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Multilateral Index Number Methods for Consumer Price Statistics

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@TheIFS

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Background

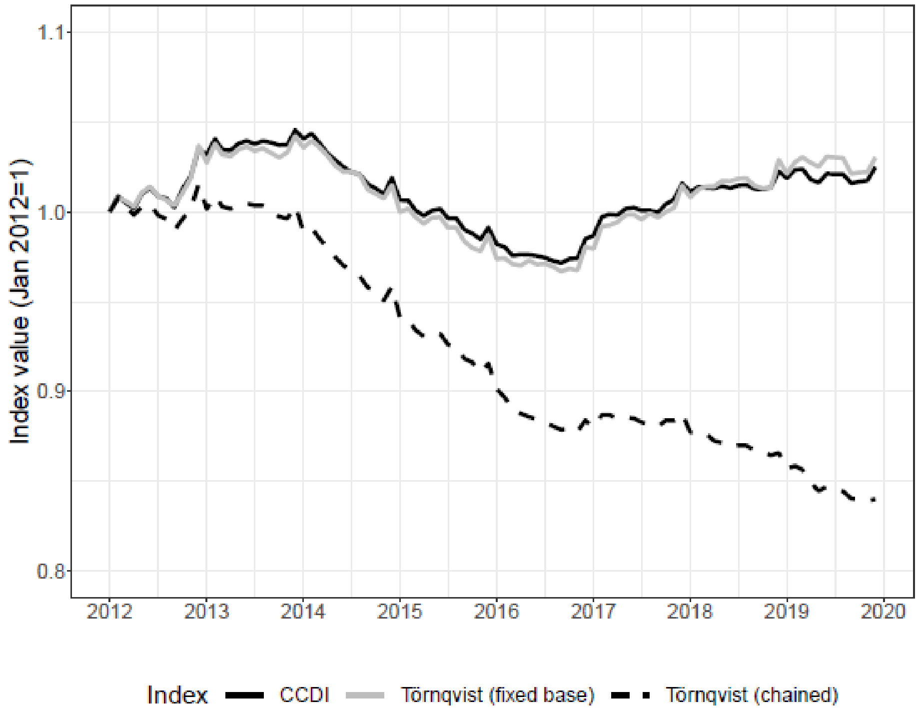
- Growing interest by NSIs in using transactions level (“scanner”) data for price measurement
  - EPOS data from retailers have much larger **sample sizes** all production of index numbers at **greater frequency** than traditional price surveys

- Production of higher frequency indices (e.g. month to month price changes) creates new challenges
  - Traditional (“bilateral”) index number methods can exhibit worryingly large “chain drift”

- Engaged by ONS through ESCoE to review ONS plans for using ***multilateral index number methods*** in the CPI
  - Report: ESCoE Discussion Paper No. 2022-08 April 2022

Why multilateral index numbers

- Chaining indexes is desirable because we want accurate measures of inflation between consecutive periods and we have product churn – don't want the basket to get out of date
- But chaining month-to-month with transaction level data can lead to massive chain drift



Why multilateral index numbers

- Multilateral indexes introduced to this context for the purpose of controlling chain drift

- The CCDI index in the previous figure is a multilateral method calculated over the full sample
  - By definition does not suffer from chain drift bias – uses all periods of data

- With non-revisable CPIs, need a method for ***extending*** the series when new data is released
  - Simply expanding the window for multilateral indexes can result in a re-writing of history.
  - Extend series by splicing “windows” together so that old price comparisons are unaffected

- Extending the series reintroduces chain drift to some degree
  - Empirical question how much

This paper

- Empirically assess different **multilateral index number methods, window lengths and extension methods** using a wide variety of goods (N=178) over a long period of time (2012-2019)
  - Draw on household scanner data from the UK
  - Use IndexNumR package in R written by Graham White

- Previous work has tended to look at smaller numbers of products over short time periods (Chessa 2021, Ivancic et al. 2011, Lamboray 2017)
  - Generalisable?

- Examine sources of chain drift bias
  - We believe novel to the literature

Findings

- Confirm that bilateral indices suffer serious chain drift and that fixed base indices tend to become unrepresentative
- GEKS-Fisher and GEKS-Walsh indices largely similar to CCDI (GEKS-Tornqvist) with occasional outliers. Differences with the Geary Khamis (GK) index more substantial.
- Different extension methods associated with similar chain drift biases. GK more sensitive to choice of extension method.
- 25-month window needed when extending indices to substantially reduce chain drift
- Recommendation: CCDI index extended using mean splice and at least a 25 month window
  - CCDI-favoured relative to other GEKS indices because it is possible to impute missing prices

Findings

- Product churn is strongly correlated with rates of chain drift bias

- High frequency (monthly) churn a problem when window lengths are short, low frequency (annual) churn still an issue for longer window lengths

Multilateral indices

- Various options – GEKS

$$\mathbb{P}^{\tau}_{GEKS-F} = \prod_t \left[P_F^{\tau,t}\right]^{1/T} \quad \text{where } P_F^{\tau,t} \text{ is a Fisher index}$$

$$\mathbb{P}^{\tau}_{CCDI} = \prod_t \left[P_{Tq}^{\tau,t}\right]^{1/T} \quad \text{where } P_{Tq}^{\tau,t} \text{ is a Törnqvist index}$$

$$\mathbb{P}^{\tau}_{GEKS-W} = \prod_t \left[P_W^{\tau,t}\right]^{1/T} \quad \text{where } P_W^{\tau,t} \text{ is a Walsh index}$$

- Or Geary-Khamis

$$b_n = \sum_t \left(\frac{q_n^t}{q_n}\right)\left(\frac{p_n^t}{\mathbb{P}^t_{GK}}\right) \quad \text{for } n = 1, \dots, N$$

$$\mathbb{P}^t_{GK} = \frac{\mathbf{p}^{t\prime}\mathbf{q}^t}{\mathbf{b}'\mathbf{q}^t} \quad \text{for } t = 1, \dots, T.$$

The linking problem

- The indices satisfy the multiperiod identity test ($P^{1,2}P^{2,3}P^{3,1} = 1$)
- But.. when new months are included in the index, past prices will need to be revised
- One set of solutions is *rolling window* to link indices calculated in different windows (1,…,T) and (2,..,T)
  - “roll forward” index P by one period to get $\tilde{P}$
  - Use an overlapping period *s* to extend the index

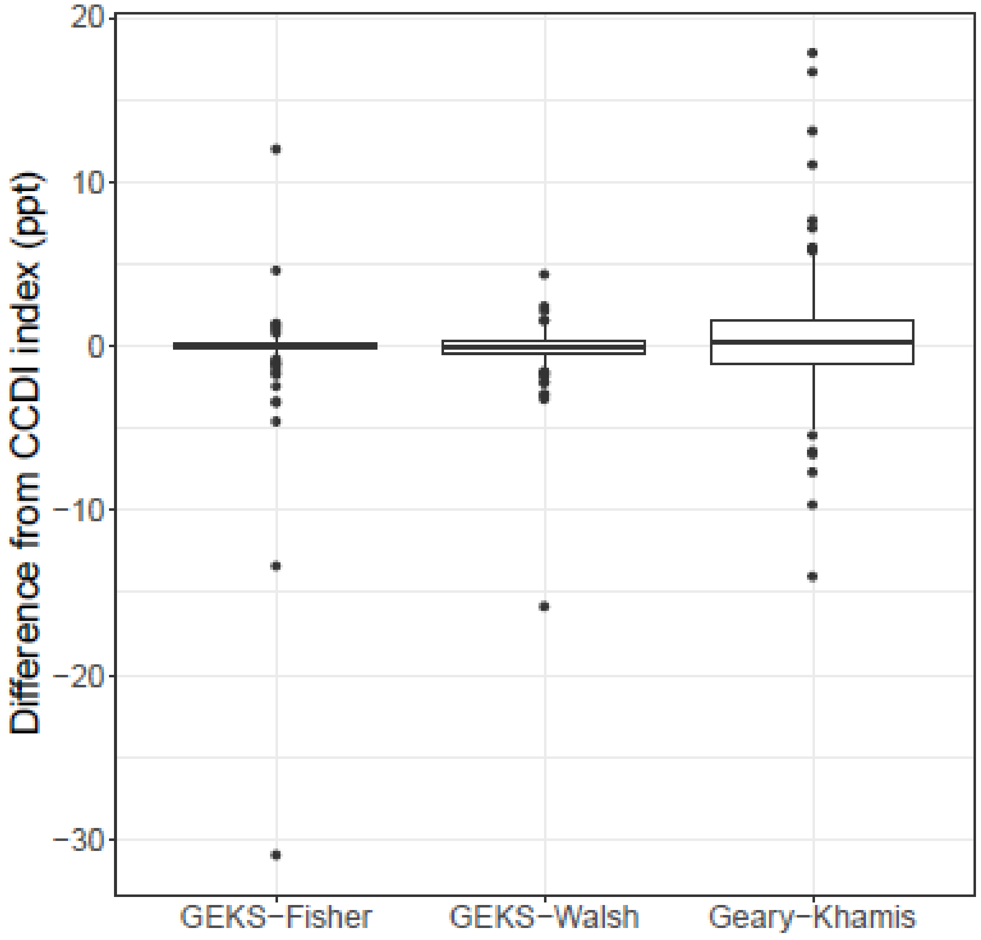
$$\rho^{T+1}(s) = \frac{\mathbb{P}_s}{\mathbb{P}_1}\frac{\widetilde{\mathbb{P}}^{T+1}}{\widetilde{\mathbb{P}}^{s}}$$

- Rolling window approaches use different splice periods, *s* (window, half, movement etc.)
  - Mean splice takes geometric average using all possible splicing periods
- Other extension methods are possible (and we include)

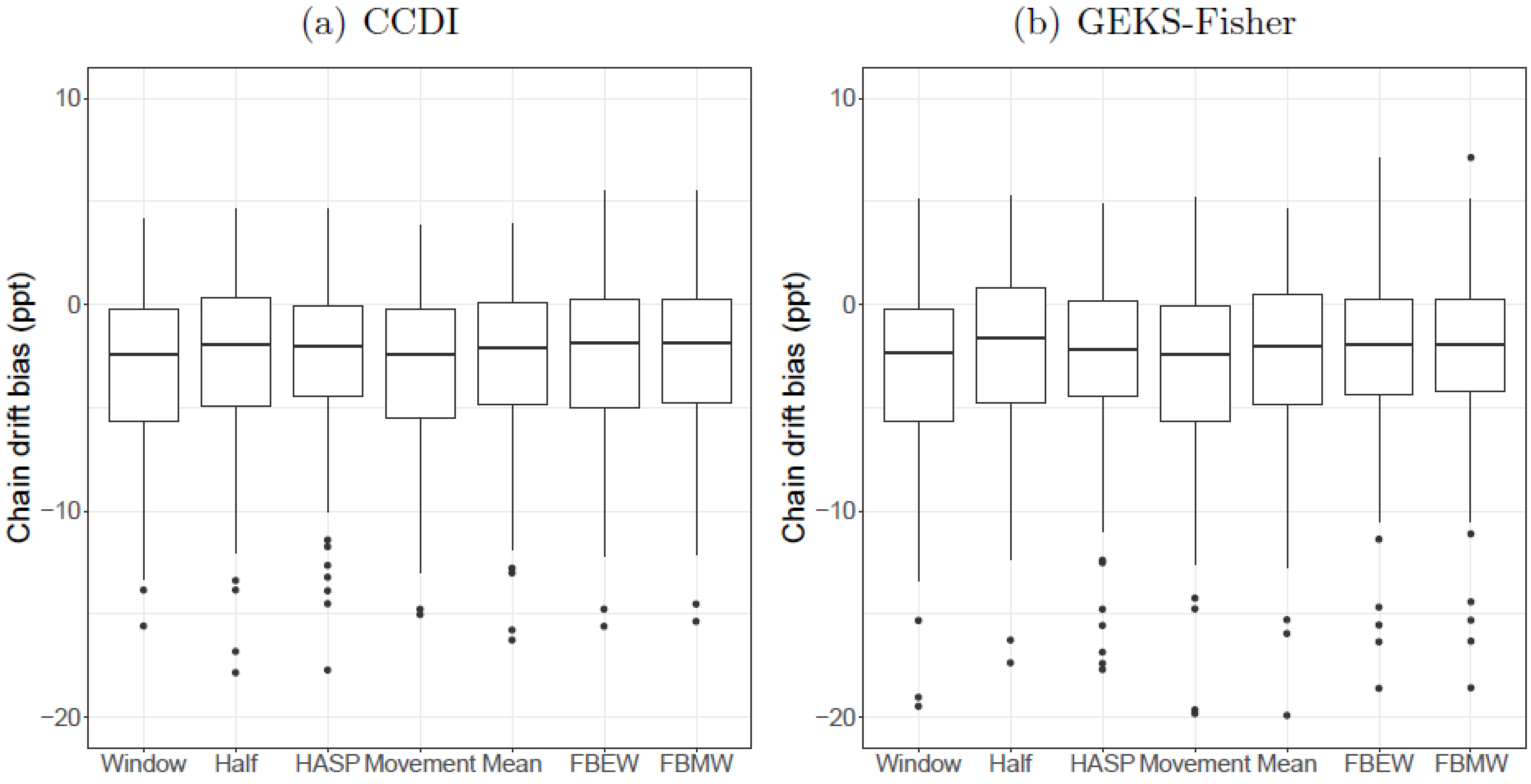
Chain drift

- Splicing allows the index to be updated without altering the series that has been published
- But reintroduces chain drift
- We assess chain drift bias across different indices, window lengths and extension methods
- Bias defined in Fisher sense (difference between index calculated over the whole period and spliced index)

Comparison of different indices (using all periods)

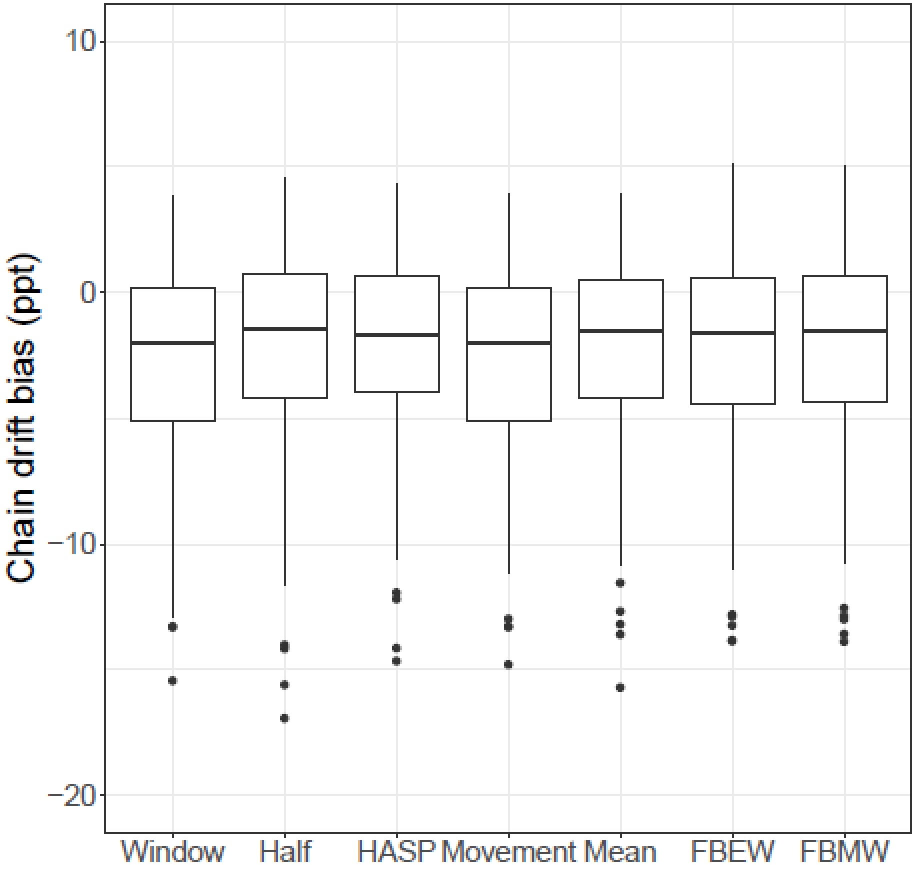


Chain drift bias with different splicing methods (13 month window)

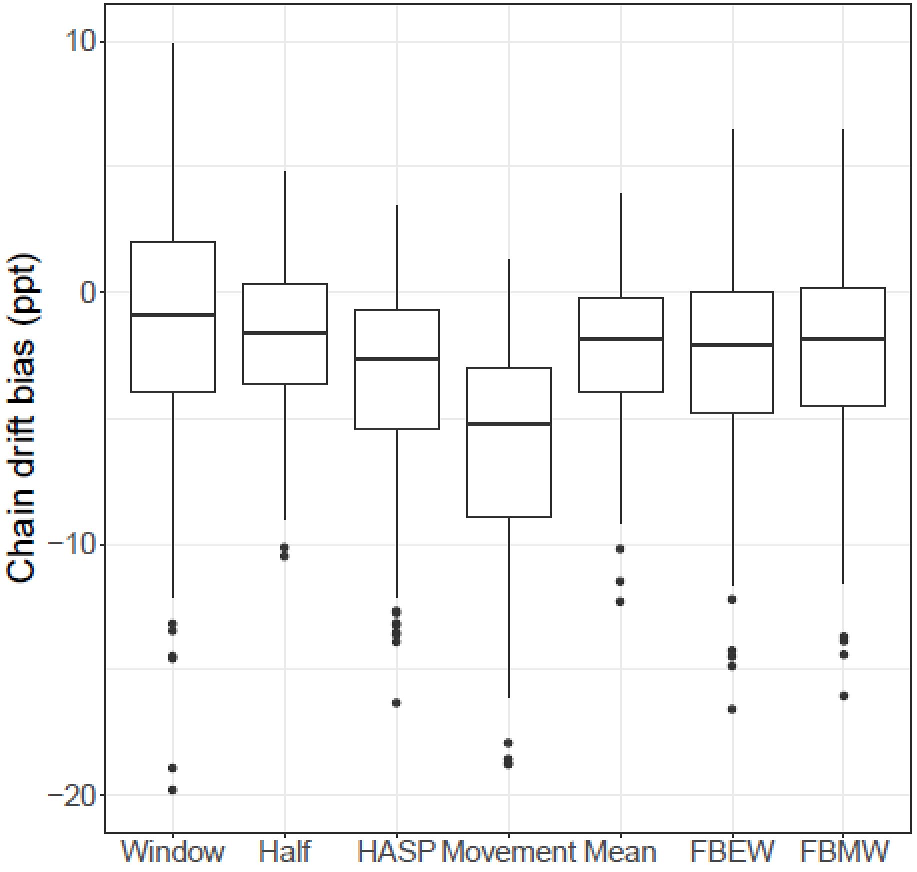


Chain drift bias with different splicing methods (13 month window)

(c) GEKS-Walsh

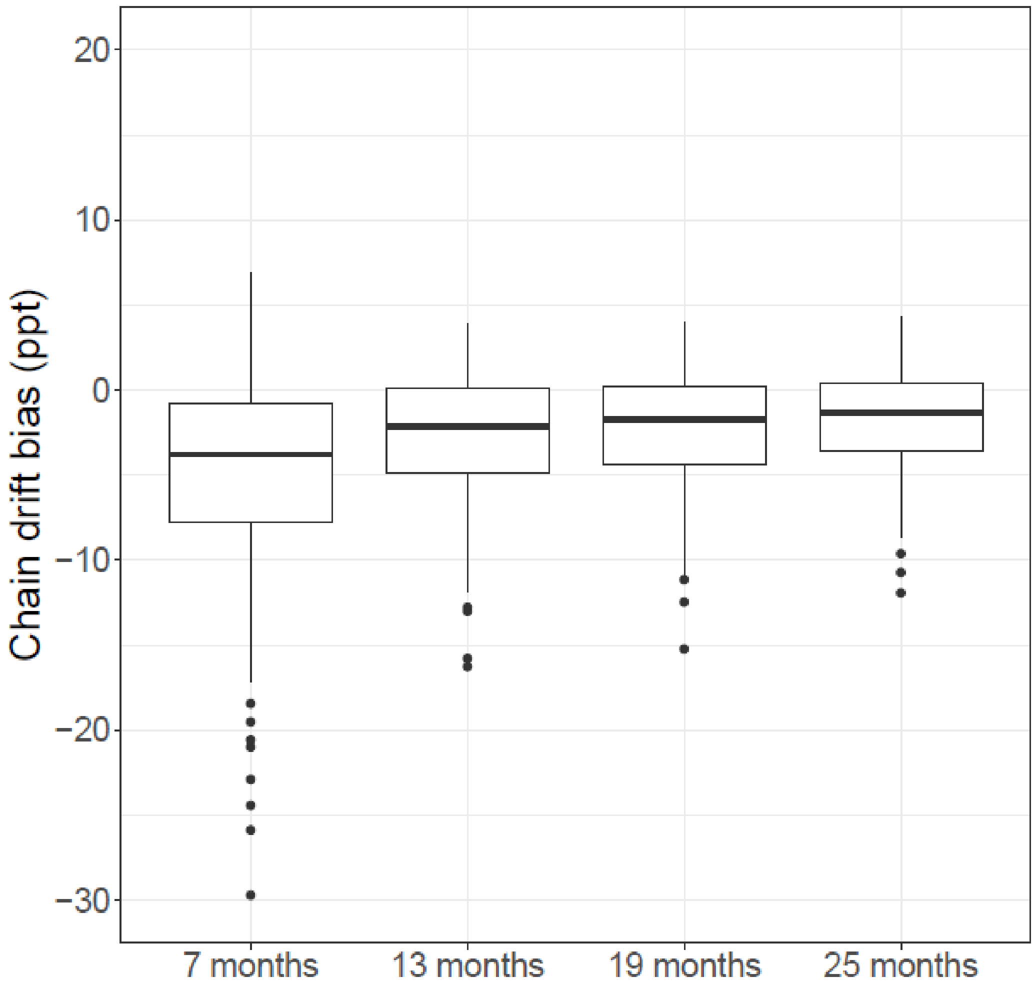


(d) GK



Chain drift bias using different window lengths (mean splice)

(a) CCDI



Possible determinants of chain drift bias

- **Regress absolute chain drift bias on …**

- **Monthly churn:** share of spending on products in the current month that were not observed purchased in the previous month
- **Annual churn:** share of spending on products in the current year that were not observed purchased in the previous year (e.g. run-out sales Melser and Webster (2021))
- **Seasonality in pricing (‘weak seasonality’):** estimated from fixed effects regressions of log prices on monthly dummies
- **Proportion of products on price promotion each year**
- **Proportion of products on quantity promotion each year**

Determinants of chain drift bias (7 month window length)

	CCDI	GEKS-Fisher	GEKS-Walsh	GK
	(1)	(2)	(3)	(4)
Pricing seasonality	−0.022	0.006	0.017	0.015
	(0.110)	(0.117)	(0.095)	(0.099)
Quantity promotions	−0.105*	−0.099	−0.086*	−0.125**
	(0.059)	(0.063)	(0.051)	(0.053)
Price promotions	0.030	0.031	0.019	0.024
	(0.041)	(0.043)	(0.035)	(0.037)
Annual churn	0.479***	0.479***	0.425***	0.389***
	(0.107)	(0.113)	(0.092)	(0.095)
Monthly churn	0.497**	0.478*	0.458**	0.640***
	(0.243)	(0.257)	(0.211)	(0.217)
Observations	175	175	175	175
R^2	0.202	0.181	0.213	0.220

Note: All indexes are extended using the mean splice. *$p<0.1$; **$p<0.05$; ***$p<0.01$

Determinants of chain drift bias (25 month window length)

	CCDI	GEKS-Fisher	GEKS-Walsh	GK
	(1)	(2)	(3)	(4)
Pricing seasonality	0.001	0.023	0.001	−0.028
	(0.048)	(0.053)	(0.045)	(0.033)
Quantity promotions	−0.009	−0.021	−0.006	−0.023
	(0.027)	(0.030)	(0.026)	(0.018)
Price promotions	−0.024	−0.037*	−0.031*	−0.001
	(0.019)	(0.021)	(0.018)	(0.012)
Annual churn	0.149***	0.154***	0.129***	0.061*
	(0.046)	(0.052)	(0.044)	(0.033)
Monthly churn	0.075	0.078	0.022	0.140*
	(0.108)	(0.122)	(0.103)	(0.074)
Observations	175	175	175	175
R^2	0.110	0.100	0.085	0.073

Note: All indexes are extended using the mean splice. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Conclusions and directions for future research

- Recommend the use of the CCDI index with mean splice and 25 month window
  - GEKS Fisher appears to have occasional outliers
  - Can use imputation for missing prices
- When does product missingness become a problem?
- Does the timing of product entry and exit affect the optimal splicing period/method?
- More empirical examination of “similarity” linking methods

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