Revisiting Taste Change in Cost-of-Living Measurement

Robert S. Martin

Office of Prices and Living Conditions

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Disclaimer

All estimates and analyses based on Nielsen data are by the author and not the data provider.

Contents

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  - Capturing taste change effects a la Redding and Weinstein requires strong assumptions
- I apply to retail scanner data for 70 food and beverage product groups
  - COLIs that condition on current quarter tastes exceed those that condition on year-ago tastes by 0.5 to 2.9 percentage points per year on average, depending on the category

Selected references

- Price index manuals
  - CNSTAT (eds. Shultze and Mackie, 2002), ILO (2004)
- COLI
  - Konüs (1924), Diewert (1976), Pollak (1989)
- Include models with preference change
  - Fisher and Shell (1972), Samuelson and Swamy (1974), Muellbauer (1975), Caves, Christiansen, and Diewert (1982), Heien and Dunn (1985), Pollak (1989), Balk (1989), Nevo (2003), Feenstra and Reinsdorf (2007)
  - Recently, Ueda, et. al. (2019), Redding and Weinstein (2020), Hottman and Monarch (2018), Gábor-Tóth and Vermeulen (2018), Ehrlich, et. al. (2019), Zadrozny (2019)

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  - Preferred CPI target of ILO (2004), CNSTAT (2002), and BLS

Parameter-free Conditional COLI

Formulas

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- Caves, Christensen, and Diewert (1982): With translog expenditure function, the **Tornqvist** index is exact for the COLI that conditions on the geometric average of tastes and utility
- Feenstra and Reinsdorf (2007): With CES expenditure function, the **Sato-Vartia** index is exact for a COLI that conditions on intermediate (relative) tastes

Unconditional COLI when preferences change

- Unconditional COLI: the proportional change in minimum expenditure required to achieve a *constant standard-of-living* between two situations

$$\Phi_U(\boldsymbol{p}_0, \boldsymbol{p}_1, \bar{u}; \varphi_0, \varphi_1) = \frac{C(\boldsymbol{p}_1, \bar{u}; \varphi_1)}{C(\boldsymbol{p}_0, \bar{u}; \varphi_0)} \quad (2)$$

for a given $\bar{u}$.

- E.g., Redding and Weinstein (2020)

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  - Cardinal utility
  - Restriction on evolution of tastes (e.g., normalization)

Unconditional and conditional COLI

- Possible decomposition

$$\underbrace{\ln \Phi_U(\boldsymbol{p}_0, \boldsymbol{p}_1, \bar{u}; \varphi_0, \varphi_1)}_{\text{Uncond. COLI}} = \underbrace{\ln \Phi(\boldsymbol{p}_0, \boldsymbol{p}_1, \bar{u}; \varphi_1)}_{\text{Cond. COLI}} + \underbrace{\ln \left[\frac{C(\boldsymbol{p}_0, \bar{u}; \varphi_1)}{C(\boldsymbol{p}_0, \bar{u}; \varphi_0)} \right]}_{\text{Pure taste effects}} \quad (3)$$

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- Conditional COLIs contain the full contribution of changing *prices*

CES Preferences

Assume:

$$C(\boldsymbol{p}, \bar{u}; \varphi) = \bar{u}\left[\sum_{i \in \mathcal{I}} \left(\frac{p_i}{\varphi_i}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{4}$$

- Elasticity of substitution σ constant between 0 and 1
- $\mathcal{I}$ has dimension N
- Homothetic preferences $\rightarrow$ can focus on unit expenditure $c(\boldsymbol{p}; \varphi) \equiv C(\boldsymbol{p}, 1; \varphi)$
- Expenditure shares: For $i \in \mathcal{I}$, $t = 0, 1$

$$s_i(\boldsymbol{p}_t; \varphi_t) = \frac{(p_{it}/\varphi_{it})^{1-\sigma}}{[c(\boldsymbol{p}_t; \varphi_t)]^{1-\sigma}} = \frac{p_{it} q_{it}}{\sum_{j \in \mathcal{I}} p_{jt} q_{jt}} \equiv s_{it} \tag{5}$$

CES Indexes with Taste Change

Name	Formula	COLI target
Lloyd-Moulton	$P_{LM} = \left\{ \sum_{i \in \mathcal{I}} s_{i0} \left(\frac{p_{i1}}{p_{i0}} \right)^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}$	$\Phi(\varphi_0)$

Lloyd (1975) and Moulton (1996)

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Lloyd (1975) and Moulton (1996)		
Backwards L.M.	$P_{BLM} = \left\{ \sum_{i \in \mathcal{I}} s_{i1} \left(\frac{p_{i0}}{p_{i1}} \right)^{1-\sigma} \right\}^{\frac{-1}{1-\sigma}}$	$\Phi(\varphi_1)$
Lloyd (1975)		

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LMM	$P_{LMM} = \sqrt{P_{LM} P_{BLM}}$	$\sqrt{\Phi(\varphi_0)\Phi(\varphi_1)}$

Lloyd-Moulton: Lloyd (1975) and Moulton (1996)

Backwards L.M.: Lloyd (1975)

LMM: Balk (1999). Equals Quadratic Mean of Order r Index (Diewert, 1976) where $r = 2(1-\sigma)$

CES Indexes with Taste Change (continued)

Name	Formula	COLI target
Sato-Vartia[1]	$P_{SV} = \prod_{i \in \mathcal{I}} \left(\frac{p_{i1}}{p_{i0}} \right)^{w_i}$	$\Phi(\bar{\varphi})$

Sato (1976) and Vartia (1976). $\varphi_{i0} / \prod_{i \in \mathcal{I}} \varphi_{i0}^{w_i} \leq \bar{\varphi}_i \leq \varphi_{i1} / \prod_{i \in \mathcal{I}} \varphi_{i1}^{w_i}$ (Feenstra and Reinsdorf, 2007)

CES Indexes with Taste Change (continued)

Name	Formula	COLI target
Sato-Vartia[1]	$P_{SV} = \prod_{i \in \mathcal{I}} \left(\frac{p_{i1}}{p_{i0}} \right)^{w_i}$	$\Phi(\bar{\varphi})$

Sato (1976) and Vartia (1976). $\varphi_{i0} / \prod_{i \in \mathcal{I}} \varphi_{i0}^{w_i} \leq \bar{\varphi}_i \leq \varphi_{i1} / \prod_{i \in \mathcal{I}} \varphi_{i1}^{w_i}$ (Feenstra and Reinsdorf, 2007)

CCV	$P_{CCV} = \prod_i \left(\frac{p_{i1}}{p_{i0}} \right)^{\frac{1}{N}} \left(\frac{s_{i1}}{s_{i0}} \right)^{\frac{1}{N(\sigma - 1)}}$	$\Phi_U(\ddot{\varphi}_0, \ddot{\varphi}_1)$

Redding and Weinstein (2020). $\ddot{\varphi}_{it}$ normalized to have time-constant unweighted geometric mean.

[1] $w_i = \left[(s_{i1} - s_{i0}) / (\ln s_{i1} - \ln s_{i0}) \right] / \left[\sum_{k \in \mathcal{I}} (s_{k1} - s_{k0}) / (\ln s_{k1} - \ln s_{k0}) \right]$

Application to Retail Scanner Data

- Nielsen Scantrack: Retail point-of-sale data from Sept. 2005-Sept. 2010 for mainly chain grocery and drug stores. Looking at 70 food and beverage product groups from 8 departments. Weekly revenues, quantities, unique items (e.g., UPCs), brand information, some characteristics ▸ Stats

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- As in RW, product group-level (g) indexes track price change from quarter $t-4$ to t
- Basket $\mathcal{I}_g$ is all UPC's available in both t and $t-4$ (as in RW, 2018)

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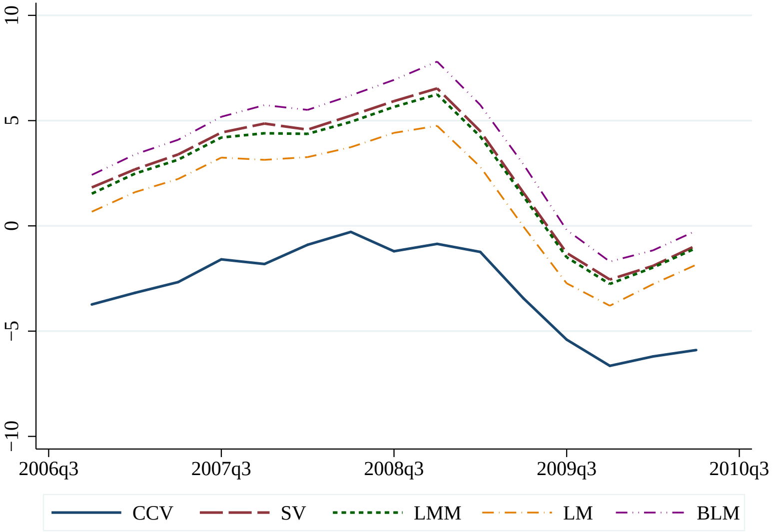
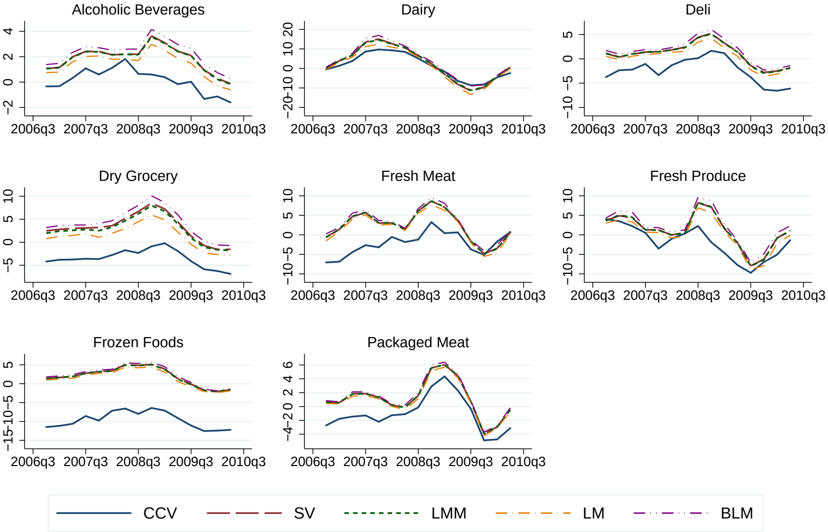
- Basket $\mathcal{I}_g$ is all UPC's available in both t and $t-4$ (as in RW, 2018)
- Estimation of the σ_g follows Broda and Weinstein (2010), based on Feenstra (1994) ▸ Sigmas
- Presenting index averages weighted by expenditure share of the product group in quarter t

Mean CES Price Indexes (percent change versus year ago)



Mean CES Price Indexes for Food and Bev. Departments



Mean CES Index Differences by Dept. (percentage points)

▸ Levels

	SV – CCV	SV – LMM	SV – BLM	BLM – LM
Alcoholic Beverages	1.7740	0.0302	−0.4167	0.8912
Dairy	1.5146	0.0409	−1.2250	2.4992
Deli	3.4615	0.0477	−0.6147	1.3201
Dry Grocery	6.6622	0.4250	−1.0722	2.9221
Fresh Meat	4.3377	−0.0096	−0.6363	1.2490
Fresh Produce	3.1727	−0.0114	−1.0365	2.0388
Frozen Foods	11.5876	0.0460	−0.4386	0.9644
Packaged Meat	2.2057	0.0092	−0.2619	0.5413
All	*5.6359*	*0.2437*	*−0.9297*	*2.3014*

Note: Based on data provided by The Nielsen Company (U.S.), LLC. Statistics are average differences between product group-level indexes weighted by the product group's share of expenditure in the comparison period. CCV refers to RW's CES Common Varieties Index, SV refers to Sato-Vartia, LM refers to Lloyd-Moulton, BLM refers to Backwards Lloyd-Moulton, and LMM refers to the geometric mean of LM and BLM.

Conclusions and Extensions

- Conditional COLI can vary by choice of taste parameter
- Whether to characterize as “bias” depends on intended target
- Under cardinal utility and this specific normalization, taste effects often dominate price effects in unconditional COLI estimates

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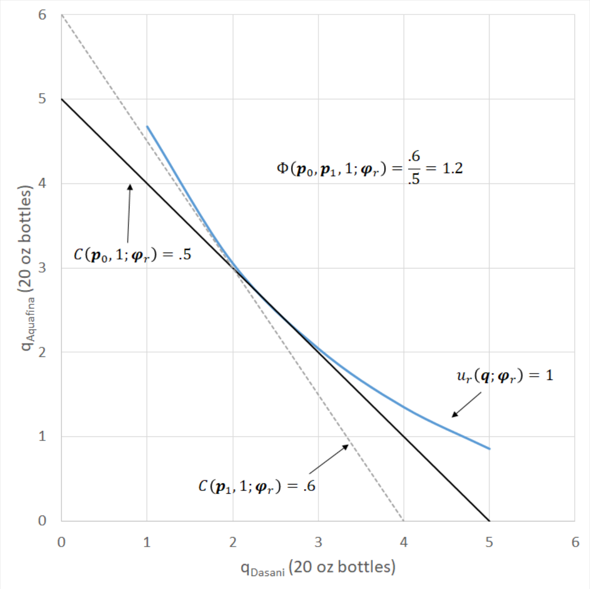
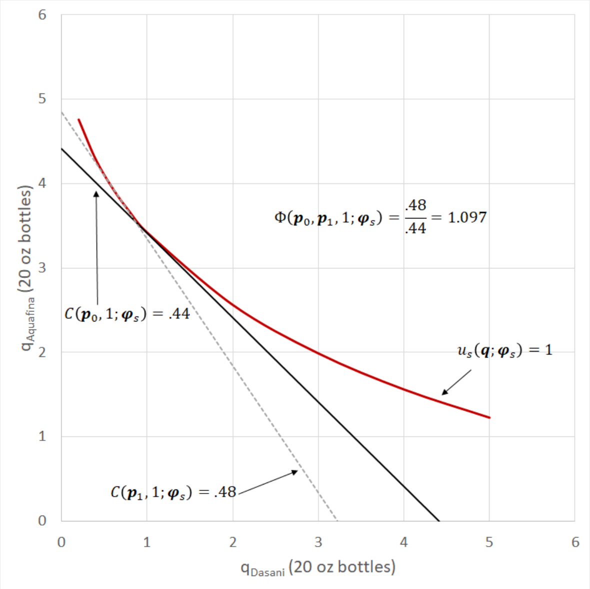
- In paper: accounting for variety-level tastes is infeasible given current BLS data collection constraints. Category-level tastes may have relatively little impact on conditional COLI estimates using U.S. CPI data
- More research needed into robustness of P_{CCV}, P_{LM}, P_{BLM}
  - Kurtzon (2020). "Examining the Robustness of Normalizing Time-varying Preferences."
  - Martin (2020). "Taste Change vs. Specification Error in Cost-of-Living Measurement."

CONTACT INFORMATION

Robert S. Martin
Division of Price and Index Number Research
Bureau of Labor Statistics
2 Massachusetts Ave, NE
Washington, DC 20212
Email: Martin.Robert@bls.gov


$\Phi(\boldsymbol{p}_0, \boldsymbol{p}_1, 1; \boldsymbol{\varphi}_r) = \frac{.6}{.5} = 1.2$
$C(\boldsymbol{p}_0, 1; \boldsymbol{\varphi}_r) = .5$
$u_r(\boldsymbol{q}; \boldsymbol{\varphi}_r) = 1$
$C(\boldsymbol{p}_1, 1; \boldsymbol{\varphi}_r) = .6$
$q_{Aquafina}$ (20 oz bottles)
q_{Dasani} (20 oz bottles)
0
1
2
3
4
5
6

Return


$\Phi(\boldsymbol{p}_0, \boldsymbol{p}_1, 1; \boldsymbol{\varphi}_s) = \frac{.48}{.44} = 1.097$
$C(\boldsymbol{p}_0, 1; \boldsymbol{\varphi}_s) = .44$
$u_s(\boldsymbol{q}; \boldsymbol{\varphi}_s) = 1$
$C(\boldsymbol{p}_1, 1; \boldsymbol{\varphi}_s) = .48$
$q_{Aquafina}$ (20 oz bottles)
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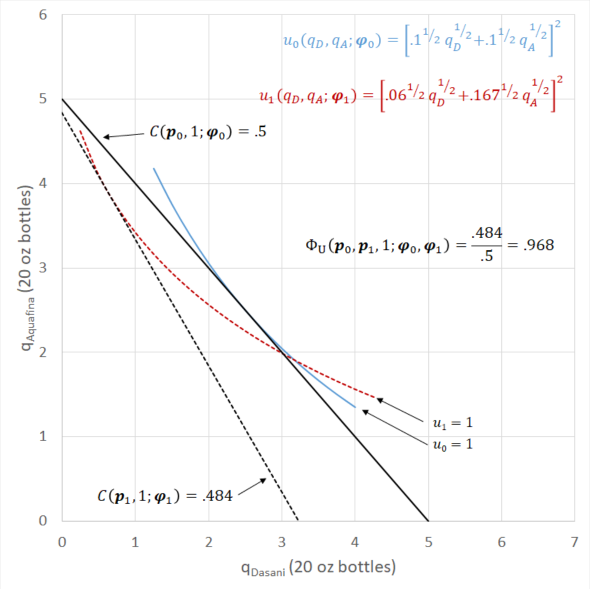
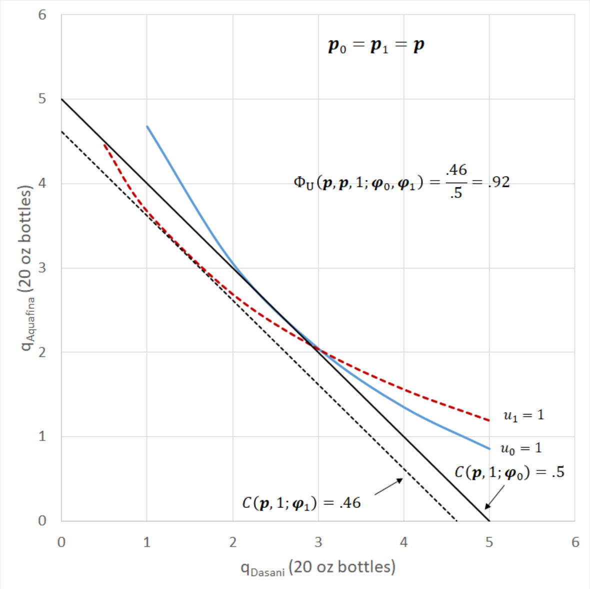


$u_0(q_D, q_A; \boldsymbol{\varphi}_0) = \left[.1^{1/2} q_D^{1/2} + .1^{1/2} q_A^{1/2}\right]^2$
$u_1(q_D, q_A; \boldsymbol{\varphi}_1) = \left[.06^{1/2} q_D^{1/2} + .167^{1/2} q_A^{1/2}\right]^2$
$C(\boldsymbol{p}_0, 1; \boldsymbol{\varphi}_0) = .5$
$\Phi_U(\boldsymbol{p}_0, \boldsymbol{p}_1, 1; \boldsymbol{\varphi}_0, \boldsymbol{\varphi}_1) = \frac{.484}{.5} = .968$
$u_1 = 1$
$u_0 = 1$
$C(\boldsymbol{p}_1, 1; \boldsymbol{\varphi}_1) = .484$
$q_{Aquafina}$ (20 oz bottles)
q_{Dasani} (20 oz bottles)

Return



$p_0 = p_1 = p$
$\Phi_U(p, p, 1; \varphi_0, \varphi_1) = \frac{.46}{.5} = .92$
$u_1 = 1$
$u_0 = 1$
$C(p, 1; \varphi_0) = .5$
$C(p, 1; \varphi_1) = .46$
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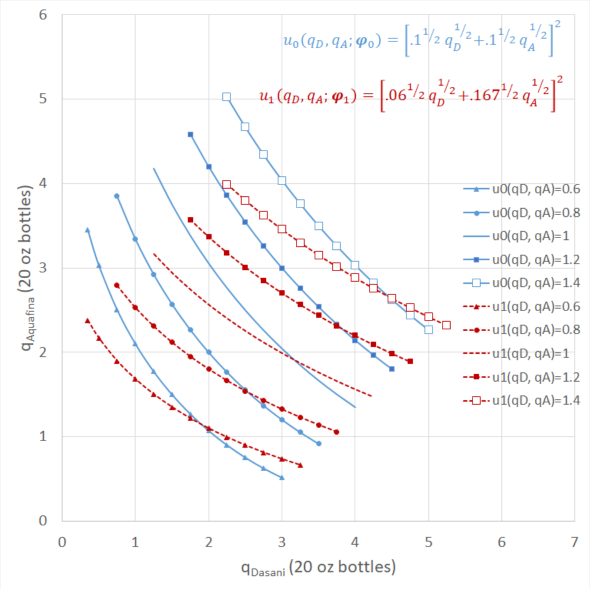

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$u_1(q_D, q_A; \varphi_1) = \left[.06^{1/2} q_D^{1/2} + .167^{1/2} q_A^{1/2}\right]^2$
u0(qD, qA)=0.6
u0(qD, qA)=0.8
u0(qD, qA)=1
u0(qD, qA)=1.2
u0(qD, qA)=1.4
u1(qD, qA)=0.6
u1(qD, qA)=0.8
u1(qD, qA)=1
u1(qD, qA)=1.2
u1(qD, qA)=1.4
$q_{Aquafina}$ (20 oz bottles)
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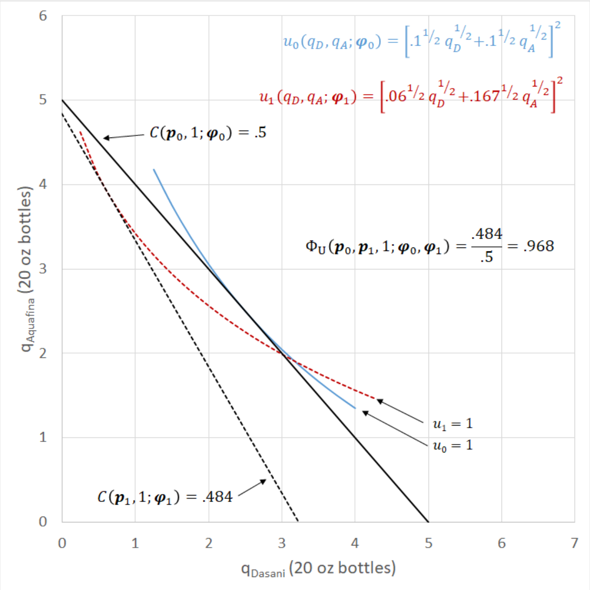
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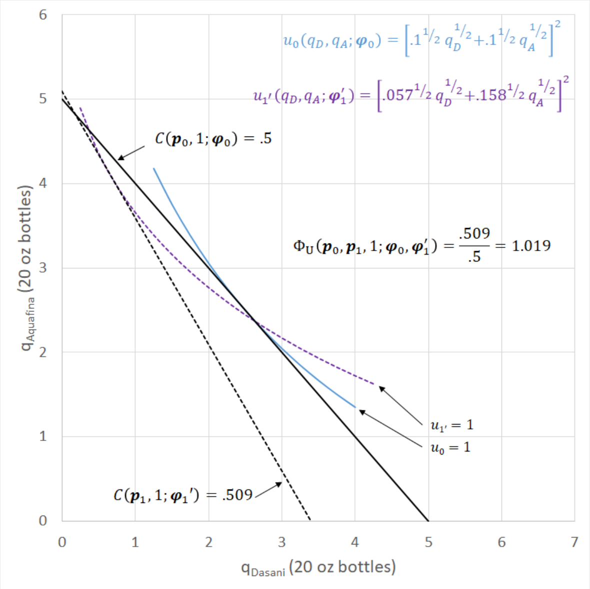

$u_0(q_D, q_A; \varphi_0) = \left[.1^{1/2} q_D^{1/2} + .1^{1/2} q_A^{1/2}\right]^2$
$u_{1'}(q_D, q_A; \varphi_1') = \left[.057^{1/2} q_D^{1/2} + .158^{1/2} q_A^{1/2}\right]^2$
$C(\boldsymbol{p}_0, 1; \boldsymbol{\varphi}_0) = .5$
$\Phi_U(\boldsymbol{p}_0, \boldsymbol{p}_1, 1; \boldsymbol{\varphi}_0, \boldsymbol{\varphi}_1') = \frac{.509}{.5} = 1.019$
$u_{1'} = 1$
$u_0 = 1$
$C(\boldsymbol{p}_1, 1; \boldsymbol{\varphi}_1') = .509$
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q_{Dasani} (20 oz bottles)
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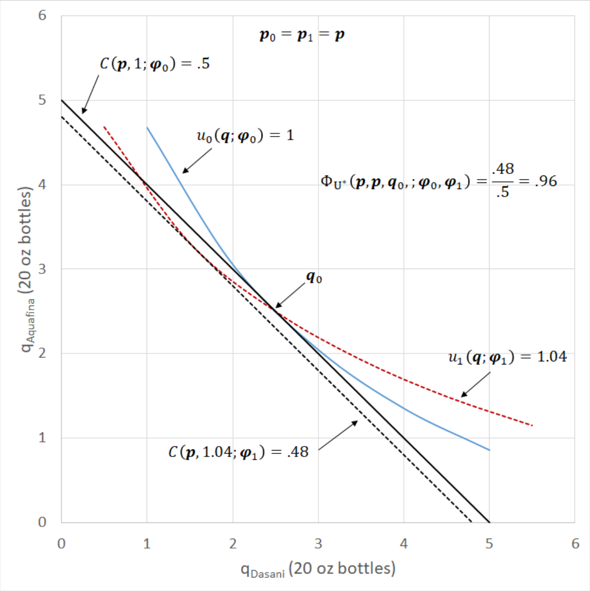
Alternative "constant standard-of-living"

- Balk (1989)

$$\Phi_{U^*}(\boldsymbol{p}_0, \boldsymbol{p}_1, \boldsymbol{q}_r; \varphi_0, \varphi_1) = \frac{C(\boldsymbol{p}_1, u_1(\boldsymbol{q}_r); \varphi_1)}{C(\boldsymbol{p}_0, u_0(\boldsymbol{q}_r); \varphi_0)} \tag{6}$$

  for a given $\boldsymbol{q}_r$, where $u_t(\boldsymbol{q})$ is the direct utility function
- Between two situations, the change in minimum expenditure required for an agent to reach an indifference curve passing through a fixed bundle
- See also Gábor-Tóth and Vermeulen (2018)

▸ UCOLI ▸ Maps



$p_0 = p_1 = p$
$C(p, 1; \varphi_0) = .5$
$u_0(q; \varphi_0) = 1$
$\Phi_{U^*}(p, p, q_0,; \varphi_0, \varphi_1) = \frac{.48}{.5} = .96$
q_0
$u_1(q; \varphi_1) = 1.04$
$C(p, 1.04; \varphi_1) = .48$
q_{Aquafina} (20 oz bottles)
q_{Dasani} (20 oz bottles)
0
1
2
3
4
5
6

- Laspeyres: $P_L = \frac{\sum_{i\in\mathcal{I}} p_{i1}q_{i0}}{\sum_{i\in\mathcal{I}} p_{i0}q_{i0}}$
- Paasche: $P_P = \frac{\sum_{i\in\mathcal{I}} p_{i1}q_{i1}}{\sum_{i\in\mathcal{I}} p_{i0}q_{i1}}$
- Fisher: $P_F = \sqrt{P_L P_P}$
- Tornqvist: $P_T = \prod_{i\in\mathcal{I}} \left(\frac{p_{i1}}{p_{i0}}\right)^{0.5(s_{i0}+s_{i1})}$,
  $s_{it} = \frac{p_{it}q_{it}}{\sum_{j\in\mathcal{I}} p_{jt}q_{jt}}$, $t = 0, 1$.
- Sato-Vartia: $P_{SV} = \prod_{i\in\mathcal{I}} \left(\frac{p_{i1}}{p_{i0}}\right)^{w_i}$,
  $w_i = \left[\frac{s_{i1}-s_{i0}}{\ln s_{i1} - \ln s_{i0}}\right] / \left[\sum_{k\in\mathcal{I}} \frac{s_{k1}-s_{k0}}{\ln s_{k1} - \ln s_{k0}}\right]$

Return

Scantrack Data by Department

Department	# PG	# UPC	Exp. Share
Alcoholic Beverages	4	46,656	0.073
Dairy	12	46,686	0.153
Deli	1	22,061	0.022
Dry Grocery	40	412,319	0.541
Fresh Meat	1	1,934	0.006
Fresh Produce	1	20,244	0.052
Frozen Foods	12	64,635	0.115
Packaged Meat	1	18,401	0.039
All	*72*	*632,936*	*1.000*

Note: Based on data provided by The Nielsen Company (U.S.), LLC.

▸ Return

Scantrack vs. Official Sources

Table: Food and Beverage Expenditures (Billions of Dollars)

Source	2006	2007	2008	2009
CE	465.2	471.3	505.8	506.1
PCE	699.8	736.9	768.7	772.6
Scantrack	767.2	802.1	834.4	841.9
Scantrack/CE	1.65	1.70	1.65	1.66
Scantrack/PCE	1.10	1.09	1.09	1.09

Note: Based on data provided by The Nielsen Company (U.S.), LLC.
CE = Consumer Expenditure Survey (BLS)
PCE = Personal Consumption Expenditures (BEA)

Return

Summary Statistics for $p_{it}/p_{i,t-4}$ by Department

	Obs	Mean	StDev	Skew	Kurt	Min	Max
Alcoholic Beverages	343,007	1.021	0.118	0.415	7.163	0.270	2.098
Dairy	383,519	1.037	0.137	0.908	6.577	0.469	2.256
Deli	128,081	1.025	0.117	0.322	6.578	0.500	1.635
Dry Grocery	2,941,985	1.036	0.141	0.777	9.977	0.210	2.782
Fresh Meat	12,162	1.028	0.117	0.767	6.633	0.557	1.759
Fresh Produce	113,895	1.033	0.165	0.844	6.490	0.458	1.992
Frozen Foods	454,187	1.027	0.125	0.253	6.360	0.281	1.807
Packaged Meat	148,512	1.025	0.106	0.516	5.623	0.625	1.618
All	*4,525,348*	*1.033*	*0.136*	*0.74*	*9.254*	*0.21*	*2.782*

Note: Based on data provided by The Nielsen Company (U.S.), LLC.

Return

Summary Statistics for $s_{it}/s_{i,t-4}$ by Department

	Obs	Mean	StDev	Skew	Kurt	Min	Max
Alcoholic Bev.	343,007	1.444	2.808	39.6	5798.3	0.002	570.0
Dairy	383,519	1.303	2.163	44.2	6005.1	0.000	412.3
Deli	128,081	1.515	2.692	7.4	74.4	0.003	52.0
Dry Grocery	2,941,985	1.471	5.160	129.2	29494.4	0.000	1796.8
Fresh Meat	12,162	1.354	2.416	12.5	256.5	0.002	81.6
Fresh Produce	113,895	2.090	5.808	8.9	103.9	0.003	125.4
Frozen Foods	454,187	1.426	4.463	113.5	24294.4	0.000	1256.3
Packaged Meat	148,512	1.258	1.481	6.6	61.5	0.006	24.8
All	*4,525,348*	*1.460*	*4.632*	*127.8*	*31713.4*	*0.000*	*1796.8*

Note: Based on data provided by The Nielsen Company (U.S.), LLC.

Return

Elasticity of Substitution Estimates by Department

	# Prod. Gr.	P25	Med	P75
Alcoholic Beverages	4	5.96	7.06	8.63
Dairy	10	3.31	3.65	4.05
Deli	1	3.96	3.96	3.96
Dry Grocery	40	3.85	4.68	6.50
Fresh Meat	1	3.37	3.37	3.37
Fresh Produce	1	2.94	2.94	2.94
Frozen Foods	12	3.31	3.94	6.33
Packaged Meat	1	3.12	3.12	3.12
All	*70*	*3.39*	*4.32*	*6.29*

Note: Based on data provided by The Nielsen Company (U.S.), LLC.

Return

Mean CES Indexes by Department (percent change)

Differences

	CCV	SV	LMM	LM	BLM
Alcoholic Beverages	0.0845	1.8585	1.8283	1.3839	2.2751
Dairy	1.3019	2.8165	2.7756	1.5423	4.0415
Deli	−2.4059	1.0556	1.0079	0.3502	1.6703
Dry Grocery	−3.4241	3.2381	2.8131	1.3882	4.3103
Fresh Meat	−2.0699	2.2678	2.2774	1.6551	2.9040
Fresh Produce	−2.0258	1.1468	1.1583	0.1446	2.1833
Frozen Foods	−9.6467	1.9408	1.8948	1.4150	2.3794
Packaged Meat	−1.0369	1.1688	1.1596	0.8894	1.4307
All	*−2.9549*	*2.6810*	*2.4373*	*1.3093*	*3.6107*

Note: Based on data provided by The Nielsen Company (U.S.), LLC. Statistics are averages of product group-level indexes weighted by the product group's share of expenditure in the comparison period. CCV refers to RW's CES Common Varieties Index, SV refers to Sato-Vartia, LM refers to Lloyd-Moulton, BLM refers to Backwards Lloyd-Moulton, and LMM refers to the geometric mean of LM and BLM.