European Research Studies Journal
Volume XXVII, Issue 4, 2024

pp. 472-485

Comparison of Transitive Bennet and Montgomery Indicators on the Basis of Scanner Data Sets

Submitted 04/09/24, 1st revision 14/09/24, 2nd revision 16/10/24, accepted 30/10/24

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Abstract:

Purpose: *The main purpose of the study is to assess the practical applicability of Bennet and Montgomery indicators for analysing electronic transaction data in the form of scanner data. The specific goal is to compare transitive versions of these indicators on the basis of dynamic scanner data, where there is a high turnover of products.*
Design/Methodology/Approach: *The model for considerations is developed based on a comprehensive review of existing literature. Authors adopt the transitive Bennet and Montgomery indicators from the field of inter-firm comparisons and use the Fox's transformation for obtaining multilateral versions of these indicators being applicable in the scanner data case.*
Findings: *The transitive Bennet formula leads to greater differences in values between the price and quantity indicators than the transitive Montgomery formula. This conclusion is identical for each type of data filter and for each data aggregation level. However, it can be seen that for a higher level of data aggregation (COICOP level 6), the differences between the corresponding multilateral Bennet and Montgomery indicators are much smaller than for the barcode level (GTIN level). In principle, it can be said that at a higher level of aggregation, the Bennet and Montgomery multilateral indicators lead to fairly similar values and any differences between their values are substantial at the disaggregated level.*
Practical Implications: *The Benet and Montgomery transitive indicators can be useful in analysing scanner data if retail chain managers want to decompose sales value into a price and quantity factor. The framework provides a roadmap for practical using these multilateral indicators for dynamic scanner data sets. The adoption of the transitive indicators for the scanner data analysis can lead to substantial improvements in the management of product sales by the retail chain. Areas of potential application for the approach based on price and quantity differences could be also, for example: profit and cost change decompositions or the analysis of changes in consumer surplus.*
Originality/Value: *The added value of the work is the identification of potential differences between the multilateral Bennet and Montgomery indicators calculated on scanner data sets obtained from retail chains. In particular, it is pioneering to determine the magnitude of these differences depending on the level of data aggregation and the type of data filters used.*

Keywords: *Scanner data, price and quantity indicators, Bennet indicator, Montgomery indicator, transitivity.*

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JEL codes: *C43, E31.*

Paper type: *Research article.*

Acknowledgements: *Publication co-financed from the funds of state budget within the program of the Minister of Education and Science under the title „Doskonała nauka – Wsparcie konferencji naukowych", project no. DNK/SP/549670/2022, amount of funding PLN 147,570.90, total value of the project PLN 165,839.60.*

1. Introduction

The modern price index theory is based on comparisons of ratios of prices, quantities and expenditures of goods and services (von der Lippe, 2007; International Labour Office, 2004; International Monetary Fund, 2020). These index numbers are used to build various economic measures, such as the Gross Domestic Product (GDP), the Producer Price Index (PPI) or the Consumer Price Index (CPI).

Nevertheless, in many business contexts we may be more interested in the magnitude of differences in prices, quantities and sale values. Areas of potential application for the approach based on price and quantity differences could be, for example, revenue change decompositions, profit and cost change decompositions, or the analysis of changes in consumer surplus (Diewert, 2005).

An important benefit of using such differences is that there is no problem associated with the occurrence of zero prices and quantities, a problem that arises when we work with ratios. The problem with zero prices or zero quantities may be very serious in many business applications where not all goods are produced and purchased in every period. Zero prices and quantities are common in scanner data sets obtained from retail chains due to the high product churn observed in supermarkets.

In the case of scanner data and the multilateral index (or indicator) approach in which we observe price and quantity processes over a fixed time window, the construction of a price and quantity indicators is complicated. The added value of the work is the identification of potential differences between the multilateral Bennet and Montgomery indicators calculated on scanner data sets obtained from retail chains. In particular, it is pioneering to determine the magnitude of these differences depending on the level of data aggregation and the type of data filters used.

The main conclusion obtained from empirical considerations based on real scanner data sets is that the transitive Bennet formula leads to greater differences in values between the price and quantity indicators than the transitive Montgomery formula. This conclusion is identical for each type of data filter and for each data aggregation level. However, it can be seen that for a higher level of data aggregation (COICOP level 6), the differences between the corresponding multilateral Bennet and Montgomery indicators are much smaller than for the barcode level (GTIN level). In principle, it can be said that at a higher level of aggregation, the Bennet and Montgomery multilateral indicators lead to fairly similar values and any differences between their values are substantial at the disaggregated level.

2. Literature Review

The price and quantity indicators theory is well established in the economic literature, where it was introduced in the early 20th century (Bennet, 1920; Montgomery, 1929). Professor Diewert (2005) was the first to call index numbers expressed in terms of difference as "indicators". Recently, one can see a return of interest in this approach on the part of statisticians and economists (Balk *et al.,* 2004; Diewert, 2005; Fox, 2006; Cross and Färe, 2009; de Boer and Rodrigues, 2020).

Most often, papers on indicators revolve around issues related to company operations (e.g., Fox, 2006; Cross and Färe, 2009). Nevertheless, economic papers which apply price and quantity indices to areas of scanner data analysis can be also found (e.g., Białek, Pawelec, 2024).

3. Methodology: Bilateral Indicators

In a static world of products (i.e., when the set of products is the same in the periods being compared), we can construct bilateral price and quantity indexes in a number of ways. One approach to constructing a proper price index is the axiomatic approach, in which the index should satisfy a series of required postulates (so-called *tests*).

Let p_i^τ and q_i^τ denote the price and quantity of the $i-$th product at the time $\tau \in \{0,t\}$. Let p_τ and q_τ denote vectors of prices and quantities observed at the time $\tau \in \{0,t\}$. We can now signify the price and quantity indices that compare the current period t with the base period 0 as respectively: $P_{0,t} \equiv P_{0,t}(p_0, q_0, p_t, q_t)$ and $Q_{0,t} \equiv Q_{0,t}(p_0, q_0, p_t, q_t)$. Let us also denote by $IP_{0,t} \equiv IP_{0,t}(p_0, q_0, p_t, q_t)$ and $IQ_{0,t} \equiv IQ_{0,t}(p_0, q_0, p_t, q_t)$ the price and quantity indicators that operate on price and quantity differences. The value of products consumed at the time $\tau \in \{0,t\}$ can be computed as $V_\tau = \sum_i p_i^\tau q_i^\tau$. Price index theory considers a restrictive *factor reversal test* (von der Lippe, 2007) that expects an index to satisfy an equation: $V_t / V_0 = P_{0,t} Q_{0,t}$. The main idea of creating indicators is such their design that ensures that: $V_t - V_0 = IP_{0,t} + IQ_{0,t}$ (Balk *et al.*, 2004; Diewert, 2005).

Due to the high turnover of scanner products, a frequently used approach in determining price indices is the matched sample approach. Let $G_{0,t}$ denote a set of matched products in both considered periods, i.e. $G_{0,t} = G_0 \cap G_t$. Let also G_0^t denote a set of all available products in both considered periods, i.e. $G_0^t = G_0 \cup G_t$.

In the paper, we will only consider the case of all available products, which is technically more difficult than the case of matched products due to the nature of the Montgomery indicators (see Section *The Montgomery indicator*). In the case of the Bennet indicator, the situation of product unavailability in period τ is technically simple, i.e. we just assume that $p_i^\tau = q_i^\tau = 0$. We refer the reader interested in the case of matched products to the paper by Bialek and Pawelec (2024).

3.1 The Bennet Indicator

Under the above signification, the Bennet price and quantity indicators can be written respectively as follows (Bennet, 1920):

$$IP_{0,t}^B = \sum_{i \in G_0^t} \frac{q_i^0 + q_i^t}{2} (p_i^t - p_i^0) \tag{1}$$

and

$$IQ_{0,t}^B = \sum_{i \in G_0^t} \frac{p_i^0 + p_i^t}{2} (q_i^t - q_i^0) \tag{2}$$

It can be shown (Bennet, 1920) that

$$V_t - V_0 = IP_{0,t}^B + IQ_{0,t}^B, \tag{3}$$

which means that the Bennet indicators meet the *sum test* (or the *value change test*).

3.2 The Montgomery Indicator

Please note that in the case of scanner data, the set of products available in the base and current periods, i.e., $G_0^t = G_0 \cup G_t$, is generally an oversampling of the set of matched products $G_{0,t} = G_0 \cap G_t$. In the case of the Bennet indicators, this does not generate technical problems in their calculation since it is simply assumed that a product that is available in the period t_1, but is not available in the period t_2, has zero price and quantity in the period t_2. Such a procedure does not apply to the Montgomery indicators since they use logarithms from prices and quantities in their syntax. However, it can be shown (Białek and Pawelec, 2024) that the determination of prices and quantities of mismatched products in the periods being compared can effectively follow the following procedure:

$$p_i^t = q_i^t = \varepsilon \text{, for } i \in G_0 \setminus G_t \text{, and } p_i^0 = q_i^0 = \varepsilon \text{, for } i \in G_t \setminus G_0 , \tag{4}$$

which must hold for a very small, positive and real number ε.

With the above-presented procedure for treating mismatched products we can define the Montgomery indicators for all available products (including mismatched products) as follows:

$$IP_{0,t}^M = \sum_{i \in G_0^t} L(p_i^t q_i^t, p_i^0 q_i^0) Ln(\frac{p_i^t}{p_i^0}), \tag{5}$$

and

$$IQ_{0,t}^M = \sum_{i \in G_0^t} L(p_i^t q_i^t, p_i^0 q_i^0) Ln(\frac{q_i^t}{q_i^0}), \tag{6}$$

where $L(x, y)$ denotes the *Vartia* (1976) *mean* of two positive real numbers x and y, which is known in the mathematical literature as the *logarithmic mean* (von der Lippe, 2007) and is defined as follows:

$$L(x, y) = \begin{cases} \dfrac{x-y}{Ln(x) - Ln(y)} : x \neq y \\ x : x = y \end{cases} \tag{7}$$

Please note that in general, when $G_0^t \neq G_{0,t}$, the Montgomery indicators (5) and (6) are functions of the parameter ε (under the assumption (5)), and thus they can be signified by $IP_{0,t}^M(\varepsilon)$ and $IQ_{0,t}^M(\varepsilon)$. Nevertheless, the Montgomery indicators satisfy the *sum test* (otherwise known as the *value change test*) with a good approximation if the procedure (4) is taken into consideration (Białek & Pawelec, 2024). In other words it holds that

$$V_{G_0^t}^t - V_{G_0^t}^0 \equiv \sum_{i \in G_t \setminus G_0} p_i^t q_i^t - \sum_{i \in G_0 \setminus G_t} p_i^0 q_i^0 + \sum_{i \in G_{0,t}} p_i^t q_i^t - \sum_{i \in G_{0,t}} p_i^0 q_i^0 = \lim_{\varepsilon \to 0^+} (IP_{0,t}^M(\varepsilon) + IQ_{0,t}^M(\varepsilon)). \tag{8}$$

In the empirical study conducted, we will use the value $\varepsilon = 0.000001$, which provides a very accurate approximation (4).

4. Discussion: Indicators Applied for Scanner Data

Zero prices and quantities are common in scanner data sets due to the high product churn observed in supermarkets. Scanner data, which support CPI calculations in many countries, mean transaction data that specify turnover and numbers of items sold by barcodes, e.g., Global Trade Article Number (GTIN), European Article Number (EAN), or Stock Keeping Unit (SKU) codes.

Scanner data have numerous advantages compared to traditional survey data collection because such data sets are much bigger than traditional ones and they contain complete transaction information, i.e., information about prices and quantities at the barcode level and also many other product characteristics (i.e., product grammage, sales unit, product label, VAT level, etc.).

Nevertheless, at the barcode level, the occurrence of zero-scanner prices is quite common because in supermarkets we often see a variety of discounts and price reductions (even down to zero), as well as a significant turnover of products. It causes analytical problems for statistical offices as well as for supermarket owners wishing to compare the sales performance of different product segments in two time periods.

Thus, an approach based on differences in price values, quantities and expenditures can also be very useful in analysing scanner data. However, according to the best of the authors' knowledge, there is a lack of papers in the literature that apply the indicators to the analysis of scanner data, which is the main objective of this paper. One of the few papers that does this is that of Bialek and Pawelec (2024).

In the case of scanner data and the multilateral index (or indicator) approach in which we observe price and quantity processes over a fixed time window, the construction of a price and quantity indicators is more complicated. In addition, it should be taken into consideration that the world of scanner products is not static, i.e., dynamic scanner data sets related to product turnover (so-called *product churn*) are observed. For this reason, in the remainder of the paper, the consideration of price and quantity indicators will be transferred to scanner data case.

5. New Approach: Transitivity and Multilateral Indicators for Scanner Data Analysis

5.1 Transitivity

For international or inter-regional comparisons, *transitivity* means that estimates of price dynamics and quantities of selected attributes do not depend on the choice of underlying country or region. Similarly, for comparisons across firms, computing transitive price and quantity indices (indicators) do not depend on the choice of the firm-benchmark. A lack of index transitivity is a well-known problem in the literature on international comparisons or scanner data (Gini, 1931; Eltetö and Köves, 1964; Szulc, 1964; Ivancic *et al.*, 2011; Chessa, 2016). By definition, *transitivity* eliminates the chain drift problem. To omit this problem one can expect that when all prices and quantities in a current period revert back to their values from the base period, then the index should indicate no price change and it should equal one. In the same situation, the price indicator should equal zero.

In the case of any price indicator IP and quantity indicator IQ, *transitivity* means that the following relationships occur for any $0 < s < t$:

$$IP_{0,s} + IP_{s,t} = IP_{0,t} \text{ and } IQ_{0,s} + IQ_{s,t} = IQ_{0,t} . \quad (9)$$

It is easy to verify that bilateral Bennet and Montgomery indicators are not transitive. In fact, using the *coffee* data set from the *PriceIndices* R package (Białek, 2021; 2022), taking *March 2019* as the base period 0, *April 2019* as an internal period s, and *May 2019* as the current period t, and running the *bennet()* and *montgomery()* package functions, we obtain:

$$IP^B_{0,s} + IP^B_{s,t} = 55529.61 \neq IP^B_{0,t} = 62461.82 , \quad (10)$$

and

$$IP^M_{0,s} + IP^M_{s,t} = 44803.48 \neq IP^M_{0,t} = 57397.08 . \quad (11)$$

5.2 The Transitive Bennet and Montgomery Indicators

Let us denote by $[0,T]$ the considered time interval, which typically (while computing multilateral indices) consists of 13 or 25 months (Eurostat, 2022). Let $G_{[0,T]}$ denote the set of available products in the whole interval $[0,T]$, i.e., $G_{[0,T]} = \bigcup_{\tau=0}^{T} G_\tau$. The following design of the multilateral Bennet and Montgomery indicators is an adaptation of the Fox's (2006) transformation for the scanner data case (Białek and Pawelec (2024) for details). For comparison any periods τ and t let us generally denote by $IP_{\tau,t}$ the price (Bennet or Montgomery) indicator and by $IQ_{\tau,t}$ the quantity (Bennet or Montgomery) indicator (both calculated on the basis of products from a set $G_{[0,T]}$). Let us use the following, additional significations:

$$\overline{IP}_{\tau_0} = \frac{1}{T+1} \sum_{\tau=0}^{T} {}_T \, IP_{\tau,\tau_0} , \quad (12)$$

$$\overline{IQ}_{\tau_0} = \frac{1}{T+1} \sum_{\tau=0}^{T} {}_T \, IQ_{\tau,\tau_0} . \quad (13)$$

Now, having significations (12) and (13), the price and quantity multilateral indicators can be defined respectively:

$$MIP_{0,t} = \overline{IP}_t - \overline{IP}_0, \tag{14}$$

$$MIQ_{0,t} = \overline{IQ}_t - \overline{IQ}_0. \tag{15}$$

Please note that the multilateral indicators (14) and (15) are *transitive*, i.e.

$$MIP_{0,s} + MIP_{s,t} = \overline{IP}_s - \overline{IP}_0 + \overline{IP}_t - \overline{IP}_s = \overline{IP}_t - \overline{IP}_0 = MIP_{0,t}, \tag{16}$$

$$MIQ_{0,s} + MIQ_{s,t} = \overline{IQ}_s - \overline{IQ}_0 + \overline{IQ}_t - \overline{IQ}_s = \overline{IQ}_t - \overline{IQ}_0 = MIQ_{0,t}.$$

In the rest of the paper, we will distinguish multilateral Bennet indicators from multilateral Montgomery indicators using symbols, respectively: $MIP_{0,t}^B, MIQ_{0,t}^B$ and $MIP_{0,t}^M, MIQ_{0,t}^M$. In can be shown that indicators $MIP_{0,t}^B, MIQ_{0,t}^B$ satisfy the *sum test*, i.e.,

$$V_{G_{[0,T]}}^t - V_{G_{[0,T]}}^0 = MIP_{0,t}^B + MIQ_{0,t}^B, \tag{17}$$

and indicators $MIP_{0,t}^M, MIQ_{0,t}^M$ satisfy asymptotically the *sum test*, i.e.,

$$V_{G_{[0,T]}}^t - V_{G_{[0,T]}}^0 = \lim_{\varepsilon \to 0^+} (MIP_{0,t}^B(\varepsilon) + MIQ_{0,t}^B(\varepsilon)). \tag{18}$$

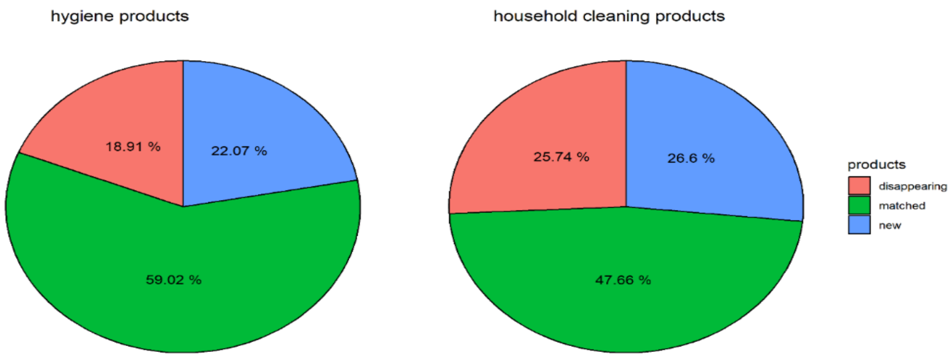
6. Empirical Study

In this empirical study we use scanner data obtained from single retail chain operating in Poland. We analyze monthly data regarding *hygiene products* and *household cleaning products* (COICOP 5 levels: 121322 and 056111 respectively). This data is from December 2022 to December 2023, respectively 390277 and 1132189 records.

The columnar variables, which are in the *hygiene products* and *household cleaning products* data set, are as follows: **time -** the date of the transaction, **prices -** prices of the sold product (PLN), **quantities** – quantities of the sold product; **prodID -** unique product codes assigned after the matching of products over time, **description -** a description of the sold products (i.e., the product label).

Figure 1 shows the new, matched and disappearing products detected for both scanner data sets during a 13 month time window.

Figure 1. *A comparison of the structure of considered data sets due to new, disappearing and matched products.*



Source: *https://cran.r-project.org/web/packages/PriceIndices/index.html*

As one can see, the numbers of disappearing and new goods are bigger in the case of household cleaning products and as a consequence, the number of matched products (over these 13 months) is bigger in the case of hygiene products (59.02% vs 47.66%). Thus, there is a need to use indicators which are not sensitive on such a large product turnover and resulting zero prices.

For compare our data we main use functions from the *PriceIndicies* R Package. (Białek, 2022)**.** One of the initial tasks was to develop the *data_selecting()* function, which involved compiling dictionaries with key words and phrases essential for distinguishing various product categories. Following this, the *data_classification()* function was employed to address products that posed classification challenges, requiring the manual creation of training samples from historical data.

Later on, product matching was executed by utilizing GTIN (Global Trade Item Number) barcodes, internal retail chain codes and product labels. This matching process was facilitated, specifically through the implementation of the *data_matching()* package function. Multilateral Bennet and Montgomery indicators were computed by using the *mbennet()* and *mmontgomery()* package functions.

6.1 Disaggregated vs Aggregated Data Description

The hygiene products consists 7 products subgroups: *toilet paper (*128 IDs*), wet wipes (*95 IDs*), sanitary wipes* (56 IDs)*, baby diapers (*210 IDs*), tampons (*25 IDs), *sanitary pads* (80 IDs*) and hygiene pads* (20 IDs). The household cleaning products consists 18 subgroups: *dishwasher tablets (*183 IDs*)*, *pipe cleaner* (37 IDs*)*, *stain remover (*85 IDs*)*, *fabric softener powder* (2 IDs), *insecticide* (17 IDs*)*, *toilet bowl cleaner (*203 IDs*)*. *laundry detergent* (214 IDs), *laundry powder* (116 IDs), *laundry pods* (254 IDs), *dishwashing liquid* (188 IDs), *fabric softener* (362 IDs), *glass cleaner* (93 IDs), *furniture polish (*39 IDs), *shoe polish* (50 IDs*)*, *floor cleaner* (88 IDs), *toilet cleaner* (113 IDs), *all-purpose cleaner* (37 IDs), *solvent* (18 IDs).

6.2 Data Filters Used

The datasets were filtered by using three typical filters from the *PriceIndices* package: the extreme price filter, the dump prices filter, the low sales filter. The extreme price filter rejects 1% of the lowest and 1% of the highest price changes comparing December 2022 to December 2023. The dump price filter rejects products with the price ratio being less than 0.7 and with the expenditure ratio being less than 0.7 in the same time and the low sales filter rejects products with relatively *low sale* in compared months.

Table 1 shows how data counts change depending on the use of a particular filter or all filters at once.

Table 1. *Change in count depending on the filter used*

hygiene products					
	without filters	extreme price filter	dump price filter	low sales filter	all filtres
number of products	390 277	190 706	192 073	113 733	112 549
household cleaning products					
	without filters	extreme price filter	dump price filter	low sales filter	all filtres
number of products	1 132 189	427 194	428 877	297 461	295 959

Source: *Own elaboration in the PriceIndices R package.*

For hygiene products, the use of all three filters resulted in a reduction of products by 277846 rows. If we are talking about household cleaning products, this change is much bigger, as we use of three filters, because it reduces nearly 80% of products.

6.3 Research Results

The effect of data filtering and aggregation on the differences between transitive Bennet and Montgomery indicators is shown in Table 2 and Table 3. These tables show the detailed values of the transitive Bennet and Montgomery indicators in five cases: (1) without use of any data filters; (2) after the use of extreme prices filter; (3) after the use of dump prices filter; (4) after the use of low sales filter; and (5) after the application of all data filters. These data are presented in two variants: the first variant concerns the lowest data aggregation level, i.e. the GTIN code level, and the second variant, considers a homogeneous product more broadly, i.e. on the basis of the COICOP 6 category.

Table 2. *Comparison of the multilateral Bennet and Montgomery indicators across data aggregation level and data filtering for hygiene products (all available products are considered, the normalized values are in brackets)*

Multilateral Bennet indicator					
GTIN level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	-5807345 (100)	-5024354 (100)	-4774773 (100)	-4231513.4 (100)	-4501442.05 (100)
price indicator	1108525 (-19,09)	323699 (-6.44)	187465.9 (-3.93)	-1115400.55 (26.36)	-973784.79 (21.63)
quantity indicator	-6915870 (119,09)	-5348053 (106.44)	-4962239 (103.93)	-3116112.85 (73.64)	-3527657.26 (78.37)
COICOP 6 level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	-5807345 (100)	-4169073 (100)	-4774773 (100)	-2930963 (100)	9893952.63 (100)
price indicator	244962.3 (-4.22)	-224275.2 (5.38)	-91943.86 (1.93)	-303933.7 (10.37)	4781424.23 (48.33)
quantity indicator	-6052307 (104.22)	-3944798 (94.62)	-4682829 (98.07)	-2627030 (89.63)	5112528.4 (51.67)
Multilateral Montgomery indicator					
GTIN level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	-5807345 (100)	-5024354.28 (100)	-4774772.71 (100)	-4231513.4 (100)	-4501442.05 (100)
price indicator	966705.56 (-16.65)	258197.17 (-5.14)	148426.46 (-3.11)	-973717.05 (23.01)	-861018.08 (19.13)
quantity indicator	-6774050.29 (116.65)	-5282551.45 (105.14)	-4923199.17 (103.11)	-3257796.35 (76.99)	-3640423.97 (80.87)
COICOP 6 level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	-5807345 (100)	-5024354 (100)	-4774773 (100)	-2930963 (100)	9893952.63 (100)
price indicator	232706.28 (-4.01)	258197.2 (-5.14)	-97453.59 (2.04)	-304561.2 (10.39)	3586784.89 (36.25)
quantity indicator	-6040051 (104.01)	-5282551 (105.14)	-4677319 (97.96)	-2626402 (89.61)	6307167.74 (63.75)

Source: *Own elaboration in the PriceIndices R package.*

Table 3. *Comparison of the Bennet indicators and Montgomery indicators across data aggregation level and data filtering for household cleaning products (the normalized values are in brackets)*

Multilateral Bennet indicator					
GTIN level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	4050926 (100)	1846788 (100)	1682243 (100)	1531750 (100)	1695315 (100)
price indicator	7156013 (176.65)	3365233 (182.22)	3445489 (204.82)	1213404 (79.22)	1208138 (71.26)
quantity indicator	-3105088 (-76.65)	-1518445 (-82.22)	-1763247 (-104.82)	318346.3 (20.78)	487177.1 (28.74)
COICOP 6 level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	4050926 (100)	1729723 (100)	1682243 (100)	1173459 (100)	-443792.4 (100)
price indicator	5200080 (128.37)	2824730 (163.31)	3108084 (184.76)	2389376 (203.62)	1424843 (-321.06)
quantity indicator	-1149155 (-28.37)	-1095007 (-63.31)	-1425842 (-84.76)	-1215917 (-103.62)	-1868636 (421.06)
Multilateral Montogomery indicator					
GTIN level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	4050926 (100)	1846788 (100)	1682243 (100)	1531750 (100)	1695315 (100)
price indicator	6069437 (149.83)	2859077 (154.81)	2914184 (173.23)	1167059 (76.19)	1167627 (68.87)
quantity indicator	-2018511 (-49.83)	-1012289 (-54.81)	-1231941 (-73.23)	364691.1 (23.81)	527688.2 (31.13)
COICOP 6 level					
characteristics	without filters	extreme price filter	dump price filter	low sales filter	all filtres
sales value	4050926 (100)	1729723 (100)	1682243 (100)	1173459 (100)	-443792.4 (100)
price indicator	5144017 (126.98)	2778356 (160.62)	3057751 (181.77)	2343151 (199.68)	1516226 (-341.65)
quantity indicator	-1093091 (-26.98)	-1048633 (-60.62)	-1375508 (-81,77)	-1169692 (-99.68)	-1960018 (441.65)

Source: *Own elaboration in the PriceIndices R package.*

7. Conclusions

The use of data filters, regardless of the data set used, level of data aggregation considered and indicator formula adopted, shallows the difference between the value of price and quantity indicators. Sometimes, data filtering even leads to a change in the sign of the indicator (more often price than quantity), which can be observed in particular for the low sales filter and hygiene products (Table 2). Observing the results obtained for both scanner data sets, we can draw the recurring conclusion that the transitive Bennet formula leads to greater differences in values between the price and quantity indicators than the transitive Montgomery formula.

This conclusion is identical for each type of data filter and for each data aggregation level (Table 2 and Table 3). However, it can be seen that for a higher level of data aggregation (COICOP level 6), the differences between the corresponding multilateral Bennet and Montgomery indicators are much smaller (regardless of the scanner dataset) than for the barcode level (GTIN level).

In principle, it can be said that at a higher level of aggregation, the Bennet and Montgomery multilateral indicators lead to fairly similar values and any differences between their values are substantial at the disaggregated level. Please note that the above conclusions should be regarded as preliminary, since they concern only a specific group of products, one year of observation and one retail chain. In the future, the authors of the paper plan to expand the study to other product groups by obtaining data from more retail chains.

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