent reaction to wholesale prices is indicated by the average across-price-zone correlation of a brand's retail price. Since that statistic is very high for all laundry detergent brands and since wholesale prices are not among those forces causing the across-price-zone average correlation to be less than 1, we see empirical support for the contention that for laundry detergent brands, there is no price-zone-specific independent reaction to wholesale prices and, hence, that BDG overstate the number of independent observations by a factor of 15. Appendix C, which reports similar analyses for each of BDG's other 10 categories, indicates that in those categories, too, there are no price-zone-specific independent reactions to wholesale prices. Hence, we conclude that BDG also overstate the number of independent observations in those categories by a factor of 15.

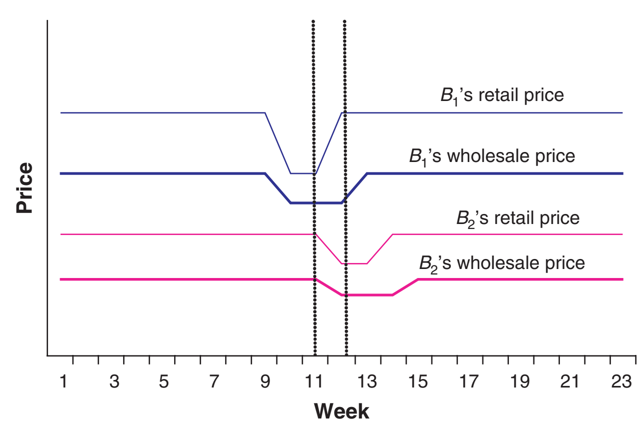
4. Implications of 15-Fold Replication of 52 Independent Observations

Given the very high level of average across-price-zone correlation of a brand's retail price that holds for all 11 of BDG's categories, and given the fact that those phenomena which cause these average correlations to be less than 1 are *not* driven by wholesale prices, BDG's estimation of their model of the impact of wholesale prices on a brand's retail price with 780 observations is approximately equivalent to estimating that model with 15 identical copies of a single data set of 52 independent observations. Thinking of the data in this way helps explain the many statistically significant coefficients that BDG found for other brands' wholesale prices.

4.1. 15-Fold Replication of a Data Set Turns Promotion Timing "Coincidences" into Signficant Coefficients for Other Brands' Wholesale Prices

By repeating 52 independent observations 15 times, any coincidence that occurs even once during the 52 weeks appears to have happened 15 times and can therefore be captured by the model as an important, frequently occurring manifestation of retailer pricing behavior. Figure 4, reporting retail and wholesale prices for hypothetical brands B_1 and B_2, provides an example of this phenomenon. In Figure 4 we see a retail promotional price reduction for B_1 in weeks 10 and 11 supported by a wholesale promotional price reduction for B_1 in weeks 10–12. We also see a retail promotional price reduction for B_2 in weeks 12 and 13 supported by a wholesale promotional price reduction for B_2 in weeks 12–14. Notice that from week 11 to week 12, B_2's wholesale price drops and B_1's retail price rises, a pattern that could be mistaken for negative cross-brand pass-through of B_2's wholesale price reduction to B_1's retail price. In fact, what we have

Figure 4 **Illustration of B_2's Retail Promotion Immediately Following B_1's Retail Promotion: A "Coincidence" That Can Be Mistaken for Cross-Brand Pass-Through**



is one brand's retail promotion immediately following another brand's retail promotion, not cross-brand pass-through. If this particular sequence of retail promotions occurred only once in a 780-observation data set, it would probably have little influence on model parameters. However, BDG's use of what are essentially 15 copies of a single data set would make it look as though the pattern of prices in weeks 11 and 12 happened 15 times, and 15 observations of this pattern probably would be influential in shaping model parameter estimates.

In BDG's data, not all "coincidences" that 15-fold replication magnify into a significant relationship are driven by promotion sequencing. As will be discussed in the next subsection, complex manufacturer-retailer "deals" and DFF's average acquisition cost model of wholesale price can combine to make it virtually impossible to identify a brand's regular (i.e., unpromoted) wholesale price, or to tie that brand's wholesale promotional support to the associated retail promotional event. The "noise" introduced into a brand's wholesale price in this desynchronization process can result in "coincidences" which when replicated 15 times cause that brand's wholesale price to appear to be a significant predictor of a target brand's retail price.

4.2. "Deals" and DFF's Wholesale Price Model Can Create "Coincidences" That 15-Fold Replication Exploits

If it were the case that all manufacturer-provided promotional support were reflected in the number that the retailer records as wholesale price during the weeks that a brand experiences a retail promotion (as is illustrated in Figures 1 and 2), it would simplify the problem of studying promotion pass-through. However, complex manufacturer-retailer "deals" make it unlikely that wholesale promotional support and the associated retail promotional events will always be closely linked.

Appendix D gives a description of manufacturer-retailer promotion negotiations and some of the promotional instruments used in those negotiations. From that appendix, we see that a brand's wholesale price reduction can occur before the associated retail promotion (e.g., off-invoice), during the associated retail promotion (e.g., scan back), and after the associated retail promotion (e.g., bill back). Further, Blattberg and Neslin (1990), Kim and Staelin (1999), Dreze and Bell (2003), Hauser et al. (1997), Lariviere and Padmanabhan (1997), and Chintagunta (2002) all point out that not all of the wholesale promotional support supplied by a brand is accounted for in the number that a retailer records for that brand's "wholesale price." (Examples of the kinds of promotional support that may not be recorded in a brand's wholesale price include manufacturer participation in a retailer's frequent shopper program, special financing terms offered by the manufacturer, and store fixtures that the manufacturer supplies to a retailer.)

The interpretability of a brand's wholesale price is further obscured by DFF's average acquisition cost model of wholesale price. That model defines wholesale price in week t as the weighted average of the price the retailer paid for any packages added to inventory in week t and the average wholesale price from the previous week. If, in week t, DFF acquires packages of a product at a price higher than that product's average wholesale price in week $t-1$, then wholesale price at time t will increase relative to $t-1$. If instead, in week t, DFF acquires packages of a product at a price lower than that product's average wholesale price in week $t-1$, then wholesale price at time t decreases relative to $t-1$. (See Appendix E for a more detailed description of DFF's average acquisition cost model of wholesale price.)

To see how manufacturer-retailer "deals" and DFF's average acquisition cost model of wholesale price can yield a nonintuitive pattern for a brand's wholesale price, consider Figure 5 which plots DFF's wholesale and retail prices for Cheer 128 oz. in BDG's price zone 7 for the period of observation. The vertical bars in the chart at weeks 4, 13, 18, 20, 34, 42, 44, 46, and 47 mark points at which the pattern of Cheer 128 oz. wholesale price changes from increasing to decreasing, or vice versa. When wholesale price is increasing, DFF must be adding packages of Cheer 128 oz. to inventory that have a higher wholesale price. When wholesale price is decreasing, DFF must be adding packages of Cheer 128 oz. to inventory that have a lower wholesale price. Appendix D speculates about the sequence of manufacturer-retailer "deals" that might have resulted in the pattern of retail and wholesale prices reflected in Figure 5.

To show how the "noise" introduced into a brand's wholesale price by "deals" and DFF's model of wholesale price can cause what seems to be cross-brand pass-through, consider the model for the retail price of All 128 oz. in which our replication of BDG's analysis yields significant positive coefficients for the wholesale price of All 128 oz. and for the wholesale price of Cheer 128 oz. In Figure 6, tracking All 128 oz.

Figure 5 Cheer 128 oz. Wholesale and Retail Prices in Zone 7

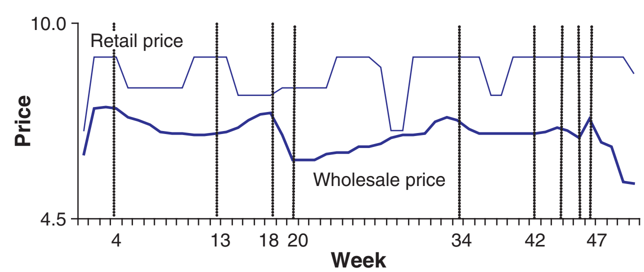
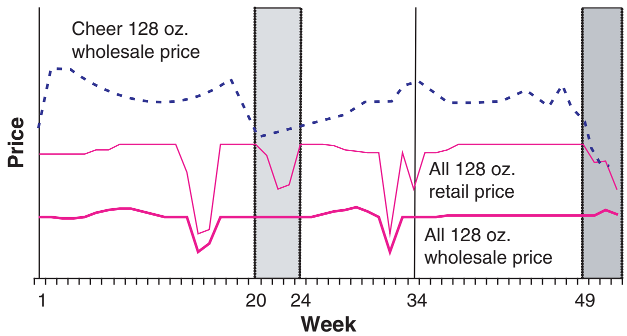


Figure 6 Relationship Between Wholesale Price of Cheer 128 oz. and Across-Price-Zone Average Retail Price of All 128 oz.



wholesale price (thick solid line) and its across-price-zone average retail price (thin solid line) across time, it is easy to see why All 128 oz. wholesale price had a significant positive coefficient in the model of All 128 oz. retail price. Both wholesale and retail prices fell markedly during the deep cut retail promotions on All 128 oz. in weeks 15–16 and in week 32. Note, though, that All 128 oz. wholesale price does not dip in weeks 22–23, in week 34, or in weeks 49–52 when there were shallow cut retail promotions on All 128 oz. (See Appendix D for speculation about the possible wholesale promotions for All 128 oz. that may have caused this pattern of wholesale and average retail prices for All 128 oz.)

Also plotted in Figure 6 is the wholesale price of Cheer 128 oz. (dashed heavy line) which is also a significant predictor of All 128 oz. retail price. If we plotted the incremental contribution of each predictor variable to the estimate of All 128 oz. retail price, it would show that the points at which the Cheer 128 oz. wholesale price makes its most important contributions to the prediction are the shaded weeks 20–24 and 49–52. During those weeks, as can be seen in Figure 5, Cheer 128 oz. wholesale and retail prices also fall. Are weeks 20–24 and 49–52 examples of cross-brand pass-through or are they "coincidences" in the timing of Cheer 128 oz. and Wisk 128 oz. retail promotions? To explore that question, consider the remaining weeks of the observation period. Those weeks show no additional situations which can be interpreted as instances of positive cross-brand pass-through from Cheer 128 oz. wholesale price to All 128 oz. retail price. In week 1, when Cheer 128 oz. wholesale price is especially low, both the retail and wholesale prices of All 128 oz. are at their regular levels. In week 34, All 128 oz. experiences a shallow cut retail promotion, there is no change in All 128 oz. wholesale price, and Cheer 128 oz. wholesale price is in its *highest* region. Positive cross-brand pass-through of Cheer 128 oz. wholesale price to All 128 oz. retail price would suggest that Cheer 128 oz. wholesale price should be in its *lowest* region in week 34.

4.3. 15-Fold Replication Yields Significant Coefficients of Other Brands' Wholesale Prices in Simulated Cross-Brand-Pass-Through-Free Data

To address the question of whether the significant coefficients for other brands' wholesale prices that BDG report might be "coincidences" amplified by 15-fold replication, we simulate a 52-week set of cross-brand-pass-through-free wholesale and retail prices and estimate BDG's model with a data set that includes 15 copies of that simulated 52-week data set. Finding significant coefficients for other brands' wholesale prices in this cross-brand-pass-through-free simulated data provides evidence that "coincidences" unrelated to cross-brand pass-through, some induced by the desynchronization of brands' retail and wholesale promotions, can cause significant coefficients for other brands' wholesale prices when one assumes 780 independent observations.

We simulate prices using the inferred promotion calendar in Appendix A. For the simulation, all brands have a regular retail price of 2.0 and a regular wholesale price of 1.0. When a brand is on deep discount retail promotion, it is assigned a retail price of 1.0 and a wholesale price of 0.5. When a brand is on a shallow discount retail promotion, it is assigned a retail price of 1.5 and a wholesale price of 0.75. To mimic the noise added to the system by various wholesale promotional instruments, we disturb the perfect synchronization of retail and wholesale prices. A brand's wholesale price is switched to the promoted value one week before the retail promotion begins and its wholesale price stays at the promoted value for one week after the retail promotion ends. This gives us 52 weeks of cross-brand-pass-through-free simulated data for each of the 12 brands. We create a 780-observation data set by including 15 copies of the 52 weeks of simulated prices. Since we use 15 exact copies of the 52 simulated weekly observations, it is not possible to estimate zone-specific constants or zone-specific coefficients for a target brand's own wholesale price. The model we estimate with the 780 simulated observations is BDG adapted model (2):

$$\begin{aligned}\ln(P_{\text{target},z,t}) &= \alpha_{\text{target}} + \gamma_{\text{target}} \ln(C_{\text{target},t}) + \sum_{j\neq\text{target}} \beta_{\text{target},j} \ln(C_{j,t}) \\ &\quad + \text{holiday terms} + \varepsilon_{\text{target},z,t}. \qquad (2)\end{aligned}$$

To be clear about the differences between BDG model (1) and BDG adapted model (2), recall that using 780 observations of DFF data, BDG's model (1) estimated for each brand 15 zone-specific constants, 15 zone-specific coefficients for the target brand's own wholesale price, 11 coefficients for other brands' wholesale prices, and 1 coefficient for the holiday dummy. Using 780 observations of simulated data, the

Table 2 **Stability of Significant Coefficients of Other Brands' Wholesale Prices (BDG's Indicator of Cross-Brand Pass-Through) in the Laundry Detergent Category**

	Number of significant coefficients ($p < 0.05$) in 52 weeks of data	Number of significant coefficients ($p < 0.05$) in first 26 weeks of data	Number of significant coefficients ($p < 0.05$) in second 26 weeks of data	Number of significant coefficients in first half still significant in second half
BDG model (1) with 780 observations of DFF laundry detergent data				
Total significant	94	87	75	30
Significant positive	39	31	37	11
Significant negative	55	56	38	19
Adapted BDG model (2) with 780 observations of simulated cross-brand-pass-through-free data				
Total significant	90	82	68	17
Significant positive	40	42	34	11
Significant negative	50	40	34	6
Adapted BDG model (3) with 52 independent observations of DFF laundry detergent data				
Total significant	9	3	0	0
Significant positive	3	1	0	0
Significant negative	6	2	0	0

Note. The top section assumes that *each* price zone responds to wholesale prices independently when it sets a brand's retail price. The bottom section assumes that *no* price zone responds to wholesale prices independently when it sets a brand's retail price. None of the analysis directly incorporates the possibility that a price zone might react partially independently to wholesale prices when it sets a brand's retail price. This is done because Hoch et al. (1995), Montgomery (1997), and Chintagunta et al. (2003) all tell us that DFF responded to wholesale promotions with a single chainwide retail promotional price, i.e., that DFF price zones did not react independently or even partially independently to wholesale promotions.

adapted BDG model (2) estimates for each brand only 1 constant and 1 coefficient for the target brand's own wholesale price, but still estimates 11 coefficients for other brands' wholesale prices and 1 coefficient for the holiday dummy.

From the second section of Table 2, we see that despite the fact that we *know* there is no cross-brand pass-through in the 780 observation simulated data, estimating the adapted BDG model (2) for each of the 12 laundry detergent brands with this data yields 90 statistically significant coefficients for other brands' wholesale prices (40 significantly positive coefficients and 50 significantly negative coefficients). This pattern of significant coefficients found in the simulated, cross-brand-pass-through-free data is very similar to the pattern found when estimating BDG's model (1) for each of the 12 laundry detergent brands using 780 observations of DFF data. (The top section of Table 2 reports that estimating model (1) using 780 observations of DFF data yields 94 statistically significant coefficients for other brands' wholesale prices: 39 significantly positive coefficients and 55 significantly negative coefficients.[3] Hence, we conclude that "coincidences" in brands' promotion timing and the desynchronization of a brand's retail and wholesale promotions, if replicated 15 times, can present the analyst with a large number of statistically significant coefficients for other brands' wholesale prices even when cross-brand pass-through was not practiced.

[3] Note that we use Hayes and Cai's (2005) algorithm to ensure heteroscedasticity-consistent standard error estimates (White 1980).

4.4. Summary

BDG (p. 129) told us that a brand's wholesale price does not differ across price zones. Sections 3 and 4 of this paper showed us that there is little difference across price zones in the pattern of a brand's retail price through time and that those across-price-zone differences in a brand's retail price that do exist are not driven by wholesale prices. This suggests that for modeling the impact of wholesale prices on a brand's retail price, each of BDG's data sets is essentially 52 independent observations replicated 15 times. In §4, we explored the implications of 15-fold replication. Using a hypothetical example, we showed that 15-fold replication has the potential to turn coincidences of promotion timing into statistically significant coefficients for other brands' wholesale prices. Exploring the implications of coefficients from our estimation of BDG's model (1) with 780 observations of DFF laundry detergent data, we showed that the desynchronization of a brand's retail and wholesale promotions creates additional coincidences that can be magnified into significant coefficients for other brands' wholesale prices. Consistent with the possibility that 15-fold replication of "coincidences" may account for BDG's many statistically significant coefficients for other brands' wholesale prices, estimating BDG's adapted model (2) with 780 observations of simulated cross-brand-pass-through-free data was shown to produce approximately the same pattern of statistically significant coefficients for other brands' wholesale prices as was produced estimating BDG's model (1) with 780 observations of DFF data.

5. Accounting for the Fact That There Are Only 52 Independent Observations Reveals Instability in BDG's Estimated Coefficients

In §4, we showed that one can find many significant coefficients for other brands' wholesale prices even if cross-brand pass-through does not happen. In §5, we look directly at the coefficients that BDG estimated and ask whether they are stable through time and whether any of the coefficients remain stable and statistically significant when we adjust for the fact that there are only 52 independent observations of the impact of wholesale prices on a brand's retail price.

5.1. There is No Stable Evidence of Cross-Brand Pass-Through When One Adjusts for the Fact That There Are Only 52 Independent Observations

Even before accounting for the fact that the number of independent observations is overstated by a factor of 15, we can see that in the laundry detergent category (Table 2), coefficients for other brands' wholesale prices (BDG's indicator of cross-brand pass-through) estimated with the first 26 weeks of data are quite different from those coefficients estimated with the second 26 weeks of data. In the top 3 rows, reporting statistics related to the estimation of BDG's model (1) for each of the 12 laundry detergent brands using 780 observations of DFF laundry detergent data, we see that of the 56 significant negative coefficients for other brands' wholesale prices estimated using the first 26 weeks of data, only 19 are significant and negative when estimated using the last 26 weeks of data. Of the 31 significant positive coefficients for other brands' wholesale prices estimated using the first 26 weeks of data, only 11 are significant and positive when estimated using the last 26 weeks of data.

The second 3 rows of Table 2 report that a similar pattern of unstable coefficients for other brands' wholesale prices can be seen when we estimate the adapted BDG model (2) with 780 observations of cross-brand-pass-through-free simulated data.

The last 3 rows in Table 2 report results of estimating BDG's model for each of the 12 laundry detergent brands using DFF's laundry detergent data when we account for the fact that for each brand, there is only 1 independent observation each week of the impact of wholesale prices on that brand's retail price. We account for the fact that there is only 1 independent observation each week by constructing a data set with 52 independent observations of the impact of wholesale prices on a brand's retail price. To understand the logic behind the construction of the 52 independent observation data set, recall that each week each brand has only 1 wholesale price across all price zones. We create, each week for each brand, a single retail price by averaging that brand's retail price across price zones. We lose no information about the impact of wholesale prices on a brand's retail price in this process because differences in a brand's retail price across price zones are not driven by wholesale prices. (Recall that differences in a brand's retail price across price zones are driven by differences in grocery shoppers' price sensitivities in those zones, by DFF's price experimentation and adaptation, by mismatches between promotion period and data collection week, and by data recording errors.) Adapting BDG's model to these 52 observations of DFF data, we get:

$$\begin{aligned}\ln(P_{\text{target},\,t}) &= \alpha_{\text{target}} + \gamma_{\text{target}} \ln(C_{\text{target},\,t}) + \sum_{j\neq\text{target}} \beta_{\text{target},\,j} \ln(C_{j,\,t}) \\ &\quad + \text{ holiday terms } + \varepsilon_{\text{target},\,t}. \end{aligned} \tag{3}$$

To be clear about the differences between BDG model (1) and adapted BDG model (3), recall that using 780 observations of DFF laundry detergent data, BDG's model (1) estimated, for each laundry detergent brand, 15 zone-specific constants, 15 zone-specific coefficients for the target brand's own wholesale price, 11 coefficients for other brands' wholesale prices, and a coefficient for the holiday dummy. Using 52 independent observations of DFF laundry detergent data, adapted BDG model (3) estimates for each brand only 1 constant and 1 coefficient for the target brand's own wholesale price, but still estimates 11 coefficients for other brands' wholesale prices and a coefficient for the holiday dummy.

As can be seen in the last 3 rows of Table 2, adapted BDG model (3) with 52 independent observations of DFF laundry detergent data, when considered relative to BDG model (1) with 780 observations of DFF laundry detergent data, reduces the number of significant coefficients for other brands' wholesale prices by an order of magnitude, from 94 to 9. Importantly, there are no coefficients that have statistical significance and the same sign in both the first and second halves of the data. Neither the 1 significant positive nor the 2 significant negative coefficients of other brands' wholesale prices when adapted BDG model (3) is estimated with the first 26 weeks of DFF laundry detergent data are statistically significant when that model is estimated with the second 26 weeks of data.

Hence, we see that BDG's indicators of cross-brand pass-through (coefficients of other brands' wholesale prices) are not stable through time even when estimated using 780 observations. When we account for the fact that there are only 52 independent observations of the impact of wholesale prices on a target brand's retail price, we find that there is no significant coefficient for another brand's wholesale price that has the same sign and statistical significance in the model estimated with the second 26 weeks of data that it had when estimated with the first 26 weeks of the data. In sum, there is no evidence that DFF systematically passed one laundry detergent brand's wholesale promotional support through to the retail prices of other brands in the laundry detergent category. Appendix F reports results of similar analyses for BDG's other 10 categories. Using 52 independent observations, on average 50.5 coefficients for other brands' wholesale prices were estimated in each category and on average less than 1 of those estimated coefficients (about 1% of estimated coefficients for other brands' wholesale prices) was significant and stable in each category. From those results, we conclude that there is no evidence that DFF systematically passed one brand's wholesale promotional support through to the retail prices of other brands in any of the categories studied by BDG.

5.2. Some Coefficients for a Target Brand's Own Wholesale Price (Indicators of Own-Brand Pass-Through) Are Significant and Stable

Consistent with the industry belief that a brand's wholesale promotions *are* passed through to its own retail price but *not* to other brands' retail prices, coefficients of a target brand's own wholesale price show more stability than do coefficients of other brands' wholesale prices. Estimating BDG model (1) for each of the 12 laundry detergent brands when we assume 780 independent observations involves 180 coefficients for a target brand's own wholesale price, of which 135 were statistically significant. When we estimate adapted BDG model (3) for each of the 12 laundry detergent brands recognizing the fact that there are only 52 independent observations, 69 of the estimated 180 coefficients for a target brand's own wholesale price were statistically significant and stable (significant and positive both when estimated with the first 26 weeks of data and when estimated with the second 26 weeks of data). That is, after adjusting for the fact that there are only 52 independent observations of the impact of wholesale prices on a brand's retail price, about 40% of the coefficients of a brand's own wholesale price (69 of the 180 estimated coefficients) were statistically significant and stable. Hence, though we found no evidence of cross-brand pass-through, in laundry detergent we do find evidence that DFF passed through a brand's wholesale price reductions to that brand's own retail price. Appendix G reports results of similar analyses for BDG's other 10 categories. Using 52 independent observations, across those categories, on average 7 coefficients for a target brand's own wholesale price were estimated in each category. On average 4.5 (or 64%) of those estimated coefficients were significant and stable in each category. From these results, we conclude that there is evidence in all BDG categories that DFF passed a brand's wholesale price reductions through to that brand's retail price.

5.3. Interpreting the Coefficient of a Brand's Own Wholesale Price

Before closing this section, we consider BDG's assumption that the coefficient of a brand's own wholesale price is an indicator of the extent to which that brand's wholesale promotional support was passed through to that brand's own retail price. If each brand's wholesale and retail promotions were perfectly synchronized, this assumption would be reasonable. However, as described in §4.2, DFF's average acquisition cost model of wholesale price and the highly variable structure of wholesale promotional "deals" can desynchronize a brand's wholesale and retail promotions.

Consider BDG's Table 4 (BDG, p. 131) which reports the average own-brand pass-through rate (i.e., average coefficient value across price zones for a target brand's own wholesale price). From that table, we see that All 128 oz. has the highest average value of coefficients for its own wholesale price and Cheer 128 oz. has one of the lowest. Looking back to Figures 5 and 6, it is easy to see why this pattern of coefficients occurs: All 128 oz. wholesale and retail promotions are fairly well-synchronized while Cheer 128 oz. wholesale and retail promotions are not.

However, the fact that Cheer 128 oz. wholesale and retail promotions are not well-synchronized does not necessarily mean that Cheer 128 oz. wholesale promotional support was not passed through to its retail price. While we can only speculate about the exact nature of the promotional "deals" between Cheer and DFF, it is a fact that Cheer 128 oz. wholesale price rose and fell during the period of observation. In addition, it is almost surely the case that multiple promotion negotiations between Cheer and DFF played a part in determining those decreases and increases in wholesale price and that those negotiations also resulted in the retail promotional price cuts observed in weeks 1, 5–9, 15–23, 29–30, 38–39, and 52. We contend that there was, in fact, pass-through of Cheer 128 oz. wholesale promotional support to Cheer 128 oz. retail price. Given the forces shaping the number that DFF records as "wholesale price," though, it is impossible to uncover that relationship with BDG's model and DFF's data.

When using a model structured like that of BDG with DFF's data, coefficients for a target brand's own wholesale price may be better thought of as indicators of the extent to which that brand's wholesale and retail promotions are well-synchronized than as indicators of the extent to which a brand's wholesale promotional support was passed through to its retail price.

5.4. Summary

After adjusting for the fact that there are only 52 independent observations of the impact of wholesale prices on a brand's retail price, we find no stable evidence that DFF practiced cross-brand pass-through in any of the 11 BDG categories. As one would expect when one estimates a model with what amounts to 15 copies of 52 independent observations, model parameters are not stable. When we adjust for the fact that there are only 52 independent observations with which to estimate model parameters, we find that the number of coefficients of other brands' wholesale prices that are significant and have the same sign in the first and second halves of the data is less than one would expect by chance.

While there is no evidence of cross-brand pass-through, BDG's model does show stable, sample-size-adjusted evidence of own-brand pass-through. We argue, though, that one must be cautious when interpreting the magnitude or even the lack of statistical significance for a coefficient of a target brand's own wholesale price. Because of the complex nature of retailer-manufacturer deals and because of the distortion caused by DFF's model of wholesale price, the coefficient of a target brand's own wholesale price is probably best interpreted as a measure of the extent to which that brand's wholesale and retail promotions are well-synchronized.

6. Summary and Conclusions

In those weeks in which a brand is not on retail promotion, it has a stable, regular (i.e., unpromoted) retail price. While that brand's stable, regular retail price differs across price zones, those differences in its regular retail price are not driven by wholesale prices; they are driven by DFF's desire to exploit differences in grocery shoppers' price sensitivities and by DFF's price experimentation. Brands' wholesale prices impact retail prices through a centrally managed process that yields simultaneous and identical retail promotions in all price zones. This implies that there is only one independent observation of the impact of wholesale prices on a brand's retail price each week.

Since each brand's wholesale price is the same in all price zones, when BDG estimated their model using 780 observations (52 weeks × 15 price zones), they implicitly assumed that price zones reacted independently to wholesale prices in setting retail prices each week. BDG's implicit assumption that there were price-zone-specific reactions to wholesale prices was probably bolstered by the fact that they were able to estimate different coefficients for a target brand's own wholesale price in different price zones. However, as explained in §3, across-price-zone differences in coefficients for a target brand's own wholesale price are not indications of price-zone-specific response to wholesale prices; they are artifacts of DFF's zone pricing.

Consistent with BDG having overstated their sample size, we find that their estimates of coefficients for other brands' wholesale prices are not stable through time. When we adjust for the fact that there are only 52 independent observations of the impact of wholesale prices on a target brand's retail price, we find that the number of significant and stable coefficients for other brands' wholesale prices is lower than one would expect by chance. There is no stable, significant evidence of cross-brand pass-through for the 11 BDG categories.

When we step back and think about it, it is unlikely that a grocery retailer would or could consistently execute a policy of positive and/or negative cross-brand pass-through. Consider the situation in which a grocery retailer responded to hypothetical brand B_1's wholesale promotions by reducing the retail price of both brand B_1 (positive own-brand pass-through) and competitive brand B_2 (positive cross-brand pass-through). Because as much as two-thirds of a brand's marketing budget is tied up in wholesale promotions, manufacturers monitor the execution of the promotional "deals" they strike with retailers. The manufacturer of B_1 would almost surely react if the retailer systematically lowered the price of competitive brand B_2 each time B_1 was given retail promotional support. Consider also the fact that practicing cross-brand pass-through would mean that the retailer would have to parameterize complex models (see Sudhir 2001, Shugan and Desiraju 2001, and Moorthy 2005 for examples of such models) to set prices each week rather than using simple pricing rules like those outlined in §2. Further, consider the implications of BDG's conclusion that DFF responded to the change in a brand's wholesale price by changing the prices of two-thirds of the brands in the category. Because of the noise added to brands' wholesale prices by complex "deals" and by DFF's model of wholesale price, on average in the laundry detergent category wholesale prices change for 7 of BDG's 12 laundry detergent brands each week. If each wholesale price change resulted in changes to the retail prices of two-thirds of the brands in the category, then seven wholesale price changes each week would imply that the retail price of essentially every laundry detergent brand would be expected to change every week.[5] Visual inspection

[5] P[retail price of target brand changes in week t due to the change in another brand's wholesale price] $= 1 - P$[retail price of target brand does not change in week t due to the change in another brand's wholesale price] (assuming that wholesale price changes are independent across brands $\rightarrow$) $= 1 - P$[wholesale price does not change for any of the on average eight brands whose whole-

of Figures 3, 5, and 6 shows that it is not even approximately the case that each laundry detergent brand's retail price changed every week.

While we would not expect a retailer to systematically pass through one national brand's wholesale promotional support to a competitive national brand's retail price, we might see some manipulation of retail prices to protect or enhance a retailer's own private label brand because, as Ailawadi and Harlam (2004) tell us, private label brands have higher percentage margin than national brands and when a private label brand has a high share in a category, the retailer gets a higher percentage margin on national brands in that category. Hoch (1996, p. 91) points out that "…[o]pportunistic retailers can gain…by piggybacking on traffic-generating national-brand feature advertising with shallow in-store price reductions on their store brands during the same week." Hence, one might expect that the most likely case for cross-brand pass-through would be the pass-through of a national brand's wholesale promotional support to the retail price of a private label. In fact, BDG's second-stage exploratory analysis shows further lack of face validity when it indicates that a private label brand's wholesale promotional support is more likely to be used to lower the retail price of the national brand during the private label brand's promotion than vice versa.

It is unlikely that we will ever get an accurate assessment of the extent to which the wholesale promotional support provided to the retailer by a brand is passed through to that brand's retail price using DFF's posted "wholesale price" data with a model like that proposed by BDG or with models that BDG refer to as "accounting method" (Chevalier and Curhan 1976, Walters 1989, Armstrong 1991) in which one first identifies retail promotion events and then computes the ratio of retail price change to wholesale price change during that event. To fully capture own-brand pass-through, one needs to consider promotion-driven wholesale price changes that fall outside the period of the retail price promotion and wholesale promotional funds that are accounted for in places other than the number that DFF records as the brand's "wholesale price." This requires knowledge of the details of all of the deals between the manufacturer and the retailer. Ailawadi et al. (2004) provide an example of this sort of comprehensive accounting for all wholesale promotional support. For their study of the forces that drive promotion profitability at CVS, Ailawadi et al. (2004) identify retail prices from scanner data. Rather than using something like DFF's average acquisition cost for "wholesale price," for each promotion studied Ailawadi et al. (2004) were able to identify, in CVS's financial records, the price CVS paid the manufacturer for the cases sold on retail promotion and (from a different account in CVS's financial records) the amount of promotional funds provided by the manufacturer to support the promotion. If one could also access financial records that captured the financial consequences of any forward buying or diverting that might have been associated with cases bought from the manufacturer on promotion but not sold during the retail promotion, one would then have the data needed to assess the degree to which the retailer is passing through manufacturer-provided promotional funds to the end consumer.

If it is unlikely that we can get an accurate assessment of own-brand pass-through using DFF's posted "wholesale price" data, then it is extremely unlikely that we will be able to detect more subtle, cross-brand pass-through effects (assuming they exist) using that data. Anyone attempting to model the impact of wholesale prices on a brand's retail price using DFF's posted data should keep in mind the fact that, in this data, neither stores nor price zones react independently to wholesale prices when they set a brand's retail price. Hence, there is only one independent observation of the impact of wholesale prices on a brand's retail price each week, regardless of the number of stores or price zones in the sample.

The broader implications of this paper for future research concern the way we build and test models of marketplace phenomena. Ideally, we should begin by developing, through significant interaction with practitioners who are struggling with that marketplace phenomenon, a deep understanding of the phenomenon and the data used to model it. We should validate our models on data that was not used to estimate them. If our findings are not stable in an out-of-sample test, then we need to rethink our models. Further, when we have found statistically significant effects, we should plot the data to confirm our interpretation of those significant effects. If visual inspection does not allow us to confirm our interpretation, we should think again about our interpretation. Finally, we should discuss our findings with practitioners. While we should not abandon a project that does not conform to practitioner intuition, we should be particularly diligent about out-of-sample testing and about finding ways to visually demonstrate our interpretation of effects when our

sale prices have significant coefficients in the model for the target brand's retail price] $= 1 - P$[wholesale price does not change for one of the eight brands whose wholesale prices have significant coefficients in the model for the target brand's wholesale price]^8 (since, on average, $7/12 = 58\%$ of the laundry detergent brands have wholesale price changes each week, if we further assume that wholesale price changes are independent across time $\rightarrow$ each brand has a 0.58 chance of experiencing a wholesale price change in any given week $\rightarrow$ each brand has a 42% chance of not experiencing a wholesale price change in any given week $\rightarrow$) $= 1 - (0.42)^8 \approx 1$.

interpretation is at odds with all prior empirical studies and at odds with practitioner intuition.

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Appendix A. Laundry Detergent Promotion Calendar for DFF During BDG Period of Observation

In Figure A.1, we present an "inferred promotion calendar" for DFF's laundry detergent category during the one-year BDG estimation period. Each column in Figure A.1 represents a particular brand-size combination. Each row represents a week during the BDG observation period. The table was completed by inspecting the laundry detergent brands' retail price patterns and inferring a deep cut

Figure A.1 **Inferred Promotion Calendar for DFF Laundry Detergent Category**

	Brand											
Week	W128	W64	A128	A64	S64	C128	C64	T128	Tb128	T96	T64	Tb64
1						D				s		
2	D									s		
3									D	s		
4				D								
5						s						
6						s						
7		s				s						
8		s				s						
9						s						
10												
11							D				D	
12							D	D	D			
13							s	D	D			
14	D						s				s	s
15	D		D			s	s				s	s
16			D			s						
17						s		D	s			
18		D				s		D	s			
19		D				s						
20	D					s						
21	D					s				D		
22			s			s				D		
23			s	s		s						
24		D		s								
25		D										
26								D				
27	D				D			D				
28					D		D					
29						D	D	s	s			
30						D		s	s			
31								s	s		D	
32			D				D	s	s			
33							D	D				
34			s				D					
35					D				s			
36									s		D	s
37									s			
38						s			s			
39						s					D	s
40	D	D					D					
41												
42							D					
43					D							
44									s			
45		D						s				
46									s			
47					s			s	s			
48	s				s			s	s			
49			s		s							
50			s		s							
51			s	D				D	D			
52			s			s						

promotion (D) for those weeks that a brand-size's retail price was deeply discounted and a shallow cut promotion (s) for those weeks that a brand's retail price was discounted by a smaller amount.

For example, consider Figure 3 in the body of the paper again. From this pricing pattern, we infer that Wisk 128 oz. had deep discount promotions during weeks 2, 14–15, 20–21, 27, and 40, and that it had a shallow discount promotion during week 48.

Brand names are abbreviated in the column heads. W indicates Wisk, A indicates All, S indicates Surf, C indicates Cheer, T indicates Tide, and Tb indicates Tide with bleach. The number following a brand name abbreviation reports package size in ounces. Thus, W128 indicates Wisk 128 oz.

Appendix B. Examination of Retail Price Patterns for the Laundry Detergent Brand with the Lowest Average Across-Price-Zone Retail Price Correlation (All 64 oz.) and for the Laundry Detergent Brand with the Lowest Minimum Across-Price-Zone Retail Price Correlation (Cheer 64 oz.)

To enhance confidence in the assertion that across-price-zone differences in a brand's retail price are not driven by wholesale prices, we examine the retail price plots for the brand with the lowest average across-price-zone retail price correlation and for the brand with the lowest minimum across-price-zone retail price correlation.

Lowest Average Across-Price-Zone Retail Price Correlation

Figure B.1 presents the retail price in 15 price zones for All 64 oz. (the brand with the lowest average across-price-zone retail price correlation). Consistent with a single promotion planning process across price zones, we see retail price promotions in weeks 4, 23–24, and 51 in all price zones with a single retail promotional price point for each promotion in all price zones. Consistent with price experimentation that leads to price zone reconfiguration, week 18 may represent a retail promotion pricing experiment which foreshadows the three distinct levels of regular retail price across price zones that emerge in week 26. Finally, in weeks 30–37 there seems to be an experiment involving All 64 oz. regular retail price, with each of the three regular retail prices ($3.29, $3.14, and $2.99) being reduced 2%–3%.

Hence, we see that most All 64 oz. promotions are consistent with a single promotion planning process across all price zones. All 64 oz. relatively low average across-price-zone retail price correlation is driven by what are probably DFF and University of Chicago GSB pricing experiments and by DFF's price zone reconfiguration in reaction to the results of those experiments.

Lowest Minimum Across-Price-Zone Retail Price Correlation: Cheer 64 oz.

Figure B.2 presents the retail price for Cheer 64 oz. (the brand with the lowest minimum across-price-zone retail price correlation) for the 15 price zones. Consistent with a single promotion planning process across price zones, we see retail price promotions in weeks 11–15, 28–29, 32–34, 40, and 42 in all price zones with a single retail promotional price point for each promotion in all price zones.

Figure B.1 All 64 oz. Retail Prices in 15 BDG Price Zones

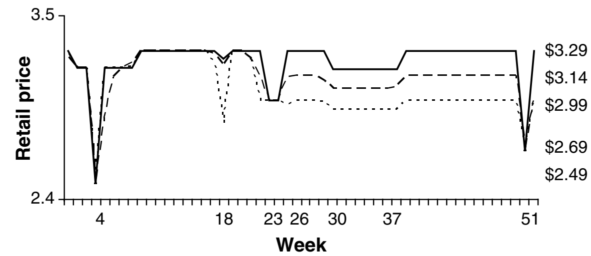


Figure B.2 Cheer 64 oz. Retail Price in 15 BDG Price Zones

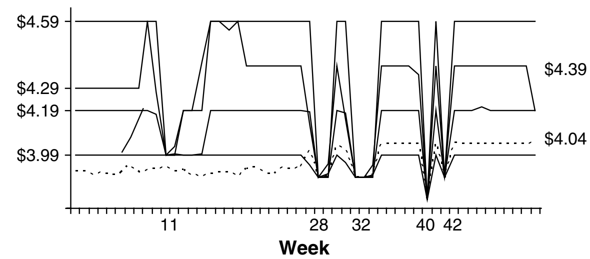
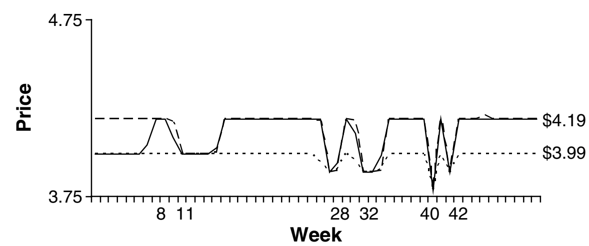


Figure B.3a Cheer 64 oz. Retail Price in DFF's Lower Priced Zones



To make it easier to see the forces influencing Cheer 64 oz. retail price, we break Cheer 64 oz. retail price history into three figures: Figure B.3a presents Cheer 64 oz. retail prices in DFF's lower priced zones; Figure B.3b presents Cheer 64 oz. retail prices in DFF's higher priced zones; and Figure B.3c presents Cheer 64 oz. retail price in BDG's price zone 6.

Figures B.3a and B.3b illustrate DFF's reconfiguration of price zones for Cheer 64 oz. In Figure B.3a, the dashed line represents six price zones (beginning regular price = $4.19) while the solid and dotted line each represent one price zone (beginning regular price = $3.99). In week 8, DFF changes Cheer 64 oz. regular retail price in the zone represented by the solid line from $3.99 to $4.19.

In Figure B.3b, the solid line represents three price zones and the dotted line represents one price zone (regular price for these four price zones at the beginning of the observation period = $4.59) while the dashed line represents one price zone (regular price at the beginning of the observation period = $4.29). In week 9, DFF changes Cheer 64 oz. regular retail price in the zone represented by the dashed line from $4.29 to $4.59. In week 20, DFF changes the regular retail price in the zone represented by the dotted line from $4.59 to $4.39.

In Figure B.3c, we see Cheer 64 oz. retail price in BDG's price zone 6. Beginning with the retail price promotion in weeks 28–29, this zone's retail promotions for Cheer 64 oz. become synchronized with those of the other BDG

Figure B.3b Cheer 64 oz. Retail Price in DFF's Higher Priced Zones

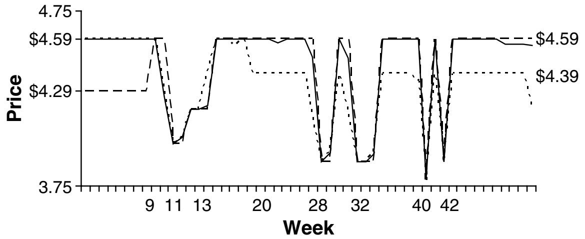
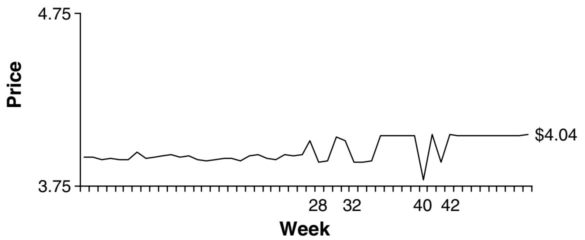


Figure B.3c Cheer 64 oz. Retail Price in BDG's Price Zone 6



price zones. The string of retail prices reported for weeks 1–27 seem to have no pattern. It is probably the case that these random seeming retail prices represent data recording errors. Keep in mind that DFF was capturing pricing information for more than 30,000 SKUs in 83 stores every day. In a database of that magnitude, it is not unusual to find data recording errors. Given the retail pricing regularity illustrated in Figure 3 in the body of the paper and in Figures B.1, B.2, B.3a, and B.3b in this appendix, it is unlikely that DFF consciously decided to let Cheer 64 oz. retail price fluctuate randomly for 27 weeks. In addition, it is unlikely that this pattern of random retail prices was a part of the DFF and University of Chicago GSB pricing experiments, since the likely pricing experiments alluded to earlier are pronounced and easily identifiable (e.g., the week 7 $4.99 retail price promotion on Wisk 128 oz. that occurred in only one price zone, and the week 18 trilevel retail price promotion for All 64. oz. that foreshadows the emergence of three regular retail prices).

In this appendix, we see further evidence of a single promotion planning process across all price zones. In addition to the examples of nonwholesale price-related causes of across-price-zone retail price differences discussed in the body of the paper (exploitation of differences in grocery shoppers' price sensitivities, price experimentation and pricing adaptation in response to those experiments, and the noise added to the data when the promotion period does not correspond with data collection period), we add data recording errors as another nonwholesale price-related cause of across-price-zone retail price differences.

Appendix C. For Brands in Each of BDG's Other Ten Categories, High Across-Zone Retail Price Correlations Are Consistent with There Being Only One Independent Observation of the Impact of Wholesale Prices on a Brand's Retail Price Each Week

While BDG gave us their laundry detergent wholesale and retail prices, for the other ten categories they provided only brands' names and sizes. Based on that BDG-supplied list of brand names and sizes, we constructed wholesale and retail prices using information from the University of Chicago Web site. From those constructed prices, we calculated, for each category, the average correlation of each brand's retail price in each of the 105 pairs of BDG price zones. To conserve space, we provide some detail but do not look as deeply at these brands' correlations as we did at the laundry detergent brands in §3 of the paper and in Appendix B. Instead, Table C.1 summarizes findings which show that the average across-brand, across-price-zone correlation for the 11 BDG categories ranges from 0.74 to 0.93 and averages 0.89. Close examination of the price patterns, analogous to that done for the laundry detergent category, confirms that the major forces causing across-brand,

Table C.1 Average Across-Brand, Across-Price-Zone Correlation of a Brand's Retail Price for BDG's 11 Product Categories

Product category	Average across-brand, across-price-zone correlation of a brand's retail price
Bath tissue	0.92
Beer	0.93
Crackers	0.90
Dish detergent	0.91
Frozen orange juice	0.92
Laundry detergent	0.90
Oat cereal	0.74
Paper towels	0.92
Refrigerated orange juice	0.87
Toothpaste	0.80
Tuna (canned)	0.92
Overall average	0.89

Table C.2 Bath Tissue

Brand number	Brand name	Brand size (count)	Average correlation of brand's retail price in pairs of BDG price zones
1	Angel	4	0.87
2	Kleenex	4	0.87
3	Charmin	4	0.98
4	Northern	4	0.90
5	Scott	1	0.94
6	Cottonelle	4	0.96
Across-brand, across-zone average			0.92

Notes. Charmin adjustment

Zones 1–10 Charmin has EDLP price, average correlation = 0.99 (9 zones → 36 zone pairs → 79% of zone pairs).

Zones 11–16 Charmin has Hi/Low price, average correlation = 0.94 (6 zones → 15 zone pairs → 21% of zone pairs).

Weighted average Charmin correlation = 0.79 (0.99) + 0.21 (0.94) = 0.98.

Scott adjustment

Nearly zone specific price experimentation in weeks 111–148.

Weeks 149–162, experiment involving three different retail pricing strategies.

Zones 1–3, 7–8, 10–13 Scott takes price up and holds it, average correlation = 0.94 (9 zones → 36 zone pairs → 84% of zone pairs).

Zones 4 and 14 Scott Hi/Low, average correlation = 0.96 (2 zones → 1 zone pair → 2% of zone pairs).

Zones 5, 6, 15, 16 Scott takes price down and holds it, average correlation = 0.94 (4 zones → 6 zone pairs → 14% of zone pairs).

Weighted average Scott correlation = 0.84 (0.94) + 0.02 (0.96) + 0.14 (0.94) = 0.94.

Table C.3 Beer

Brands number	Brand name	Brand size (pack)	Average correlation of brand's retail price in pairs of BDG price zones
1	Budweiser	6	0.88
2	Budweiser	12	0.99
3	Budweiser	24	0.87
4	Miller	6	0.88
5	Miller	12	1.00
6	Miller	24	0.94
7	Old Style	30	We found no UPCs of Old Style with sales through the observation period.
Across-brand, across-zone average			0.94

Table C.4 Crackers

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Keebler saltines	16	0.93
2	Keebler crackers	16	0.95
3	Dominick's saltines	16	0.85
4	Nabisco honey graham crackers	16	0.95
5	Nabisco unsalted crackers	16	0.81
6	Carrs crackers	5.29	0.84
7	Old London unsalted crackers	5.29	0.90
Across-brand, across-zone average			0.90

across-price-zone correlations of brands' retail prices to be less than one are DFF's exploitation of differences in grocery shoppers' price sensitivities and DFF's price experimentation and adaptation. As we argued in §3, these high correlations are consistent with a lack of price-zone-specific independent reaction to wholesale prices. From this we conclude that in those additional 10 categories, too, BDG overstated the number of independent observations by a factor of 15.

In Tables C.2–C.11, we present, for each of BDG's additional 10 categories, each brand-size included in BDG's analysis and that brand-size's average retail price correlation across BDG zone pairs. Because of DFF's extensive price experimentation during the period of observation, we sometimes make adjustments to the correlations. In particular, in many of these categories, DFF contrasted EDLP and Hi/Low pricing for a brand (see Hoch et al. 1994 for published analysis of DFF's EDLP versus Hi/Low price experiments). For such situations, we calculate an average correlation for a brand's retail price across zones in which that brand has an EDLP price and an average correlation for those zones in which it has a Hi/Low price. The correlation we report is a weighted average of those two correlations. Similar adjustments are made where needed to adjust for other manifestations of DFF's price experimentation. It is

Table C.5 Dish Detergent

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Sunlite	22	0.94
2	Ajax	22	0.91
3	Palmolive	42	0.95
4	Palmolive	22	0.95
5	Palmolive Lemon	22	0.97
6	Dawn	22	0.98
7	Ivory	22	0.99
8	Joy	22	0.61
9	Ivory	42	0.93
10	Dawn	42	0.91
11	Dominick's	22	0.85
Across-brand, across-zone average			0.91

Notes. Ajax adjustment
Dropped weeks 111–123 because data is suspect for those weeks.

Adjustment for price experimentation
There is an obvious pattern of price experimentation in this category for which we adjusted. That pattern includes:
l → h: Hi/Low with low regular price until week 147 when switch to high regular price.
h → l: Hi/Low with high regular price until week 147 when switch to low regular price.
l: Hi/Low with low regular price.
h: Hi/Low with high regular price.
EDLP: Constant price throughout period.
h/l: high and low prices throughout period.
Zones 1, 2, 5–8, 12–16: l → h for all brands.
Zones 3, 4, 10, 11 were varied as follows:

Zone	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
3	l → h	l → h	h → l	h → l	h → l	*	h → l	EDLP	h → l	h → l	h → l
4	l → h	l → h	l	h	l	l	l	EDLP	l	l	l
10	l → h	l → h	h → l	h → l	h → l	h → l	h → l	EDLP	h → l	h → l	h → l
11	l → h	l → h	h	l	h	h	h	EDLP	h	h	h

*Brand 6 in zone 3 was l → h for weeks 111–127, and then became h → l.

Table C.6 Frozen Orange Juice

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Florida	12	0.93
2	Minute Maid	12	0.96
3	Dominick's	12	0.82
4	Tropicana	12	0.93
5	Citrus Hill	12	0.94
Across-brand, across-zone average			0.92

Note. For all brands, zones 1–10 were EDLP and zones 11–16 were Hi/Low.

Table C.7 Oat Cereal

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Cream of Wheat	12–28	0.59*
2	Quaker Regular	18	0.70*
3	Quaker Instant	12–15	0.93
Across-brand, across-zone average			0.74

*Cream of Wheat and Quaker Regular had a great deal of price experimentation and price zone reconfiguration—analogous to All 64 oz. described in Appendix B. No adjustments were made to these correlations.

Table C.8 Paper Towels

Brand number	Brand name	Brand size (roll)	Average correlation of brand's retail price in pairs of BDG price zones
1	Bounty	1	0.93
2	Bounty Big Roll	1	0.96
3	Dominick's	1	We found no UPCs of Dominicks with data through the observation period.
4	Scott	1	0.82
5	Viva	1	0.93
6	Generic	1	0.94
Across-brand, across-zone average			0.92

Note. Bounty, Bounty Big Roll, Viva, and Generic adjustment
Zones 1–10 were EDLP. Zones 11–16 were Hi/Low.

Table C.9 Refrigerated Orange Juice

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Minute Maid	68	0.93
2	Dominick's	68	0.89
3	Dominick's	128	0.63
4	Tropicana Premium	64	0.95
5	Tropicana SB	64	0.95
6	Tropicana Premium	96	0.83
7	Sunny Delight	96	0.94
Across-brand, across-zone average			0.87

Notes. Tropicana Premium, 96 oz. adjustment
Zones 1, 2, 7, 8, 10: Hi/low, shifting regular price up in week 155.
Zones 4–6, 12–16: semi EDLP, shifting regular price up in week 155.
Zones 3 and 11: hi/lo, switch to semi EDLP while lowering regular price in week 155.

important to note that the phenomena for which we adjust correlations are manifestations of DFF's price experimentation and are *not* indications that price zones react independently to wholesale prices when they set retail prices.

Table C.10 Toothpaste

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Aim	6.4	0.94
2	Close-up	6.4	0.79
3	Arm & Hammer	4.5	0.89
4	Colgate	5.3	0.93
5	Colgate	6.4	0.73
6	Colgate	8.2	0.93
7	Crest	4.6	0.98
8	Crest	6.4	0.95
9	Crest	8.2	0.98
10	Aqua Fresh	6.4	0.86
Across-brand, across-zone average			0.90

Notes. Colgate 8.2 adjustment
All zones except 8 and 10 shift pricing strategy in week 144.
Crest (*4.6, 6.4, and 8.2 oz.*) *adjustment*
Two major patterns of regular price level experiments go on in zones 2, 5, 6, 8, 12–16, and in zones 1, 3, 4, and 10. Zones 4 and 11 switch their pattern of price level experiments in week 144.

Table C.11 Tuna

Brand number	Brand name	Brand size (oz.)	Average correlation of brand's retail price in pairs of BDG price zones
1	Dominick's	6.5	0.96
2	Chicken of the Sea	6.5	0.95
3	Star Kist	6.12	0.80
4	Bumble Bee	6.12	0.95
Across-brand, across-zone average			0.92

Notes. Dominick's adjustment
Zones 1–10 were EDLP. Zones 11–16 were Hi/Low.

Bumble Bee adjustment
Pricing was done for four groups of zones: Group A = zones 1, 2, 3, 7, 8, 10; Group B = zones 4, 5, 6; Group C = zones 11, 12; Group D = zones 13–16. At the beginning of the period, Groups A and C were priced similarly and Groups B and D were priced similarly. At the end of the period, Groups A and B were priced similarly and Groups C and D were priced similarly.

Complete illustration of this point for each category is foregone in the interest of brevity. The authors will be happy to reply to observations that a reader might interpret as evidence that zones are reacting independently to wholesale prices when they set retail prices.

Laundry Detergent
Covered extensively in the body of the paper and in Appendix B.

Appendix D. Complex Promotional "Deals" Make Wholesale Price Hard to Define and Interpret

Promotional Instruments and "Wholesale Price"
To decode the quantity that a retailer reports as "wholesale price," one needs to understand the vast array of promotional instruments that are used by manufacturers and retailers in their negotiations and to consider the implications of those promotional instruments for the calculation of wholesale price. The most straightforward of the promotional instruments is an "off-invoice allowance." With this instrument, the manufacturer offers, say, $1 off on each $10

case that the retailer buys. If the retailer buys 100 cases, then the manufacturer sends the retailer the 100 cases and an invoice for $900 to pay for those cases. While it is straightforward to capture such a price reduction in wholesale price, the timing of the wholesale price reduction probably would not correspond with the timing of the retail price reduction. The retailer may stock up on reduced wholesale price inventory before beginning the retail promotion. In addition, the retailer may not sell all of those units bought at the promoted wholesale price during the retail promotion period. To further complicate the interpretation of "wholesale price," often part of a retail buyer's compensation is tied to the total number of promotional dollars that buyer is able to extract from the manufacturers with whom he or she deals. With such a compensation scheme, the $100 promotional payment associated with the "off-invoice" allowance mentioned above might be accounted for in that buyer's "promotion account" and the wholesale price for those 100 cases might be recorded at the full $10 per case.

Another frequently used promotional instrument is the "bill-back allowance." With this instrument, the manufacturer might offer $1 off on each $10 case that the retailer buys. If the retailer orders 100 cases, the manufacturer sends the 100 cases and an invoice for $1,000. After the retailer delivers the agreed-upon promotional support, (e.g., the retailer advertises and sells those 100 cases at an agreed-upon promotional price), the retailer can "bill the manufacturer back" for $100 to cover the $1 allowance per case. Such an arrangement could complicate the process of linking the promoted retail price to any impact the manufacturer's promotional funds might have on wholesale price. And, again, depending on the buyer's compensation scheme, this allowance may go directly into the buyer's "promotion account" without ever even being considered a factor in the promoted brand's wholesale price.

With another promotional instrument, special financing terms, the manufacturer might reduce the finance charge associated with an invoice if the retailer commits to buy a specified amount of promoted product by a given date. If the retailer's exact dollar savings is even calculated, it would be complex for the retailer to allocate those savings back to the wholesale price of the particular packages that are sold during a promotional period.

With "advertising accrual funds," the manufacturer of brand X provides the retailer with funds to support promotional advertising in year t based on the total number of units of brand X that retailer bought in year $t-1$. It would be a waste of accounting effort to allocate the year t advertising accrual funds back to the wholesale price of units of brand X bought in year $t-1$, and it could be misleading to allocate those funds to the wholesale price of units of brand X bought in year t.

Manufacturers created "scan-back" promotion (Dreze and Bell 2003) to try to link wholesale and retail promotions more closely. With this promotional instrument, the retailer gets a discount on the number of units sold to grocery shoppers during the retail promotion rather than on the number of units bought by the retailer during a wholesale promotion.

The list of potential promotional instruments seems almost endless. Consider payments that a manufacturer makes to have several of its brands featured in a retailer's frequent shopper program. How should the retailer allocate that payment to the wholesale price of the manufacturer's different brands? A soft drink manufacturer might install cold drink cabinets near the retailer's checkout aisles. How should the retailer allocate the value of those cold drink cabinets to the wholesale price of the soft drink manufacturer's different SKUs? What if the manufacturer's salespeople agree to reset the shelves at the retailer's stores? What if the manufacturer gives the retailer free product to distribute at a new store opening? Other researchers (Blattberg and Neslin 1990, Kim and Staelin 1999, Dreze and Bell 2003, Hauser et al. 1997, Lariviere and Padmanabhan 1997, and Chintagunta 2002) have considered the implications of such "side payments" from manufacturers to retailers.

In addition to the dizzying array of promotional instruments offered by manufacturers, retailers often buy promoted products for reasons other than immediate resale at a "promoted" retail price. When a manufacturer offers a temporarily lower wholesale price, retailers sometimes buy enough inventory to cover promoted retail sales and then some. In a practice called "forward buying," the additional inventory is sold through the chain's stores after the conclusion of the retail price promotion at the brand's regular (i.e., unpromoted) retail price. In a practice called "diverting," a retailer sells the additional inventory to another retailer in a region of the country to which the manufacturer has not made a wholesale promotional offer. The retailer's profit from forward buying and diverting is often accumulated in an "inside margin" account that has no impact on the wholesale price of the brand that offered the wholesale promotional support. To look more closely at different promotional instruments, see Dreze and Bell (2003), Neslin et al. (1995), and Kahn and McAlister (1997).

Manufacturer-Retailer Deals

All of the promotional vehicles mentioned above and many, many more are involved in the complex negotiations between manufacturers and retailers. At a quarterly meeting, the manufacturer asks the retailer for a particular pattern of retail promotional support (price cuts, feature ads, displays, etc.) and makes a portfolio of promotional offers like those mentioned above. The two parties haggle as the retailer tries to "find the money in all of the manufacturer's promotional pockets." The manufacturer tries to get as much retailer promotional support for its brands as possible while yielding as little of its total promotion budget as possible. The retailer tries to get as much manufacturer promotional support as possible while building a weekly portfolio of promotional offers that will draw as many shoppers into its stores as possible (Dreze 1995, Dhar and Hoch 1997, Chintagunta 2002). Amid all this haggling, the buyer considers the promotional offers from all of the different manufacturers from whom he or she buys and then sets a promotion calendar for the category for the quarter. In a heavily promoted category like laundry detergent, that promotion calendar would show retail promotional support moving from one brand in one week to another brand the next week, and so on. In Appendix A, we present an "inferred promotion calendar" for DFF's laundry detergent category during the one-year BDG estimation period.

Speculation About the Promotions Behind Cheer 128 oz. Retail Price and Wholesale Price

Figure 5 in the body of the paper presents the average retail price and the wholesale price for Cheer 128 oz. for the observation period. At week 4, Cheer 128 oz. wholesale price begins to drop, indicating the addition to DFF's inventory of lower priced packages of Cheer 128 oz. There may have been a deal between Cheer and DFF that called for a shallow discount retail promotion on Cheer 128 oz. in weeks 5–9 and that allowed DFF to buy Cheer 128 oz. at a reduced, promotional wholesale price for weeks 4–13. During weeks 13–18 Cheer 128 oz. wholesale price rises, implying that DFF is buying Cheer 128 oz. at a higher wholesale price despite the fact that this time window includes the first four weeks (weeks 15–18) of Cheer 128 oz. second shallow discount retail promotion. Perhaps weeks 15–18 of shallow discount retail promotion were negotiated as a part of the deal that covered the shallow discount retail promotion in weeks 5–9, or perhaps they were negotiated as a part of a deal that dramatically lowered DFF's wholesale price for Cheer 128 oz. in weeks 18–20. The week 18–20 steep fall-off in Cheer 128 oz. wholesale price probably indicates the addition to DFF's inventory of a large quantity of Cheer 128 oz. at a significantly lower wholesale price. The right to buy so much Cheer 128 oz. at such a low wholesale price was probably tied to the deep discount retail promotion in weeks 29 and 30, and may have also been tied to some or all of the shallow discount promotion in weeks 15–23. Cheer 128 oz. wholesale price rises slowly from weeks 18 to 34, indicating the gradual addition to DFF's inventory of small quantities of higher priced packages of Cheer 128 oz. The decline in Cheer 128 oz. wholesale price that starts in week 34 is probably associated with a deal that caused Cheer 128 oz. shallow discount retail promotion in weeks 38 and 39. Who knows what caused the slight up and down tics in Cheer 128 oz. wholesale price in weeks 42–47 ? (Perhaps an invoice deduction got resolved. Perhaps damaged product was refunded. Perhaps an inventory audit created the need for adjustment to wholesale prices.) The precipitous drop in wholesale price that begins in week 47, however, is probably tied to a deal associated with the retail price promotion that seems to be beginning in week 52.

Speculation About the Promotions Behind All 128 oz. Retail Price and Wholesale Price

Figure 6 in the body of the paper presents the average retail price and the wholesale price for All 128 oz. This pattern of prices may have resulted from a deal negotiated by All and DFF that gave DFF an everyday low wholesale price for All 128 oz. to cover the shallow price cut promotions in weeks 22–23, 34, and 49–52, and then supplemented that everyday low wholesale price for All 128 oz. with an additional wholesale price discount for weeks 15–16 and 32 when All 128 oz. experienced deep price-cut retail promotions.

Appendix E. Dominick's Finer Foods' Average Acquisition Cost Model for "Wholesale Price" and Implications for BDG's Analysis

Let:

$W_{b,t}$ = the number that DFF records as "wholesale price" of brand b for period t as defined using their average acquisition cost model,

$I_{b,t}$ = number of units of brand b in DFF's inventory at the end of period t,

$S_{b,t}$ = number of units of brand b that DFF sells in period t,

$N_{b,t}$ = number of units of brand b that DFF buys in period t, and

$P_{b,t}$ = price that DFF pays the manufacturer of brand b for a unit of brand b that DFF buys in period t.

The "wholesale price" that DFF assigns to one unit of brand b for time period t is:

$$W_{b,t} = \frac{(N_{b,t} * P_{b,t}) + (I_{b,t-1} - S_{b,t}) * W_{b,t-1}}{I_{b,t}}.$$

If DFF sold all of its inventory of brand b by the end of each period, then the term $(I_{b,t-1} - S_{b,t}) * W_{b,t-1}$ would go to zero and DFF's average acquisition cost model would assign a "wholesale price" for brand b in period t that would be equal to the price that DFF paid b's manufacturer for a package of brand b in period t. When inventory of brand b does not go to zero at the end of each period, DFF determines a number to record for "wholesale price" of brand b such that:

i. Every unit of brand b in inventory is assigned the same "wholesale price."

ii. The resulting total cost of the inventory of brand b+ the total cost assigned to the units of brand b that have been sold = the total number of dollars that DFF paid brand b's manufacturer to acquire the units of brand b that have been sold and that are in DFF's inventory.

Alternative models for determining the "wholesale price" of those units in inventory include LIFO (last in, first out) and FIFO (first in, first out). Both LIFO and FIFO require condition (ii) above. They differ from DFF's average acquisition cost model by not requiring that all units in inventory have the same "wholesale price." Rather, under LIFO and FIFO the retailer keeps track of the sequence of shipments it receives of brand b, the number of units of brand b received in each shipment, and the price the manufacturer charged for a unit of brand b in each shipment.

Companies have different motivations for choosing different inventory valuation models. For goods whose prices are increasing or decreasing rapidly, use of LIFO versus FIFO as a model for "wholesale price" can have significant implications for taxes and for perceived firm value because the two models value the firm's inventory asset differently at different points in time and because the two models

Figure E.1 **"Wholesale Price" Assigned to a Unit of Brand *b* in Inventory Using DFF's Average Acquisition Cost Model, LIFO, and FIFO**

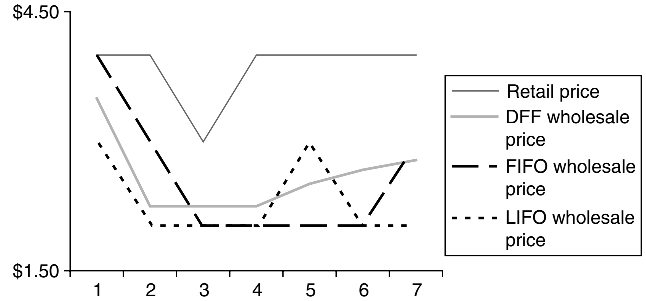


Table E.1 Illustration of LIFO, FIFO, and DFF's Average Acquisition Cost Model for "Wholesale Price"

t	Number of units of brand b in retailer's inventory end of week $t-1$	Number of units of brand b retailer acquires in week t	Acquisition price per unit of brand b the retailer acquired in week t ($)	Number of units of brand b retailer sells in week t	Number of units of brand b in retailer's inventory end of week t	Number recorded as "wholesale price" for brand b in week t ($): DFF's average acquisition cost model	LIFO	FIFO
1	200	200	3.00	200	200	3.50	3.00	4.00
2	200	1,000	2.00	200	1,000	2.25	2.00	3.00
3	800	0		400	600	2.25	2.00	2.00
4	600	0		200	400	2.25	2.00	2.00
5	400	200	3.00	200	400	2.50	3.00	2.00
6	400	200	3.00	200	400	2.67	2.00	2.00
7	400	200	3.00	200	400	2.78	2.00	3.00

can result in different profitability streams for the retailer's sales through time. An average acquisition cost model for "wholesale price" does not require the retailer to keep track of the exact sequence, size, and acquisition price for shipments received from every manufacturer for every SKU. Such a model is simpler to implement and therefore attractive to grocery retailers who manage inventory on 30,000 or more different SKUs.

Table E.1 and Figure E.1 illustrate these three models for "wholesale price" for a situation in which a retailer who comes into week 1 with 200 units of brand b in inventory at "wholesale price" of $4. Each week, this retailer typically buys 200 units of brand b at $3 per unit and typically sells 200 units of brand b at $4 per unit. In addition, this retailer carries safety stock for brand b in inventory so that inventory of the brand never goes to 0. In this example, in week 2, the retailer buys 1,000 units of brand b at a reduced acquisition price of $2 per unit. In week 3, the retailer offers a retail promotional price of $3 per unit on brand b and sells 400 units. The remaining units of brand b that the retailer acquired at $2 per unit in week 2 are sometimes referred to as "forward buy" inventory: it was bought from the manufacturer at a reduced, promotional price but will be sold to consumers in the future at the brand's "regular" retail price.

In the scenario just outlined, of the $1,000 of promotional support provided by brand b's manufacturer in week 2 (1,000 units purchased from the manufacturer at a $1 per unit price reduction), 40% was passed through to the end consumer in the week 3 retail promotion for brand b. The results of estimating pass through using a model like BDG's to relate a brand's wholesale price to its retail price are summarized in Table E.2.

Table E.2 Estimation of Retail Price as a Function of Wholesale Price Based on Different Models for "Wholesale Price"

"Wholesale price" model	Regression of "wholesale price" on retail price
DFF's average acquisition cost	Retail price = 3.11 + 0.29 "wholesale price"
LIFO	Retail price = 3.40 + 0.20 "wholesale price"
FIFO	Retail price = 3.46 + 0.15 "wholesale price"

Notes. This illustrates the potential sensitivity of the coefficient of a target brand's own wholesale price to the model a retailer uses to define the number that it records as that brand's "wholesale price." This also illustrates the fact that this coefficient for a target brand's own wholesale price can be a poor proxy for the extent to which the retailer passes through to end consumers the promotional support provided by a brand's manufacturer.

Appendix F. Coefficients for Other Brands' Wholesale Prices (Indicators of Cross-Brand Pass-Through) Are Not Stable Through Time for BDG's Other 10 Categories

We checked the stability of coefficients for other brands' wholesale prices in the remaining 10 BDG product categories using the methodology described in §5.1. Table F.1 reports those results. Given that we had only brand names and sizes for BDG's brands in the 10 additional categories, it will almost surely be the case that our construction of price data for these brand-sizes will not be exactly identical to BDG's price data for these brand-sizes. (There are often many UPCs associated with a brand-size. Some UPCs have no data for the observation period, some UPCs have data for only a few weeks of the observation period, and often UPCs for the same brand size will have very different pricing patterns. Consequently, we had to make many judgment calls as we reconstructed prices for BDG's additional 10 categories.)

Comparing the third and fourth columns of Table F.1, one can see that despite the fact that we had to recreate the BDG price data for 10 of the categories, we get approximately the same number of significant coefficients for other brands' wholesale prices as did BDG. (Using 780 observations of DFF data, we had on average 31.1 statistically significant coefficients for other brands' wholesale prices per category while on average BDG had 31.7 statistically significant coefficients for other brands' wholesale prices per category. A paired sample t-test shows that the difference between the two is not significant: $t = 0.47$, $p = 0.65$.)

The fourth and fifth columns of Table F.1 tell us that even when estimating with 780 observations of DFF data, the average number of significant and stable coefficients for other brands' wholesale prices in a category is much lower than the average number of significant coefficients for other brands' wholesale prices in that category (9.3 significant and stable coefficients on average versus 31.1 significant coefficients on average).

The seventh column of Table F.1 reports the results of estimating BDG's model for each brand in each of BDG's 11 categories when we account for the fact that for each brand there is only one independent observation each week of the impact of wholesale prices on that brand's retail price.

Table F.1 Number and Stability of Statistically Significant Coefficients for Other Brands' Wholesale Prices in 11 BDG Categories

			780 Observations of DFF data		52 Independent observations of DFF data	
Category	Number of coeffidents for other brands' wholesale prices estimated	Number of coefficients for other brands' wholesale prices that were statistically significant (positive or negative) in BDG's analysis	Number of coefficients for other brands' wholesale prices that were statistically significant (positive or negative) in our analysis	Stability: Number of coefficients for other brands' wholesale prices significant in first half, still significant and same sign in second half	Number of coefficients for other brands' wholesale prices that were statistically significant (positive or negative) in our analysis	Stability: Number of coefficients for other brands' wholesale prices significant in first half, still significant and same sign in second half
Bath tissue	30	19	12	9	4	1
Beer	42	27	24	4	7	0
Crackers	42	26	21	5	1	0
Dish detergent	110	58	68	9	27	0
Frozen orange juice	20	13	13	5	5	1
Laundry detergent	132	94	94	30	8	0
Oat cereal	6	5	5	0	3	0
Paper towels	30	18	14	7	4	0
Refrigerated orange juice	42	26	29	10	13	3
Toothpaste	90	58	58	22	16	1
Tuna	12	5	4	1	5	1
Average	50.5	31.7	31.1	9.3	8.5	0.6

We do this by constructing a 52-independent-observation data set for each brand in each category in the same way we created the 52-independent-observation data sets for the brands in the laundry detergent category (described in §5.1). Estimating the appropriately adapted BDG model (3) for each brand in each category yields on average for each category only 0.6 coefficients that are stable across the first and second halves of the data.

Here we see that for the brands in all 11 categories BDG's indicators of cross-brand pass-through (coefficients of other brands' wholesale prices) are not stable through time even when estimated using 780 observations of DFF data. When we account for the fact that there are only 52 independent observations of the impact of wholesale prices on a target brand's retail price, we find the percentage of significant and stable coefficients ($0.6/50.5 = 1\%$) is smaller than one would expect by chance, testing at the $p = 0.05$ level. We conclude that there is no stable, sample-size adjusted support in any the 11 studied categories for the hypothesis that DFF systematically passed one brand's wholesale promotional support through to the retail prices of other brands.

Appendix G. Some Coefficients for a Target Brand's Own Wholesale Price (Indicators of Own-Brand Pass-Through) Are Stable Through Time for BDG's Other 10 Categories

Table G.1 summarizes our investigation of the stability of the coefficients of a target brand's own wholesale price for BDG's 11 categories.

Comparing the fourth and fifth columns of Table G.1, one can see that despite the fact that we had to reconstruct the BDG price data for 10 of the categories we get approx-

Table G.1 Number and Stability of Statistically Significant Coefficients for a Target Brand's Own Wholesale Price in 11 BDG Categories

	Number of coefficients for target brand's own wholesale price estimated			780 observations of DFF data		52 Independent observations of DFF data	
Category	780 observations	52 Independent observations	Number of coefficients for target brand's own wholesale price that were statistically significant positive in BDG's analysis	Number of coefficients for target brand's own wholesale price that were statistically significant positive in our analysis	Stability: Number of coefficients for target brand's own wholesale price significant positive in both first and second halves of data	Number of coefficients for target brand's own wholesale prices that were statistically significant positive in our analysis	Stability: Number of coefficients for target brand's own wholesale Price significant positive in both first and second halves of data
Bath tissue	90	6	73	84	83	6	6
Beer	105	7	104	70	56	5	5
Crackers	105	7	92	98	98	7	6
Dish detergent	164	11	119	148	117	9	6
Frozen orange juice	75	5	52	70	69	5	5
Laundry detergent	180	12	153	135	69	5	2
Oat cereal	45	3	44	42	27	3	1
Paper towels	85	5	57	69	59	4	4
Refrigerated orange juice	105	7	81	78	75	6	6
Toothpaste	150	10	69	135	97	8	6
Tuna	60	4	38	47	31	4	3
Average	105.8	7	80.1	88.7	71	5.6	4.5

imately the same number of significant coefficients for a target brand's own wholesale price as did BDG.[6] (Using 780 observations, we had on average 88.7 statistically significant coefficients for a target brand's own wholesale price per category while, BDG had on average 80.1 statistically significant coefficients. A paired sample t-test shows that the difference between the two is not significant: $t = -1.10$, $p = 0.30$.)

The eighth column of Table G.1 reports the results of estimating BDG's model for each brand in each of BDG's 11 categories when we account for the fact that for each brand there is only one independent observation each week of the impact of wholesale prices on that brand's retail price. Estimating the appropriately adapted BDG model (3) for each brand in each category yields on average for each category 4.5 coefficients that were stable (i.e., significant and positive) across the first and second halves of the data.

Hence, we see that for the brands in all 11 categories BDG's indicators of own-brand pass-through (coefficients of a target brand's own wholesale price) are stable through time, even when estimated using 52 independent observations of DFF data. Of the 7 estimated coefficients for a target brand's own wholesale price on average across categories, 4.5 (64%) were significant and stable.

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[6] BDG report 153 significant positive coefficients for a target brand's own wholesale price in the laundry detergent category (BDG, Table 3, p. 121). This difference in the number of significant coefficients for a target brand's own wholesale price between our estimation of BDG's model and their estimation of that model is probably an artifact of the extremely high correlation between zone-specific dummy variables and zone-specific observations of a brand's own wholesale price. That correlation across zones and weeks is >0.99 for each laundry detergent brand. The extreme correlation is driven by the fact that for each brand of the 780 observations, there are 728 values for which the zone-specific dummy and the brand's zone-specific wholesale price are both equal to 0.

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