Challenging the CES assumption with scanner data – pitfalls of the fixed basket

Can Tongur[*], Statistics Sweden

Ottawa Group Meeting
Rio de Janeiro, Brazil
May 8-10, 2019

Abstract

A theoretical motivation for applying the geometric mean formulation (Jevons) to elementary aggregates is the embedded account for elasticity of substitution, i.e. a conception that the consumer collective behaves as theoretical economic agents and consider relative prices in any given situation and for a fixed set of commodities. A fringe benefit of having scanner data in CPI is the opportunity of empirically analyzing elasticities in the presence of a changing product universe as data reveals the empirics of reality. Since the Jevons is the standard index formula for elementary aggregates in the European HICP as well as the Swedish CPI, empirics should support theory. In this analysis, the elasticity of substitution is estimated for a set of presumably substitutable products from scanner data, in the simplest setting possible – direct matching of the current period to the base period for a fixed basket of items and stores.

Keywords: consumer price index, constant elasticity of substitution, CPI, Jevons, CES, scanner data

---

***** Any views or statements expressed in this article do not necessarily reflect those of Statistics Sweden (Statistiska centralbyrån).

1 Introduction

The advent of electronic point of sales data, scanner data, has evoked an adaptation of index formulations to large-scale price and sometimes quantity information, as opposed to traditional sparse sample data of presumably well-representative spot shelf prices. Method development is ongoing concerning the exhaustion of information from census data, as promoted by e.g. Boskin et al. (1997) in order to capture cost of living (COLI) timely. A major challenge for conventional index methodology, adhering to the philosophy of "less is more" sampling[1], has been the inconvenience of direct/exact comparisons over time. The inconvenience is due to the changing product universe, i.e. a vivid market, observed almost in real-time with scanner data. This challenge has transferred to development of methods, like GEKS, c.f. e.g. van der Grient and de Hahn (2011) or change-in-price-levels, CPL, c.f. Auer (2011) and for instance though adaptations of the Geary-Khamis method, c.f. the QU method by Chessa (2015).

The developments are in one sense in place to circumvent monthly chaining at elementary levels, i.e. basically the Jevons formulation adapted to a changing product universe. von der Lippe (2001) argues stringently against such high-frequency chaining approaches, pointing on the pitfalls of transitivity/circularity issues and their effects on chained index series. The Jevons formulation has otherwise been, at least for direct comparisons (fixed basket), a well promoted and theoretically justified method, with appealing properties and relying on a theoretical framework.

In this study, the assumption of constant elasticity of substitution (CES) is assessed empirically for some products from Swedish scanner data. The CES assumption is in a sense *the* economic theoretical motive for applying the Jevons formulation to elementary aggregates. The study relies on consumption structures found in Swedish data, however, the analysis is neither theoretically complete nor exhaustive but rather an easy case study, merely addressing the immediate lowest level substitution, elementary aggregates, and not between consumption segments/groups.

[1] Due to cost constraints for collecting price quotations and practical impossibility of covering the complete product universe. Probability sampling has hence been the conventional way forward (Neyman, 1934).

2 The CES assumption

The elasticity of substitution is the change in purchased quantities of items relative to each other when any of the prices change, i.e. new *relative* prices as well as absolute prices.[2] This is under the assumption that the two items are substitutable for each other and hence are relevant to consider in a grouping like an elementary aggregate.

Substitution may be none (zero), meaning that consumption is unaffected by changes in relative prices, or be positive (>0) and even tend to unity (→1), which means a perfect substitution relationship between the pair of items under consideration. In some cases, substitution may even exceed unity (>1), which means a larger consumption shift towards the relatively cheaper item than the corresponding percentage change in relative prices. The latter circumstance is in some sense an income effect – leading to excess total consumption than at the initial point, either due to immediate substitution or due to stocking, i.e. intertemporal substitution.

When substitution appears to be equal for *all* pairs of items included in the aggregate under consideration, e.g. an elementary price index expression, and constant over time[3] between all pairs of items, a *constant elasticity of substitution* (CES) function can describe the relationships between consumed items. Shapiro and Wilcox (1997) obtained estimates of substitution below unity for aggregate CPI with the use of a CES function and mentioned the unlikeliness in assuming constant elasticity for all pairs of products. De Haan (2001) noted that the relationship between ongoing items is the common reference to substitution, i.e. substitution in *narrow sense* whereas substitution in essence affects the target parameter, inflation, also through a changing product universe and at different levels of aggregation, i.e. substitution between elementary aggregates.

---

[2] It should borne in mind that absolute price increases, leaving relative prices unchanged, may cause substitution beyond expectations. Examples are sweetener for sugar, apple juice for orange juice, milk with home-added cocoa for chocolate flavored milk, and so on. This may imply moving from direct substitutable to indirectly substitutable items and can be considered on higher-level aggregates than the elementary. C.f. Balk (1999) for discussions on upper-level substitution, and de Haan (2001).

[3] Time-invariance implies that two overlapping baskets, sampled independently but for the same time point ($t=12, y=0$) and ($t=0$,y=1) if index base is December, will be sharing the same substitution properties.

An implication from the theoretical assumption for CES is that the average consumer exists in all given situations and discriminates accordingly between products based on relative prices.[4] Additionally, consumers have fixed predetermined taste/quality preferences - which may be the case for many but far from all consumers.

2.1 The Jevons formulation, sampling and preferences

As explained in §20.71-86 in the CPI Manual (ILO, 2004), henceforth referred to as the CPI Manual, the Jevons form of elementary price index expression reflects Cobb-Douglas preferences, as a special case of CES.

The included items' expenditure shares (quantity *levels*[5] are not explicitly considered) are assumed representative for the base period so the Jevons index formulates in log-scale as

$$\sum_{i=1}^{n} s_i^0 \, ln\left(\frac{P_i^t}{P_i^0}\right) \qquad (1)$$

where s_i^0 is the base period expenditure share for item i included in the aggregate of n items under consideration.

This is supposedly reflecting a "true elementary price aggregate" regarding two-period aggregate cost functions (ibid. §20.83) and approximates a Cobb-Douglas preferences price index (ibid. §20.84).

Jevons and sampling

The assumption of unitary and constant substitution validates the use of Jevons also under a sampling scheme (ibid. §20.83). However, if substitution is not unitary and constant it would mean in some sense that all substitutes must be in the basket at the same time – otherwise relative price changes offset representativeness assumed when forming the basket merely from sampled items.

Heterogeneity in the aggregate

The composition of included items in a Jevons aggregate is allowed to be heterogeneous since it formulates as a geometric ratio of a fixed set of items (ibid. §20.84). This is indeed an assumption of constant product universe and requires mitigation through monthly chaining in order to cover the real product universe, should Jevons still be the adequate formula as suggested (ibid. §20.112). The opening for heterogeneity in an elementary aggregate is however counterintuitive regarding the validity of the CES property; similar but not intuitively substitutable items are grouped and assumed substitutable regarding

[4] De Haan & Diewert (2017) approach the problem with leverage from imputed prices.

[5] If quantities are emphasized, then the Cobb-Douglas preferences' utility is interchanged for the Leontief preferences' utility, dissolving the need for the Jevons formulation.

price movements – if the CES is to hold. Fortunately, the CPI Manual (ibid §9.7) defines criteria that approaches the construction of elementary aggregates from a practical point of view – independent of index formulation.

A constant product universe
Further, in a motivating as-if scenario, it is stated (ibid. §20.86) that if expenditure shares are known for both base and comparison periods and applied in a weighted Jevons index, with narrowly defined unit values, the ideal type of index is achieved. Implicitly, this restricts to a constant product universe and is a seemingly strong simplification of reality as it leaves out the COLI aspect when the universe changes.

Homothetic preferences
A regulatory condition for Jevons is that consumer preferences are homothetic, i.e. utility is supposedly unaffected by income *levels* but instead by ratios of prices when income is distributed. It seems however more intuitive to consider for instance *Linear Expenditure Systems*, in which certain minimum quantities, i.e. subsistence quantities (Lloyd, 1975), always are attained for each item and demand functions are perhaps partially stepwise.

Unit elasticities more likely than zero elasticities
The following passage can be found in the CPI Manual §20.86:

"…cross-item elasticities of substitution are much more likely to be close to unity (this corresponds to the case of Cobb-Douglas preferences) than to zero (this corresponds to the case of Leontief preferences).".

This statement levies high burden on the aggregate under consideration – elasticities are assumed to approach unity from zero, but not to exceed unity.

2.2. Estimation formula for the elasticity of substitution

An estimable form for σ is provided by Balk (1999) by equating the two-period expenditure changes in a COLI index $P(p^0, p^1 \,|\, I^0, I^1)$ (Lloyd, 1975) for item sets I^t formulated as

$$\left[\sum_{i=1}^{2} s_i^0 \left({P_i^t}/{P_i^0}\right)^{(1-\sigma)}\right]^{1/(1-\sigma)} = \left[\sum_{i=1}^{2} s_i^t \left({P_i^t}/{P_i^0}\right)^{-(1-\sigma)}\right]^{-1/(1-\sigma)} \quad (2)$$

for two items, *i*=(1, 2) in two distinct time periods *t*=(0,1) with respective expenditure shares s_i^t. As noted by Balk (1999), by setting $\sigma = 0$ the left hand side becomes a Laspeyres and the right hand side becomes a Paasche index. The right hand side of (2) with some estimate on σ (other than zero) is the Lloyd-Moulton index as explained in the CPI Manual, § 17.61.

It is noteworthy that formulation (2) is a fixed base formulation – i.e. no substitution outside the universe of the items enumerated in the base period is accounted for in this simple form (again, c.f. Balk, 1999). Thus, although both Laspeyres and Paasche indices are obtainable from (2), COLI is not necessarily inferred. Some alternations of the input variables to (2) are given in Table 1.

Table 1 Approximate outcomes of $\boldsymbol{\sigma}$ by altering $\boldsymbol{s_i^1}$ or $\boldsymbol{P_1^1}$

Case	S1=s_1^1/s_1^0	S2=s_2^1/s_2^0	P1=P_1^1/P_1^0	σ
1	2/3	4/3	2	2
2	1/5	9/5	3	3
3	2/5	8/5	2	3
4	98/100	102/100	105/100	1.82

Note: Base period prices are set to unity; P_1^0 = 1 and P_2^0=P_2^1=1**,** hence P2=P_2^1/P_2^0 = 1. Base period expenditure is split (50/50) between the two items, $s_1^0 = s_1^0$ = ½.

When interpreting the outcome for $\boldsymbol{\sigma}$ in Table 1 it should be noted that expenditure shares $s_i^t = p_i^t q_i^t / \sum p_j^t q_j^t$ consist of both prices and quantities in the aggregation. Hence, the elasticity in formulation (2) becomes a rather intricate (and non-linear) parameter to grasp regarding effects from relative price changes and quantities. Table 1 is merely a conceptual visualization by isolating variables while varying relative changes.

2.3 Time asynchrony in the CES formula

Regarding σ in formulation (2), there may be an opening for asynchrony between the budget shares and the price ratios, as pointed out by Shapiro and Wilcox (1997):

"The mismatch in frequency between the price and expenditure data creates and ambiguity as to how one might best approximate the index formulas prescribed by theory".

For the CES, following three cases identify:

a) If notation is taken as monthly, (*t=0, 1*) represent the base month (*t=0*) and the comparison month (*t=1 or any m*) as usual for price quotations. In analogy, expenditure shares will be monthly spending which deviates from common practice of applying calendar year spending (i.e. "annual weights"). Results may individually be prone to random/transient effects but nevertheless transparent and interpretable.

b) If notation is taken as yearly, then (*t=0, 1*) is in fact (*y=0, 1)* and price quotations will be yearly unit values, e.g. some arithmetic average similar to monthly unit values. This is a somewhat unsubstantiated price measure – a yearly average price has dubious interpretation.[6]

c) If notation is taken as hybrid, expenditure shares reflect the complete year corresponding to respective time point (*t=0,1*) while price quotations refer to the time period in question – base or comparison month. This may impair inference for the parameter –specifics months are more prone to transient price effects than is their aggregate, and the components may point in uncoordinated directions due to seasonality or campaigns.

The monthly interpretation, option (a), is chosen for the analysis, motivated by data availability. Options (c) and (b) would imply substantially fewer analysis points.

3. Empirical elasticities from scanner data

3.1 Selected products

The following multi-brand products are chosen for the analysis:

1) Sugar free soda beverage, 1.5 Liter,
2) Dairy product, 1 Liter,
3) Coffee, 450-500 grams, grounded, all varieties, and
4) Cheese, packaged, several similar varieties.

For soda and dairy, the items from two competing brands in each store are sampled, i.e. pairwise, over several years in the CPI. Sampling is annually, proportional to expenditure and the two chosen items are here assumed being substitutes, i.e. relevant for the analysis.

For grounded coffee, the sample is a census of all available items, i.e. beyond the CPI sample, but spans merely over one index year, December (y-1) to December (y). It is unbounded regarding brand

[6] It lacks unambiguous interpretation in economic reality; indices are computed monthly and average annual prices become increasingly non-interpretable with increasing inflation.

and flavor varieties, bounded through direct matching with the base period on store level.[7]

For packaged cheese, more than 10 varieties are included in the CPI sample over two years. Perhaps not exact substitutes for consumers with specific preferences, most varieties are still somewhat exchangeable, at least between brands. Similar to coffee, cheese is subject to price competition though discounts between brands and varieties.

3.2 Coverage

The two surveyed items within soda and dairy are considered being perfect substitutes of each other, per se, except for consumers with strong preferences. They are well established/in a steady state equilibrium regarding package size and characteristics like flavor and fat content. They are rather stable regarding annual expenditures, with some local variations. For packaged cheese, the CPI comprises a cut-off sample of the most sold items corresponding to the lions' share of turnover. For coffee, the "take-all" sample of items sold in month *m* that matches with the base period implies a two-dimensional measure: the included items in month *m* constitute

a) a share of turnover in current month *m,* regardless of their turnover in the base month, and
b) a share of turnover in the base month, regardless of its turnover in the current month.

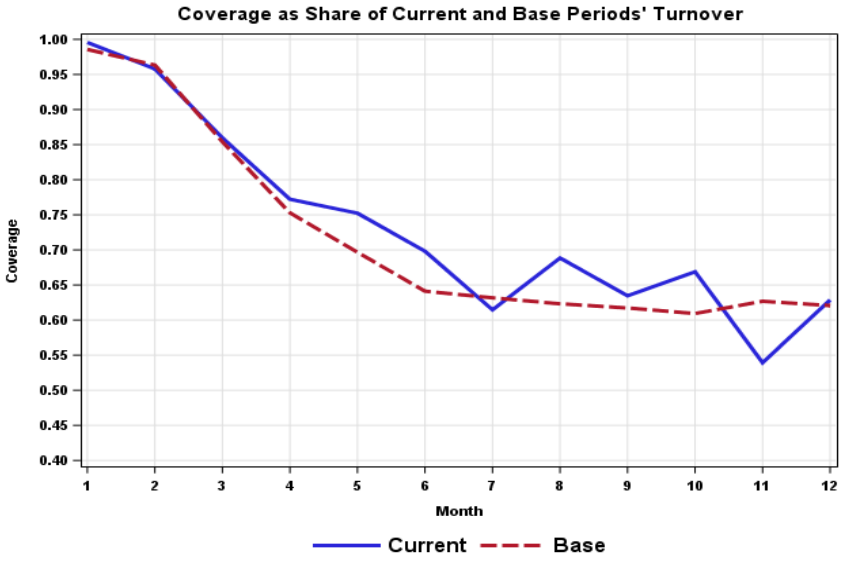
Denomination *a*) reflects the dynamics in the universe whereas *b*) reflects the basket attrition. Although providing precision, they do not provide inference about price changes – a shrinking basket may well suffice to reflect inflation, but perhaps not COLI for which the more relevant measure may the current turnover share.

In Graph 1 below, coverage in terms of both *a)* and *b*) is shown for Coffee as an aggregate over all included retail chains.[8]

---

[7] The condition is that the varieties per store must co-exist in the base as well as the comparison month in order to be relevant for the analysis. However, the number of varieties may vary between stores.
[8] C.f. Bilius et al. (2018).

Graph 1 Coverage for coffee during the analysis year



A decaying pattern for coverage is seen in Graph 1 for both *a)* the Current share in each month *m*, and *b)* the Base month share of remaining items in each *m*.

3.3 Aggregation of data and sample sizes

The scanner data is, per store, weekly turnover and amount of units sold per item. Data is aggregated over weeks to monthly turnover, if matching with the base period for the specific item and store. In turn, aggregation is over all stores to obtain the total shares and prices in formulation (2), i.e. *item aggregation over stores,* as denoted by Ivancic et al. (2010), rendering one aggregate monthly price and one aggregate expenditure share (summing to unity) per item. Discussions so far concern substitution on store level, at which substitution is likely to occur in the narrow sense.[9]

In a specific store, an item may be sold only one week in one month, but up to three weeks in the base period, or the converse, and still qualifies as a bilateral match.

Sizes of store samples cannot be revealed but is indicated whether included stores are few (more than 10 but less than 20), feasible (at least 20) or large (at least 40).

---

[9] An implicit assumption for CES is that no selective price-seeking behavior exists, i.e. consumers in general stay true to the store they have entered and do not discriminate between stores for specific items merely due to price. Price-seeking behavior has been observed in certain populations with low time costs, c.f. Lach (2007).

- For soda, the monthly sample covered the years 2013 to 2017, inclusively, starting with base period December 2012. Coverage was large regarding stores in the CPI sample.
- For dairy, the monthly sample data covered the years 2015, 2016 and 2017, starting with base period December 2014. At least half of the CPI stores were covered each month, i.e. feasibly large samples.
- For coffee, the monthly sample data covered 2017, starting with base period December 2016. The number of stores was overwhelmingly large as it was more than just the standard CPI sample.
- For cheese, data covered the years 2017 and 2018 until but not comprising the last quarter, as of base period December 2016 and was large with respect to the number of stores in the CPI sample.

3.4 Results

Estimation results for the elasticity of substitution are summarized in Table 2. For the four products, number of estimates, mean, median, standard deviation and share of "ineligible" outcomes ($\boldsymbol{\sigma}$<0) are reported. Ineligible outcomes have been included in computations (median, mean and standard deviation) to render balance to the positive extreme values, especially for dairy.

Table 2 Summary statistics on estimates of $\boldsymbol{\sigma}$

Product	#estimates	Mean	Median	Std. dev.	Share $\boldsymbol{\sigma}$ <0
Soda	144	3.6	2.05	10.35	22%
Dairy	72	9.68	1.34	63.1	44%
Coffee	36	2.56	2.92	2.03	11%
Cheese	42	4.21	4.05	1.41	-

Note: column with *#estimates* refers to number of estimated $\boldsymbol{\sigma}$ over all time points and included retail chains (one estimate per retail chain and period).

Seen in Table 2, the mean values for $\boldsymbol{\sigma}$ exceeds unity by far for all products. A substantial share of estimates fall below zero for soda and dairy compared with one tenth for coffee and no at all for cheese. Melser (2004) and Ivancic et al. (2010) obtain comparable results for soda/soft drinks and coffee.

Four price indices were computed, all derivable from formula (2). First, the standard unweighted Jevons was obtained by setting all expenditure shares equal, letting $\boldsymbol{\sigma}$=0 and using the natural logarithm of prices. Second, both the Laspeyres and Paasche were obtained since respective expenditure shares were available and by setting

σ=0. Finally, the Lloyd index with base month expenditures was obtained by using the median of estimated elasticities in Table 2 for each product[10] - the median was preferred over the mean for robustness, as can be realized from the table. For the three expenditure-share weighted price indices, monthly unit prices per item were computed over all included stores per retail chain. This was deemed consistent with the price/quantity relationships forming the expenditure shares.

Index outcomes are given in Table 3a and 3b below for Laspeyres, Paasche and the Lloyd index, expressed in percentage deviation from a Jevons index, i.e. 100×[(Paasche/Jevons)-1].

Table 3a Index outcomes, Soda and Dairy, 2017

Product	**Soda**			**Dairy**		
Period	Lasp.	Paas.	Lloyd	Lasp.	Paas.	Lloyd
1	2.5	2.7	2.2	-0.2	-0.2	-0.1
2	2.5	2.6	2.3	0.5	0.5	0.6
3	5.6	6.2	4.8	-1.7	-1.6	-1.9
4	3.8	4.3	3.1	-5.4	-5.3	-5.4
5	6.4	8.0	4.2	-5.8	-5.7	-5.8
6	11.4	16.0	7.8	-5.4	-5.4	-5.4
7	5.8	8.1	2.9	-5.9	-5.9	-5.9
8	5.9	8.1	3.3	-3.2	-3.1	-3.5
9	0.1	0.3	-0.2	-5.7	-5.7	-5.7
10	6.2	8.7	3.6	-8.2	-8.2	-8.4
11	1.7	2.3	1.2	-10.6	-10.6	-10.8
12	-0.2	-0.2	-0.3	-9.6	-9.5	-9.9

Note: Lasp. And Paas. abbreviate Laspeyres and Paasche, respectively.
Index outcomes are expressed as percentage deviation from the Jevons index.
For example, the Laspeyres deviation computes as 100×[(Laspeyres/Jevons)-1].

In Table 3a, no clear pattern is seen regarding the outcomes for dairy except that all indices fall below the unweighted Jevons index, often rather significantly. For soda, the indices most often exceed the unweighted Jevons index, also here rather significantly in most cases.

[10] Although the median is over all estimated outcomes, there were outcome sets for each retail chain. The best choice, overall median versus chain-wise median, can of course be debated.

Table 3b Index outcomes, Coffee (2017) and Cheese (2018)

Product	Coffee			Cheese		
Period	Lasp.	Paas.	Lloyd	Lasp.	Paas.	Lloyd
1	12.7	6.9	10.4	-2.4	-9.9	-6.3
2	12.4	6.4	10.1	-0.3	-6.6	-3.5
3	12.5	9.8	10.8	-4.4	-7.3	-6.6
4	6.0	4.6	4.8	-3.8	-9.3	-7.2
5	11.2	8.5	9.5	-3.5	-10.0	-7.6
6	7.5	3.7	5.9	-3.2	-6.4	-5.0
7	14.3	9.6	11.8	-3.0	-8.0	-5.8
8	10.8	6.6	8.8	-2.1	-8.0	-5.4
9	16.0	9.3	12.8	-3.1	-9.3	-7.0
10	14.7	10.2	11.9	-3.3	-9.3	-6.5
11	17.0	10.0	13.6	0.2	-5.4	-2.0
12	5.7	3.6	3.9	-0.9	-5.6	-3.0

Note: Lasp. And Paas. abbreviate Laspeyres and Paasche, respectively.
Index outcomes are expressed as percentage deviation from the Jevons index.
For example, the Laspeyres deviation computes as 100×[(Laspeyres/Jevons)-1].

In Table 3b it appears that the Lloyd index falls between the Laspeyres and the Paasche indices, systematically. For coffee, the deviations from the unweighted Jevons index are positive for all three indices whereas for cheese the deviations from the unweighted Jevons index are all negative (with one exception, November 2018 for Laspeyres), and for both products, the deviations from the unweighted Jevons index are rather large. It should be noted that for both coffee and cheese large variety samples were used.

3.5 Cautionary remarks and software

The results in Table 2 are indicative, in some cases inconclusive and must be interpreted with precaution. Concerning CES estimation, the following is pointed out by Henningsen & Henningsen (2012):

"is generally considered problematic due to convergence problems and unstable and/or meaningless results".

Some meaningless/non-interpretable results are observed ($\boldsymbol{\sigma}$ <0), mainly due to non-causal relationships between price ratios and changes in consumption shares[11], as given in the last column of Table 2. One explanation may be specific strong and non-homothetic preferences blurring the causal relationships necessary for CES, another may be intertemporal substitution effects rendering

[11] The parameter of interest has a limited entropy regarding meaningful estimates and is the outcome of a non-linear procedure. As also discussed in Subsection 2.2, expression (2) comprises both prices and quantities implicitly in the expenditure shares.

insensitive consumers in periods that follow heavy campaigns. An additional problem, considering consumer intra-month welfare, is the relationship between time points of price alternations versus pay dates for wages, pensions and welfare, i.e. timing of disposable income.

Melser (2004) observes, besides an asymmetry between new and disappearing products' expenditure shares, that the aggregation in time and over stores affects the elasticity estimate – rendering excess, and sometimes contradictory, negative outcomes. Similar issues were pointed out by Ivancic et al. (2010), especially regarding effects from aggregation order as well as negative estimates. They state that estimation results may contradict economic theory when using high frequency (weekly) micro data. In some cases, they cannot reject the null hypothesis of elasticities equivalent to one ($\boldsymbol{\sigma}=1$) while in some cases they observe elasticities strictly larger than one, ($\boldsymbol{\sigma}>1$), based on standard *t*-tests. Overall, they find support for using Jevons over simple means like Carli or Dutot indices, and that for some item categories, not even the Jevons may be appropriate in order to adequately *"capture the 'true' level of consumer substitution"*.

A standard SAS ® Base (9.4) installation was used for estimations. The iterative solving procedure PROC MODEL with the default Newton procedure was applied to obtain estimates of the substitution parameter in (2).

4. Discussion: the changing universe vs. fixed basket controversy

The main intention with this paper has been to discuss adherence to a fixed basket regime surveyed in a changing product universe of daily necessity items. Product ranges can be rather stable over time in some steady-state product segments, with some trivial changes of packages/quantities, e.g. relaunches, whereas some product segments may embed rather substantial product churn.

Product universe

Considering the product universe over time, the CPI Manual provides the following three distinctions in §8.7:

- an "*intersection universe*" of bilaterally matching items between the current and base comparison month;
- a "*dynamic double universe*", i.e. all items in the base comparison period as well as all in the current period, "*although they may be of different qualities*" and

- a *"replacement universe"*, starting with the base period universe and then including one-to-one replacement of items in the sample from the base period that successively go missing during the year.

Several elaborative studies aim a mitigating the potential bias due the product churn from new and disappearing products. Balk (1999) suggests a two-level assessment of the problem, de Haan (2001) proposes a *Generalized Fisher Price Index* to apply with scanner data on a variable set of products over time, whereas Melser (2004) provides adjustment estimates for the bias arising from following a fixed basket.

An insight from estimating elasticities appears to be that a limited, albeit well-maintained, fixed basket in which elasticity of substitution is assumed one ($\boldsymbol{\sigma}$ =1) cannot be justified, given the empirical findings here and in other studies. A similar questioning is found in Shapiro and Wilcox (1997), addressed for the geographical structure of the U.S. CPI:

"..//...more plausible than the geometric means index's assumption of a unit elasticity of substitution across areas as well as across items within areas".

The fixed basket pitfall: a-synchronic price campaigns
An implication from having a sample-based fixed basket is the "observation-in-time" limitation. Rephrased, this implies "what you see is what you get" – merely included items' campaigns affect the index, the given months. All other months in which other items have price alternations are by construction not possible to account for. Hence, the limited sample-based fixed basket, as applied in practice, misses out on the price alternation mechanism necessary to capture for COLI.

5. Concluding remarks

The assumption of unit elasticities has not been substantiated in this study, based on a limited set of products from Swedish scanner data. Acknowledging the difficulties of estimating the elasticity – and yet being uncertain if it is merely a theoretical construct, there appears no certainty on relying on unit elasticities as a motive for using the Jevons index. Especially a limited fixed basket is of high concern regarding representativeness, regardless of sampling design should the purpose be a cost of living index.

References

von Auer, L. (2011). The Generalized Unit Value Index. Universität Trier, *Research Papers in Economics* No. 12/11.

Balk, B. (1999). On Curing the CPI's Substitution and New Goods Bias.

Bilius, Å., Ståhl, O. & Tongur, C. (2018). Coverage Bias and the Effect of Re-Launches in Scanner Data: A Coffee Index. Poster presentation at UNECE 2018, Geneva.

Boskin, M. J., Dulberger, E. R., Gordon, R. J., Grilliches, Z. & Jorgenson, D. W. (1997). The CPI Commission: Findings and Recommendations. *The American Economic Review*, Vol. 87, No. 2. Papers and Proceedings of the Hundred and Fourth Annual Meeting of the American Economic Association (May 1997), pp. 78-83.

Chessa, A. (2015). Towards a generic price index method for scanner data in the Dutch CPI.

van der Grient, H. & Haan, J. de (2011). Scanner Data Price Indexes: The "Dutch Method" versus Rolling Year GEKS.

Haan, J. **de** (2001). Generalized Fisher Price Indexes and the Use of Scanner Data in the CPI.

Haan, J. de. & Diewert, W. E. (2017). Quality Change, Hedonic Regression and Price Index Construction.

Henningsen, A. & Henningsen, G. (2012). On estimation of the CES production function – Revisited. *Economic Letters* 115 (2012), pp. 67-69.

ILO (2004). ILO/IMF/OECD/UNECE/Eurostat/The World Bank. *Consumer price index manual: Theory and practice*. International Labour Office, Geneva.

Ivancic, L., Diewert, W. E. & Fox, K. J. (2010). Using a Constant Elasticity of Substitution Index to Estimate a Cost of Living Index. From Theory to Practice. School of Economics, The University of New South Wales. Discussion Paper: 2010/15.

Lach, S. (2007) Immigration and Prices. *Journal of Political Economy* (2007), vol. 115, no. 4.

von der Lippe, P. (2001). Chain Indices. A Study in Price Index Theory. Statistisches Bundesamt, Wiesbaden 2001.

Neyman, J. (1934). On the Two Different Aspects of the Representative Method: The Method of Stratified Sampling and the Method of Purposive Selection. *Journal of the Royal Statistical Society*, 97, pp. 558-625.

Shapiro, M.D., & Wilcox, D.W. (1997). Alternative strategies for aggregating prices in the CPI. National Bureau of Economic Research (NBER) Working paper 5980.