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

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What is this about?

- Established methodology –recommended and used
- A rather new data source – rendering insights (novel?)
- Some supportive theory – backing up the methodology
- An empirical study – on scanner data
- Some ideas to take home – and to think through?

The Constant Elasticity of Substitution assumption (1)

Elasticity of Substitution

- *The simplified situation of consumers discriminating between obviously substitutable items as a response to price changes (substitution in ”narrow sense”, de Haan (2001))*
  Reminisces the ex post Laspeyres v.s. Paasche discussion
- *Elasticity of substitution is a* <u>*concept*</u> *of what-for-what:*
  how many green apples for red apples, given a change in relative prices
- *In practically all cases, it is a parameter of non-negative magnitude (≥0)*

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The Constant Elasticity of Substitution assumption (2)

Assuming a constant elasticity means that…

- *…substitution is thought to be equal for all pairs of items in some aggregate under consideration and hence, in all possible baskets*
- *…there is a time invariance concept*

And it implies that…

- *…the universe of items is ”closed under sampling” (Laspeyres ⇔ Paasche)*
- *…sampling is a valid approach for including items (randomness is amical)*
- *…homothetic preferences – income levels do not affect choices (timing not an issue)*

Estimating the elasticity of substitution

- *Balk (1999) derives an expression from which estimation boils down to the application of some numerical procedure, for a basket with n items (c.f. §17.61 in the manual: the Lloyd-Moulton index):*

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

- *There is perhaps an asynchrony in general, as pointed out by Shapiro & Wilcox (1997):*

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

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A sample of items deemed suitable for analysis

The following set of multi-brand products were analyzed:

1) Sugar free soda beverage, 1.5 Liter (2 varieties, pps-sampled)
2) Dairy product, 1 Liter (2 varieties, pps-sampled)
3) Coffee, 450-500 grams, grounded (<u>all</u> varieties = census)
*4) Cheese, packaged, several similar varieties (**n** most sold varieties, cut-off-sample)*

Coverage well, representativeness well*, by-the-book approach*

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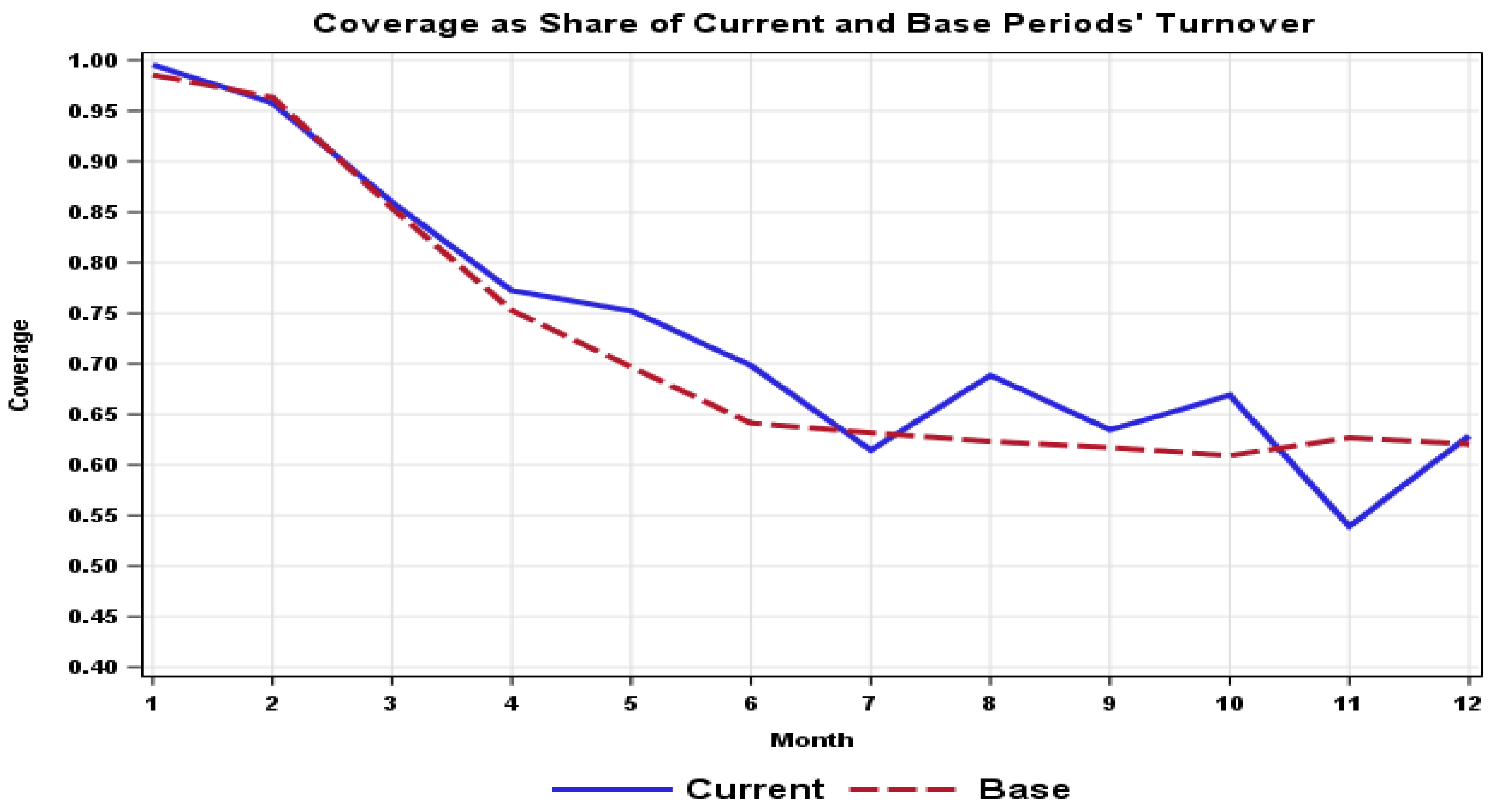
Two ways of looking at coverage



Coverage for coffee during one year, as used for analysis

How the data was used to render necessary input to the estimation

- *The scanner data is weekly turnover and amount of units sold per item (identified through EAN/GTIN) and per store*
- *Data is aggregated over weeks to a monthly turnover per store and included if it has a match with the base period for the same store (= balance)*
- *Estimations are through ”item aggregation over stores”, rendering one aggregate monthly price and expenditure share (summing to unity) per item*

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Summary statistics on estimates of σ

Product	#estimates	Mean	Median	Std. dev.	Share σ <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	-

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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)

A comparison of four price indices

Laspeyres, Paasche and Lloyd (σ = median), as per cent deviation from unweighted (standard) Jevons

	Soda *σ = 2.05*			**Dairy** *σ = 1.34*			**Coffee** *σ = 2.92*			**Cheese** *σ = 4.05*		
Period	**Lasp.**	**Paas.**	**Lloyd**	**Lasp.**	**Paas.**	**Lloyd**	**Lasp.**	**Paas.**	**Lloyd**	**Lasp.**	**Paas.**	**Lloyd**
1	*2.5*	*2.7*	**2.2**	*-0.2*	*-0.2*	**-0.1**	*12.7*	*6.9*	**10.4**	*-2.4*	*-9.9*	**-6.3**
2	*2.5*	*2.6*	**2.3**	*0.5*	*0.5*	**0.6**	*12.4*	*6.4*	**10.1**	*-0.3*	*-6.6*	**-3.5**
3	*5.6*	*6.2*	**4.8**	*-1.7*	*-1.6*	**-1.9**	*12.5*	*9.8*	**10.8**	*-4.4*	*-7.3*	**-6.6**
4	*3.8*	*4.3*	**3.1**	*-5.4*	*-5.3*	**-5.4**	*6.0*	*4.6*	**4.8**	*-3.8*	*-9.3*	**-7.2**
5	*6.4*	*8.0*	**4.2**	*-5.8*	*-5.7*	**-5.8**	*11.2*	*8.5*	**9.5**	*-3.5*	*-10.0*	**-7.6**
6	*11.4*	*16.0*	**7.8**	*-5.4*	*-5.4*	**-5.4**	*7.5*	*3.7*	**5.9**	*-3.2*	*-6.4*	**-5.0**
7	*5.8*	*8.1*	**2.9**	*-5.9*	*-5.9*	**-5.9**	*14.3*	*9.6*	**11.8**	*-3.0*	*-8.0*	**-5.8**
8	*5.9*	*8.1*	**3.3**	*-3.2*	*-3.1*	**-3.5**	*10.8*	*6.6*	**8.8**	*-2.1*	*-8.0*	**-5.4**
9	*0.1*	*0.3*	**-0.2**	*-5.7*	*-5.7*	**-5.7**	*16.0*	*9.3*	**12.8**	*-3.1*	*-9.3*	**-7.0**
10	*6.2*	*8.7*	**3.6**	*-8.2*	*-8.2*	**-8.4**	*14.7*	*10.2*	**11.9**	*-3.3*	*-9.3*	**-6.5**
11	*1.7*	*2.3*	**1.2**	*-10.6*	*-10.6*	**-10.8**	*17.0*	*10.0*	**13.6**	*0.2*	*-5.4*	**-2.0**
12	*-0.2*	*-0.2*	**-0.3**	*-9.6*	*-9.5*	**-9.9**	*5.7*	*3.6*	**3.9**	*-0.9*	*-5.6*	**-3.0**

Remarks on estimating σ

- *After some consideration, one understands the following conclusion by Henningsen & Henningsen (2012) regarding CES estimation:*

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

- *Remember that the limited sample based estimates were questionable to a large extent (σ <0)*

- *Inference should be made carefully – results indicative rather than conclusive!*

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A fixed basket in a changing universe – realistic?

- *This is actually two questions:*
  1) a fixed and **limited** *sample based basket, and*
  2) a fixed **census-like/take-all** *sample based basket (with the caveat of time *)*

- *Regardless of the results here, the validity of a limited sample can be discussed when measuring effective prices rather than list prices (offer/over-the-counter)*

  - *(*) The universe of available items is changing*

  - *The problem in estimations also stems from temporary consumption changes due to price campaigns (or perhaps random effects)*

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Thank you for your attention!

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