Unit Value Bias in Wholesale and Retail Trade Price Indexes

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Introduction

Much has been written about unit value bias in price indexes as it relates to average prices for products (Diewert and von der Lippe, 2010; Silver, 2007; Balk, 1998)[i]. However, academic literature and international guidelines on the construction of producer price indexes do not address the potential for this bias in prices collected for wholesaling and retailing products and what would constitute unit value bias in indexes for those services.

This paper examines the concept of unit value bias, the pricing methodology of the trade industries, and how bias could be present in trade prices.

Average prices and unit value bias

The Bureau of Labor Statistics (BLS) often prefers to include average, or unit value, prices in the Producer Price Index for industries in which there are large numbers of homogeneous products or services provided at different prices. With homogeneity, unit value indexes are the appropriate way to track price change. Moreover, there are two side benefits of doing so. First, the item sample size greatly increases providing a better representation of an industry's production. Second, unit values eliminate the need for frequent substitutions and better reflect competitive pricing and price adjustments than a single transaction.

For example, BLS collects unit value guestroom rental rates from hotels and motels for a specific type of room (suite vs. non-suite) and time period such as the first 21 days of the current month. Many hotels use sophisticated revenue management tools to determine what rate to charge to specific customers that consider several factors when setting the price, including the lodging date(s), the type of buyer, the amount of time between the booking and the stay, and the anticipated occupancy rate during the lodging dates. As a result, prices charged to two guests receiving the same level of service can be very different. If only a sample of single room rate transactions for a specific day of the month were tracked instead, much of the seasonal pricing and discounting would not be captured as it is in the unit value price. In another example, the average revenue per user (ARPU) collected for wireless telecommunication services reflects new plans immediately while still covering existing plans.

Many wireless companies never change their prices charged for specific plans (individual, family, data-only, etc.). They simply introduce new plans and allow customers to migrate to them – or not. Since the plans are generic, basically selling the same service with minor packaging differences, these plans represent different levels of discounting. Pricing a sample of individual plans in this industry could present a risk for new item bias.

The International Monetary Fund (IMF) guidelines specifically state that average prices are acceptable when products are "strictly homogeneous," and the price represents the current time period. When an average includes a mix of quality characteristics or terms of sale, this heterogeneity will lead to unit value bias.[ii]

The guidelines further explain that the unit value formula presents a risk of bias even when detailed item level quantity and revenue data are available. For a company that produces "thousands of an item each day, the price may not be fixed" and "minor variations in the nature of what is produced may affect the price if it is estimated as the total revenue divided by the quantity produced."[iii] For example, as an establishment moves to produce higher quality items (that are higher priced), the average price will change due to the change in item mix and will result in an upward bias.[iv] Likewise, introducing a lower quality item (that is lower priced) into the average will lead to a downward bias. In scenarios like these, where there are differences in quality for the goods or services included in the average, it becomes impossible to disentangle quality change from pure price change and a unit value price would not be appropriate.

To understand how this concept translates to the trade industries, it is necessary to discuss the pricing methodology of these industries and the challenge of determining homogeneity, particularly for a service.

Unit value bias in the trade industries

Pricing methodology

The output of the trade industries is not the products being sold, but the provision of the services required to allow others access to purchase products. BLS collects margin prices to

measure this activity. For retail trade, the margin represents the distribution, marketing, display, and storage of merchandise as well as customer service. For wholesale trade, it measures the transfer of goods to other business which includes selling and promoting, bulk breaking, warehousing, and providing market information.

The margin price is defined as the difference between the price at which the retailer or wholesaler sells the product and the price that would have to be paid to replace that same product at the time it is sold. For the PPI, the preferred margin is an average margin per unit for a comparable product line as it is more representative than individual margins for a small number of products. To be considered comparable, products included in the average must be:

- Homogeneous
- Able to be substituted for each other
- Priced on the same per unit basis
- Marketed under similar conditions to a similar demographic market
- Sold to the same customer class (e.g., national retailer, small manufacturer); wholesale trade only

Depending on the availability of data from sampled establishments, averages are defined at different levels based on these characteristics. While some report a broad product line average, others provide a very narrow average margin for a specific product.

In addition to the comparability of the products, there must also be a constant level of service being provided to sell the products included in the average. Product characteristics are used as a proxy to represent the underlying services provided by retailers and wholesalers:

- Type of product - e.g., produce, canned goods, frozen entrees
- Product manufacturer - national v. store brand (private label)
- Amount of additional services

Determining bias

When an average margin includes products associated with different levels of service, there is risk of unit value bias. It may be reasonable to assume that different margin and markup percentages reflect different service levels. If that is the case and the average includes products with varying percentages, unit value bias could be present as the product mix changes over time. It should be noted that a lack of comparability in products may not lead to bias if the level of the service is essentially the same.

Bias is more likely to appear in average margins for broadly defined product lines as they tend to be less homogeneous and, therefore, likely represent differing levels of service to sell the products included. These margins have been collected, to various extents, in the following industries or sectors:

- Merchant Wholesalers, Durable Goods
- Merchant Wholesalers, Nondurable Good
- New Car Dealers
- Recreational Vehicle Dealers
- Boat Dealers
- Fuel Dealers
- Furniture Retailers
- Floor Covering Retailers
- Building Materials and Supplies Dealers
- Nursery, Garden Center, and Farm Supply Retailers
- Supermarkets and Other Grocery Stores
- Shoe Retailers
- Office Supplies, Stationery, and Gift Retailers

Within this group, the risk for bias may be greater for some of these industries than others based on the products and services provided. However, there is no standard for making that determination. One example is merchant wholesalers of machinery, equipment, and supplies.

The variability in the products offered by these establishments, at any given time, makes it difficult to collect margins for a more detailed product line on a continual basis. Therefore, a more heterogeneous average may be a necessary fallback.

On the other hand, grocery retailers can provide a narrower product line margin. Their product lines appear to be defined such that the same level of service is required for any product included. For example, markup percentages for fresh produce are different than those for frozen foods and dry goods. Perishable items have higher markups to account for the higher risk of spoilage, and therefore, more frequent replenishing of stock. Prepared foods and deli items also have higher markups due to the additional services provided to the customer. Grocery retailers can price these broad product lines separately, minimizing the chance for bias in the average margin.

While the broad product lines appear to be homogeneous for grocery stores, one issue that could be problematic is a mix of store and national brands. Store brands have a significantly higher retail percentage margin than national brands. Ailawadi and Harlam (2002) suggest several reasons for this difference:[v]

1. Store brand suppliers have little market power since they "operate in a competitive market with no product differentiation and must sell to retailers at a price close to their marginal cost."
2. Costs to advertise and promote national brands are higher for those manufacturers and are reflected in higher wholesale prices.
3. The retailer may have a monopoly on a store brand.

Of these, differences in advertising and product promotion could mean that different levels of service are provided to sell these products, leading to bias if included in the same average margin.

Data issues

While defining the average with a finer level of detail will usually reduce the likelihood of bias (Diewert and von der Lippe, 2010)[vi], data and consistent product availability limit the ability to do so. As previously stated, the availability of data often dictates how a product line can be defined and priced over time. It also limits the ability to determine when an average margin is defined too broadly. BLS directly collects price data based on record-keeping practices of the sampled establishments and must also consider the level of respondent burden in reporting the data. As a result, there is no detail on the individual products included in the average margin. Product brands, individual margins, and quantities are unknown.

As BLS expands efforts to obtain data via alternative collection methods or from secondary sources, it may be possible to collect the details of the margin composition in some cases. This would allow for a more thorough study of margin behavior and determinants of unit value bias. Currently, BLS is offering select large companies in the retail and wholesale trade sector the option to provide expanded information on products, quantity sold, and prices via data files. However, at this time, both respondent and data processing burden limits collection and analysis of the large quantity of data captured through these files.

In addition, having detailed data does not eliminate the risk for bias as previously noted. The Office of National Statistics finds that, when using alternative data, it would be difficult to replicate "tight definitions" of items obtained via traditional collection methods and trying to do so would not make use of the full dataset. They further explain that these datasets "introduce broader consumption segments" that can be "designed at different levels of homogeneity" as well as the challenges of item classification by both humans and machine learning models.[vii]

Conclusion

Currently, the presence and extent of unit level bias in BLS' wholesale and retail trade indexes is uncertain. What is known is that for the price indexes that include broad product line averages, these margins comprise approximately one third of the prices reported across those industries.

As stated previously, broad averages are acceptable for some these industries, but we cannot determine the extent to which they may be problematic in others as we do not have a measure for assessing when an average is too broad.

Any effort to reduce bias should include an evaluation of index variance. Given the inverse relationship between bias and variance, thought should be given to how much bias is acceptable before losing precision. Broader averages should reduce variance by increasing the sample size but will lead to a greater risk of bias. These factors should be weighed against each other when considering collecting average prices as well as defining the average.

More guidance on identifying and measuring bias is needed, particularly when details about the average margin are unknown. What are the parameters of bias in an average margin? When is the average too broad? If level of service is a factor, how does one determine that level and when the mix has changed? As access to large datasets increases, BLS will be better able to analyze margin behavior and find answers to these questions. In addition, collaboration with other statistical agencies and international groups will be critical in developing guidelines on addressing unit value bias.

[i] Erwin Diewert and Peter von der Lippe, "Notes on Unit Value Bias," *Journal of Economics and Statistics*," 2010, vol.230, issue 6, 690-708.
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  Bert M. Balk, "On the Use of Unit Value Indices as Consumer Price Subindices," *Proceedings of the Fourth Meeting of the International Working Group on Price Indices*, pp. 112-120, January 1998.
[ii] *Producer Price Index Manual*: *Theory and Practice*, International Monetary Fund, September 2004.
[iii] Ibid.
[iv] Ibid.
[v] Kusum L. Ailawadi and Bari A. Harlam, "The Effect of Store Brand Share on Retail Margins: An Empirical Analysis," Marketing Science Institute Working Paper, 2002, https://www.msi.org/wp-content/uploads/2020/06/MSI_WP_02-109.pdf.
[v] Erwin Diewert and Peter von der Lippe, "Notes on Unit Value Bias," *Journal of Economics and Statistics*," 2010, vol.230, issue 6, 690-708.
[vi] Op cit.
[vii] "Automated classification of web-scraped clothing data in consumer price statistics," Office of National Statistics, September 1, 2020,
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