Variety Growth and Measurement Biases in Inflation, Output, and Productivity[1]

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- The findings and conclusions in this presentation are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.
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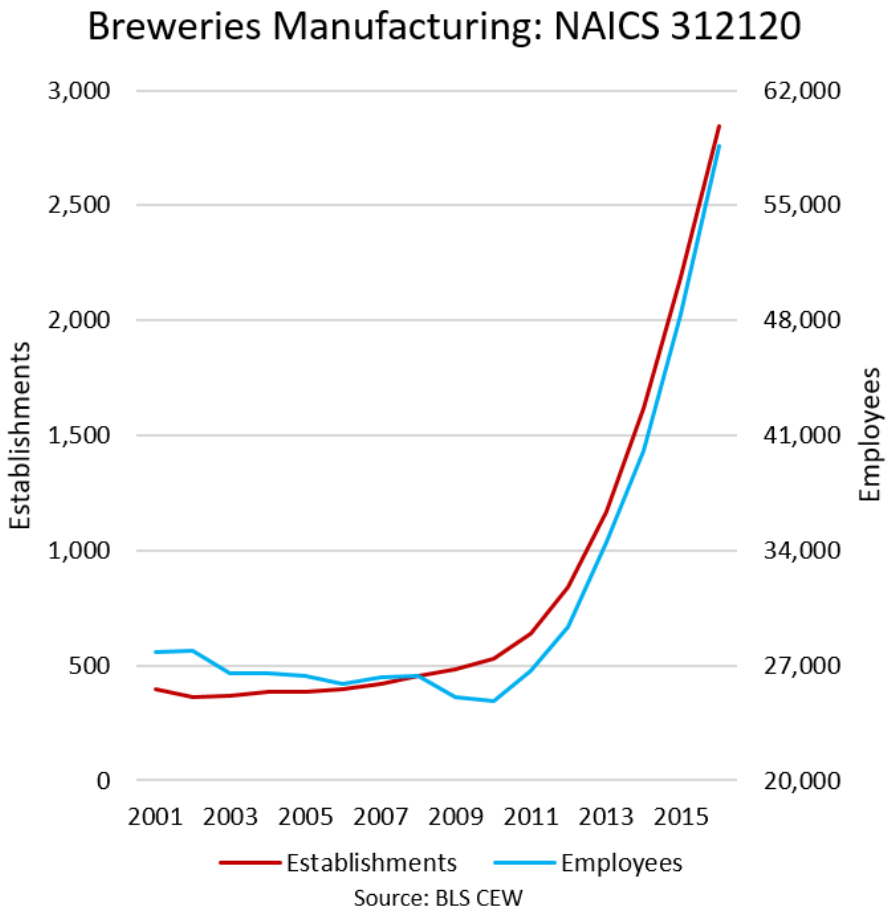
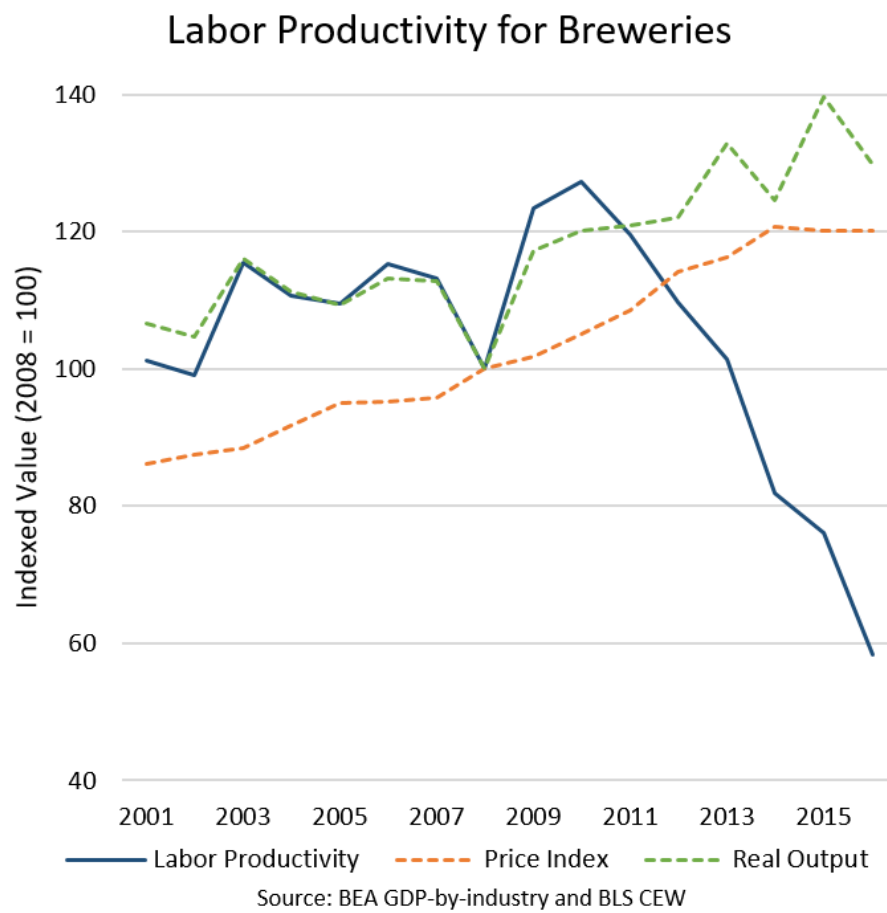
- The analysis, findings, and conclusions expressed in this presentation also should not be attributed to IRI. All estimates and analyses based on Information Resources, Inc. data are by the authors and not by Information Resources, Inc.

Overview

- "The [Boskin] commission members asked themselves how much a consumer would be willing to pay 'for the privilege of choosing from the variety of items available in today's supermarket instead of ... 30 years ago.' They concluded, based on pure introspection, 'that a conservative estimate . . . might be 10 percent for food [. . .] and 5 percent for alcoholic beverages.' [. . .] This may be plausible, or not, but there is no real basis for believing that any of these estimates is even vaguely accurate." — Martin Feldstein (2017).

Example of product variety growth: beer





- If consumers prefer variety, then official price indexes may overstate inflation and understate real output growth and productivity growth.

Questions

- In this project, we address three main questions:

1. How large is the bias in food and beverage inflation from not accounting for expanding product variety?

2. How much does correcting for product variety affect measured food and beverage manufacturing productivity growth?

3. Is measured inflation and productivity growth subject to a larger bias post-GFC than pre-GFC?

Preview of Results

- Using barcode-level datasets and a structural model of consumer demand, we estimate an upwards bias in the annual food and beverage inflation rate between 2001-2016 of about 1.5 to 2 percentage points.

- Our results imply that annual labor productivity growth for food and beverage manufacturing is understated in official measures by a similar amount.

- Depending on how we aggregate across food and beverage product categories, these biases in official measures may be moderately larger post-GFC than pre-GFC.

Overview of two datasets

Two scanner datasets from IRI:

The IRI academic marketing retail scanner dataset ("Marketing"):

- Source: Bronnenberg, Bart J., Michael W. Kruger, and Carl F. Mela, "Database Paper: The IRI Marketing Dataset", *Marketing Science*, Vol. 27, No. 4, 2008, pp. 745-748.

The IRI InfoScan retail point-of-sales dataset ("InfoScan") from the USDA:

- Source: Muth, M.K., M. Sweitzer, D. Brown, K. Capogrossi, S.A. Karns, D. Levin, A.Okrent, P. Siegel, and C. Zhen, "Understanding IRI Household-Based and Store-Based Scanner Data," Technical Bulletin 1942, USDA ERS 2016.

IRI Marketing and InfoScan Datasets

- From Marketing data we have around 600 stores over 2001-2012, from InfoScan we have around 4000 stores over 2008-2016.
- Each national in scope, covering many retail chains of grocery stores.
- Each encompasses all varieties purchased by consumers in each participating store and product category.
- Each reports, for each participating store, weekly revenue and quantity sold at the barcode level.

Thus, we have more information than would be available from CPI micro data or establishment-level Census microdata.

Defining Variety

We define a *variety* as a store-barcode pair.

- Each barcode corresponds to a product with a set of unique and constant characteristics (category, brand, size, ingredients,...)
- We observe the number of units in a multi-pack, and the net content (weight, volume, or count)

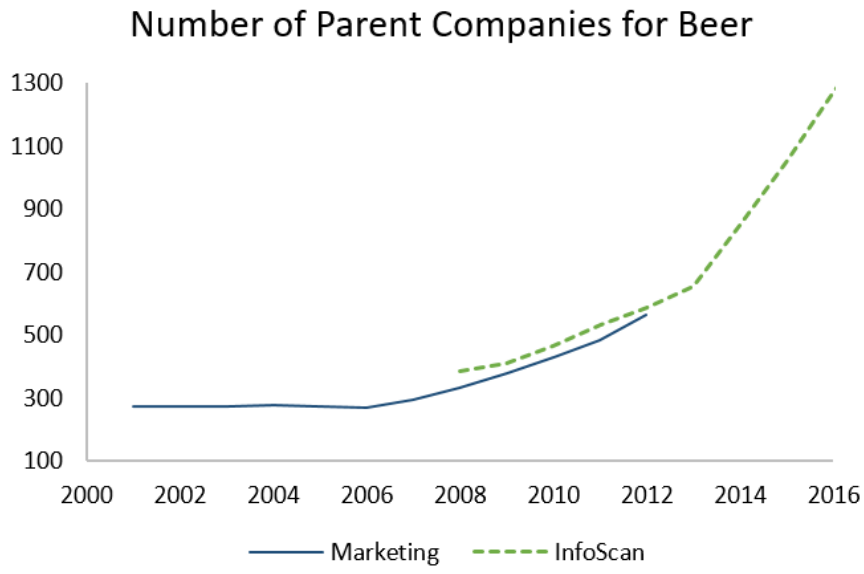
We aggregate weekly quantities and revenues to quarterly and annual frequencies to derive (quantity-weighted) average transaction prices per period for each variety.

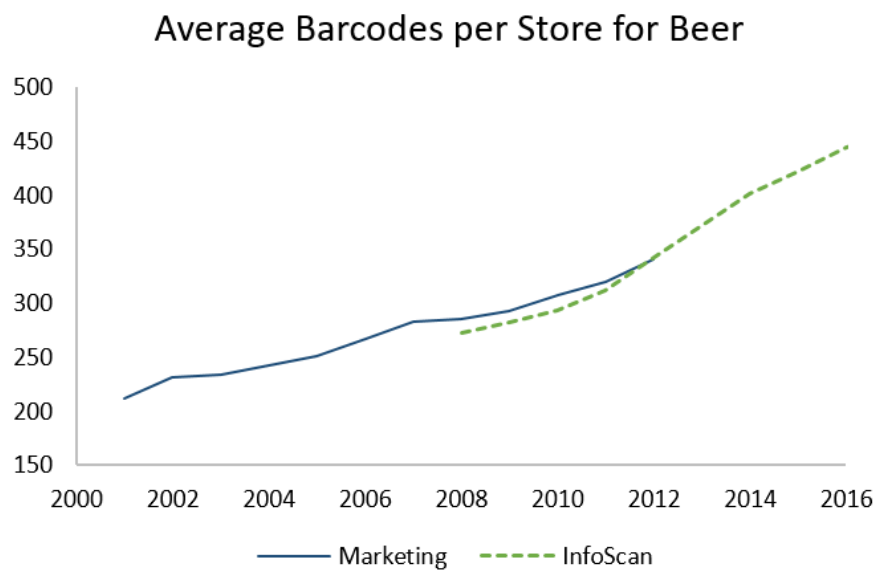
- For each barcode, we define price as the price per unit of net content (e.g., price per ounce) for comparability within a product category.

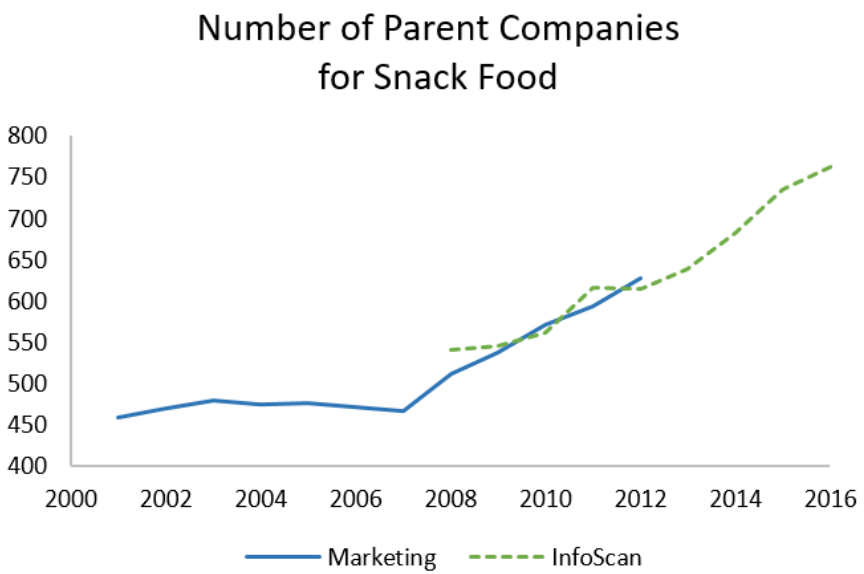
Product categories

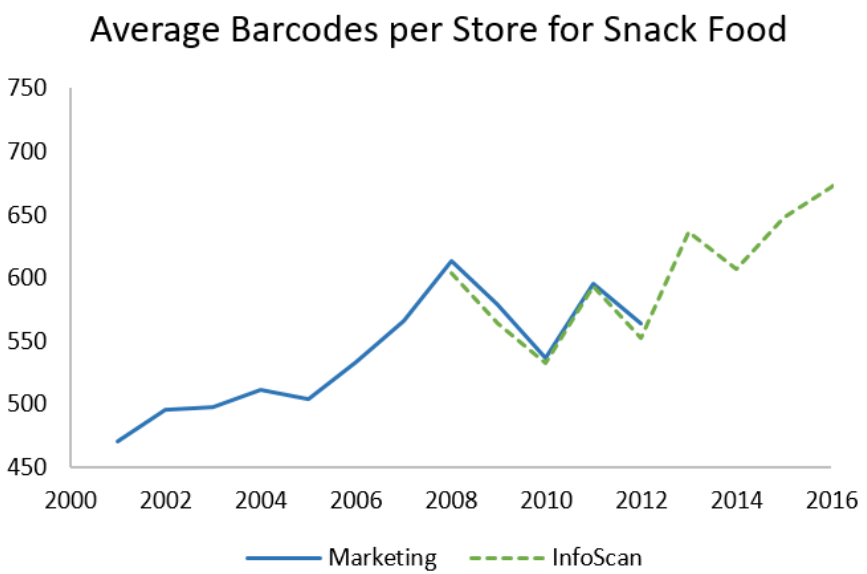
IRI Category	NAICS category
Frankfurters	31161A - Animal Processing (ex. poultry)
Cold Cereal	311230 - Breakfast Cereal Mfg.
Beer/Ale/Alcoholic Cider	312120 - Breweries
Coffee	311920 - Coffee & Tea Mfg.
Margarine/Spreads	311225 - Fats & Oils Blending
Frozen Dinners/Entrees, Frozen Pizza	311410 - Frozen Food Mfg.
Soup, Spaghetti Sauce, Ketchup/Mustard	311420 - Fruit & Vegetable Canning
Mayonnaise, Ketchup/Mustard	311940 - Seasoning & Dressing Mfg.
Salty Snacks, Peanut Butter	311910 - Snack Food Mfg.
Carbonated Beverages	312110 - Soft Drink & Ice Mfg.

Comparison across datasets

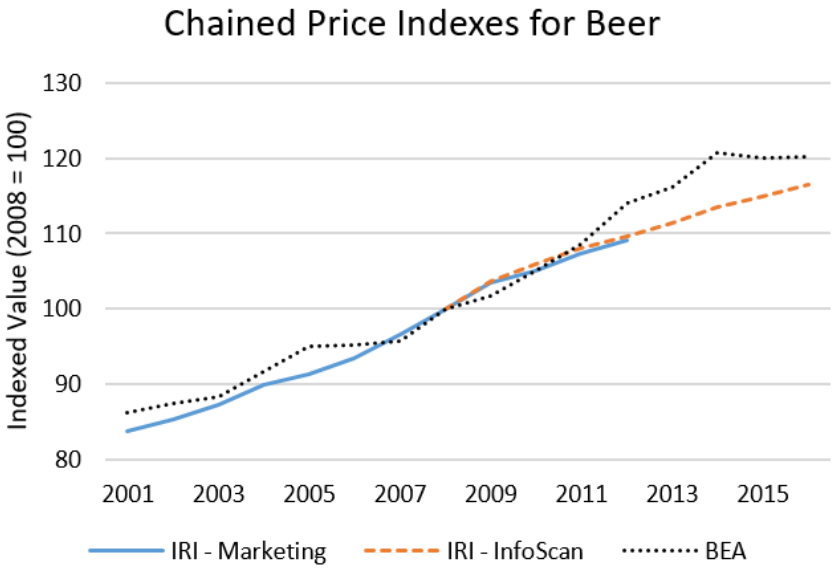


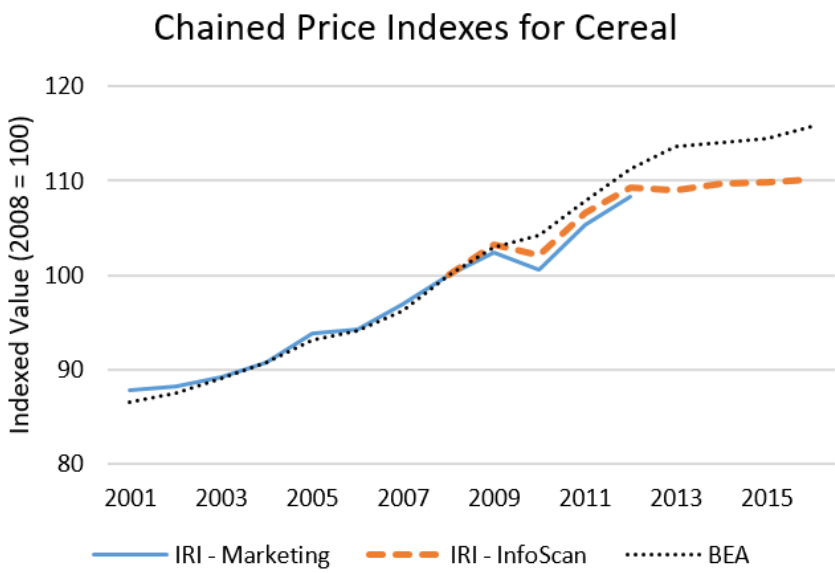


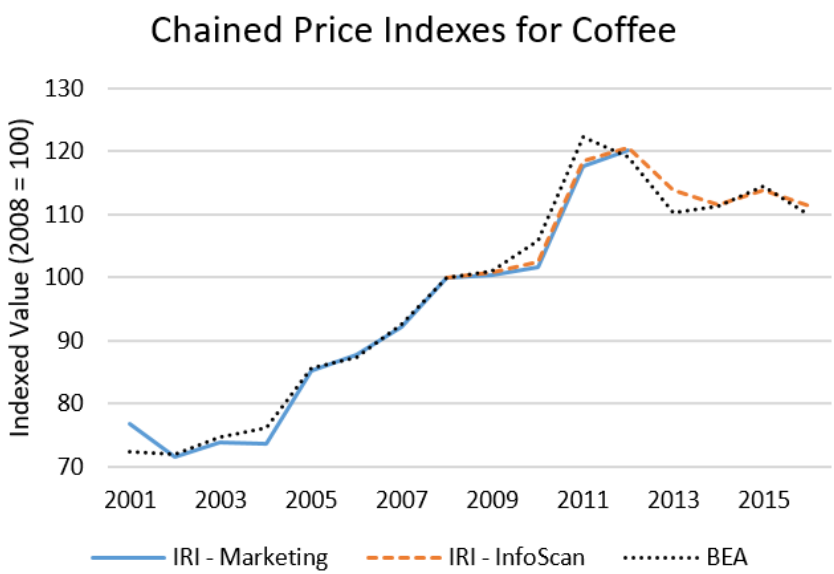


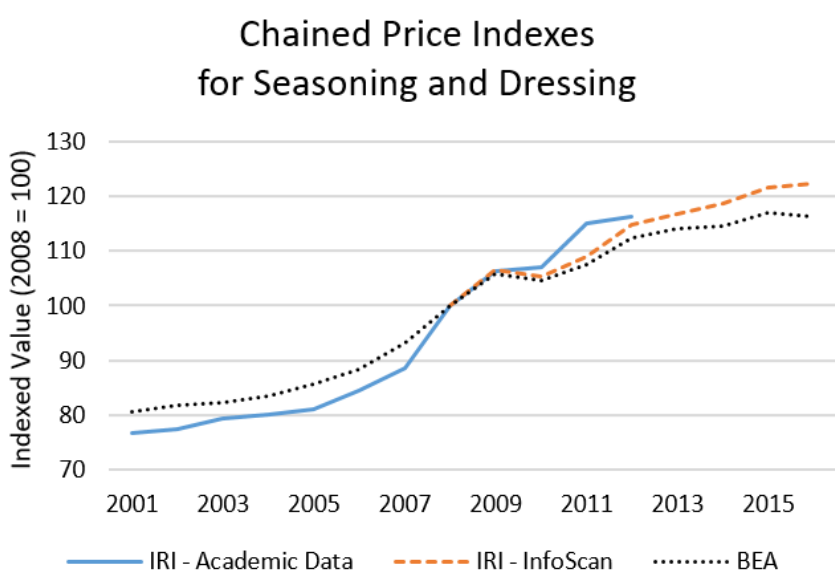


Comparing Chained Laspeyres Price Indexes









Structural Model - CES Demand

The representative U.S. consumer's demand for a particular variety v in product category g at time t is given by

$$q_{v,t} = \left(\frac{{p_{v,t}}^{-\sigma_g} \varphi_{v,t}^{\sigma_g - 1}}{\pi_{g,t}^{1-\sigma_g}} \right) Y_{g,t},$$

$$\sigma_g > 0, \ \varphi_{v,t} > 0,$$

where

- $Y_{g,t}$ is total spending in product category g at time t;
- $q_{v,t}$ is the quantity consumed of variety v at time t;
- $\pi_{g,t}$ is CES price index for category g; σ_g is elasticity parameter;
- $\varphi_{v,t}$ is a demand shifter for variety v at time t that captures time variation in consumer taste (and product quality)

CES price index

The change in the CES price index (including variety entry/exit) from time t to time $t+1$ can be written as

$$\frac{P_{gt+1}}{P_{gt}} = \frac{\left[\sum_{v \in U_{gt+1}} \left(\frac{P_{v,t+1}}{\varphi_{v,t+1}}\right)^{1-\sigma_g}\right]^{\frac{1}{1-\sigma_g}}}{\left[\sum_{v \in U_{gt}} \left(\frac{P_{v,t}}{\varphi_{v,t}}\right)^{1-\sigma_g}\right]^{\frac{1}{1-\sigma_g}}}$$

In contrast, a common goods price index of this form is

$$\frac{P^C_{gt+1}}{P^C_{gt}} = \frac{\left[\sum_{v \in U_{g,t} \cap U_{g,t+1}} \left(\frac{P_{v,t+1}}{\varphi_{v,t+1}}\right)^{1-\sigma_g}\right]^{\frac{1}{1-\sigma_g}}}{\left[\sum_{v \in U_{g,t} \cap U_{g,t+1}} \left(\frac{P_{v,t}}{\varphi_{v,t}}\right)^{1-\sigma_g}\right]^{\frac{1}{1-\sigma_g}}}$$

Our estimate of the bias from unmeasured variety growth will be the difference between these price indexes

Identification Strategy

For each product category g, the elasticity of substitution across barcodes (σ_g) is the key parameter governing gains from variety

We structurally estimate these parameters in the quarterly frequency InfoScan data, building on the identification approach of Hausman (1996).

- We estimate (quantity-weighted average) demand equations for each category, using average price of same barcode in other cities (excl. same retail chain) as an instrument. We include brand-time fixed effects to control for national advertising.

Our estimates of σ_g generally fall in the range of around 2 to 3.

Variety Bias in Price Indexes from CES

IRI category	CG minus CES Marketing	CG minus CES InfoScan	Change in Bias
A.R. (ppt.)	2001-2008	2008-2016	8-16 minus 1-8
Frankfurters	1.1	3.9	2.8
Cold Cereal	1.4	1.5	0.1
Beer/Ale/Alcoholic Cider	0.7	0.8	0.1
Coffee	3.4	0.8	-2.6
Margarine/Spreads	0.9	0.0	-0.9
Frozen Dinners/Entrees, Frozen Pizza	5.0	8.2	3.2
Soup, Spaghetti Sauce, Ketchup/Mustard	2.7	2.1	-0.6
Mayonnaise, Ketchup/Mustard	1.6	2.9	1.3
Salty Snacks, Peanut Butter	1.6	11.2	9.6
Carbonated Beverages	1.7	0.8	-0.9
Median	1.6	1.8	0.1
Weighted average	1.8	3.8	2.0

Corrected Labor Productivity Growth

- What are the implications of our variety bias for industry productivity?

NAICS category	BEA-based Labor Prod.	CES Variety Bias Adj. Labor Prod.	BEA-based Labor Prod.	CES Variety Bias Adj. Labor Prod.
A.R. (ppt.)	2001-2008	2001-2008	2008-2016	2008-2016
Animal Processing (ex. poultry)	0.9	1.8	0.7	3.0
Breakfast Cereal Mfg.	-4.1	-3.0	-0.4	0.5
Breweries	-0.2	0.5	-6.5	-5.8
Coffee & Tea Mfg.	0.0	3.6	2.1	2.9
Fats & Oils Blending	4.4	5.5	-3.5	-3.5
Frozen Food Mfg.	2.0	5.1	1.2	5.1
Fruit & Vegetable Canning	1.4	4.0	1.0	2.9
Seasoning & Dressing Mfg.	0.2	1.8	-0.1	2.1
Snack Food Mfg.	4.1	5.3	-0.2	5.7
Soft Drink & Ice Mfg.	3.3	4.8	-0.5	0.2
Median	1.2	3.8	-0.2	2.5
Weighted average	1.5	3.0	-0.2	2.0

Generalized CES model

- We also estimate a generalization of CES that shifts demand curves to the left (resulting in finite reservation prices for new varieties):

NAICS category	CG minus GCES Marketing	CG minus GCES InfoScan	Change in Bias
A.R. (ppt.)	2001-2008	2008-2016	8-16 minus 1-8
Animal Processing (ex. poultry)	1.3	2.9	1.6
Breakfast Cereal Mfg.	0.9	1.1	0.2
Breweries	0.8	1.1	0.3
Coffee & Tea Mfg.	3.9	1.1	-2.8
Fats & Oils Blending	0.6	-0.1	-0.7
Frozen Food Mfg.	2.8	3.9	1.1
Fruit & Vegetable Canning	3.8	0.2	-3.6
Seasoning & Dressing Mfg.	1.8	4.9	3.1
Snack Food Mfg.	2.2	6.5	4.3
Soft Drink & Ice Mfg.	1.8	0.9	-0.9
Median	1.8	1.1	0.3
Weighted average	1.9	2.5	0.6

Conclusion

- We have sketched a methodology for accounting for variety growth in inflation and industry productivity, and applied this approach to national datasets of retail sales at the barcode level.

- We estimate an upwards bias in annual food and beverage inflation from not accounting for variety growth of around 1.5 to 2 percentage points, and a similar downwards bias in labor productivity growth.

- Depending on how we aggregate across food and beverage product categories, these biases in official measures may be moderately larger post-GFC than pre-GFC.

- Other sectors of the economy may also feature unmeasured variety-driven productivity growth.