Storable Goods, Chain Drifts, and the Cost of Living Index: New Methodology and Application to Japanese Data

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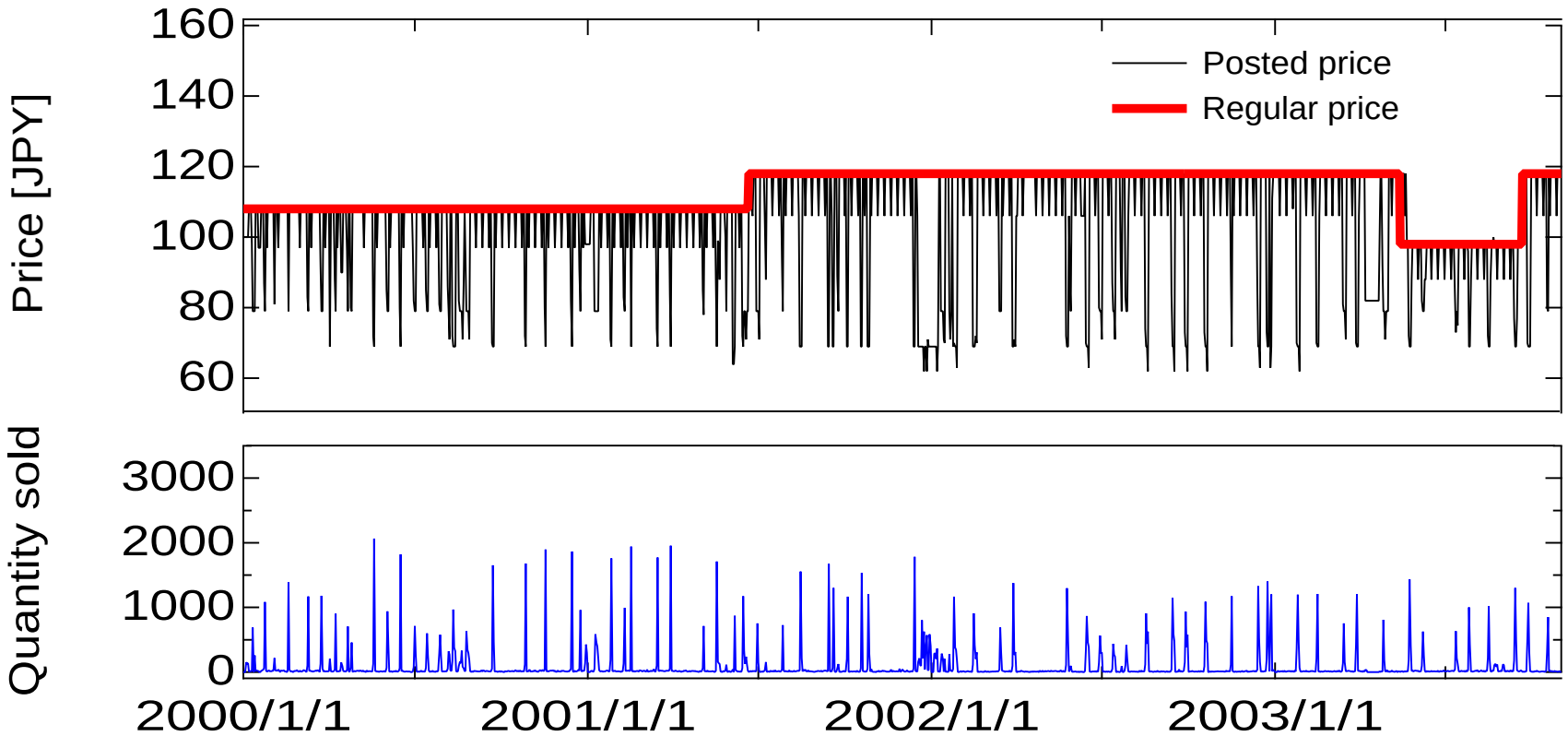
Very very preliminary

Illustrative Figure of Scanner Data

- Daily, from 1988 to 2013
- Quantity and sales **sold** for product i at retailer r on date t
- Processed food and domestic articles (17 percent of household's expenditure)

A cup noodle i sold at retailer r



Goods are not perishable but storable

The key: a discrepancy between purchase and consumption

- Previous studies on price indices typically assume that goods are perishable.
- An important implication of storability is that the purchase of goods does not coincide with the consumption of goods.
  - Scanner data includes information about purchase, not necessarily consumption.
  - Temporary sales often increase purchase more than consumption.
  - The discrepancy between purchase and cosumption is reflected in changes in household inventory.
- In the context of price index construction, goods storability yields chain drifts.
  - It may be inappropriate to use **purchase based weights**. We should use **consumption based weights**.
  - It may be inappropriate to use **purchase price**. We should use **consumption price**.

What the paper does

- Report empirical evidences associated with storable goods.
  - Huge bias in the **purchase-based** chained price index, consistent with theory
  - Evidence of household inventory, consistent with theory
- Construct a quasi dynamic model for storable goods
  - incorporate stockpiling behavior by households
  - explain the facts
- Propose a procedure to estimate consumption/inventory from the scanner data(purchase data)
  - Bias is mitigated by **consumption-based** index, but not perfectly.

Price index

- It is known that the Törnqvist price index is a good approximation of the Cost of Living Index (COLI),
  - Changes in the Törnqvist price index between $t - dt$ and t is defined as

$$\pi_{t,dt}^{C,T} = \sum_{k \in K_{t-dt} \cap K_t} \frac{W_{t-dt}^k(K_{t-dt} \cap K_t) + W_t^k(K_{t-dt} \cap K_t)}{2} \log\left(\frac{p_t^k}{p_{t-dt}^k}\right), \tag{1}$$

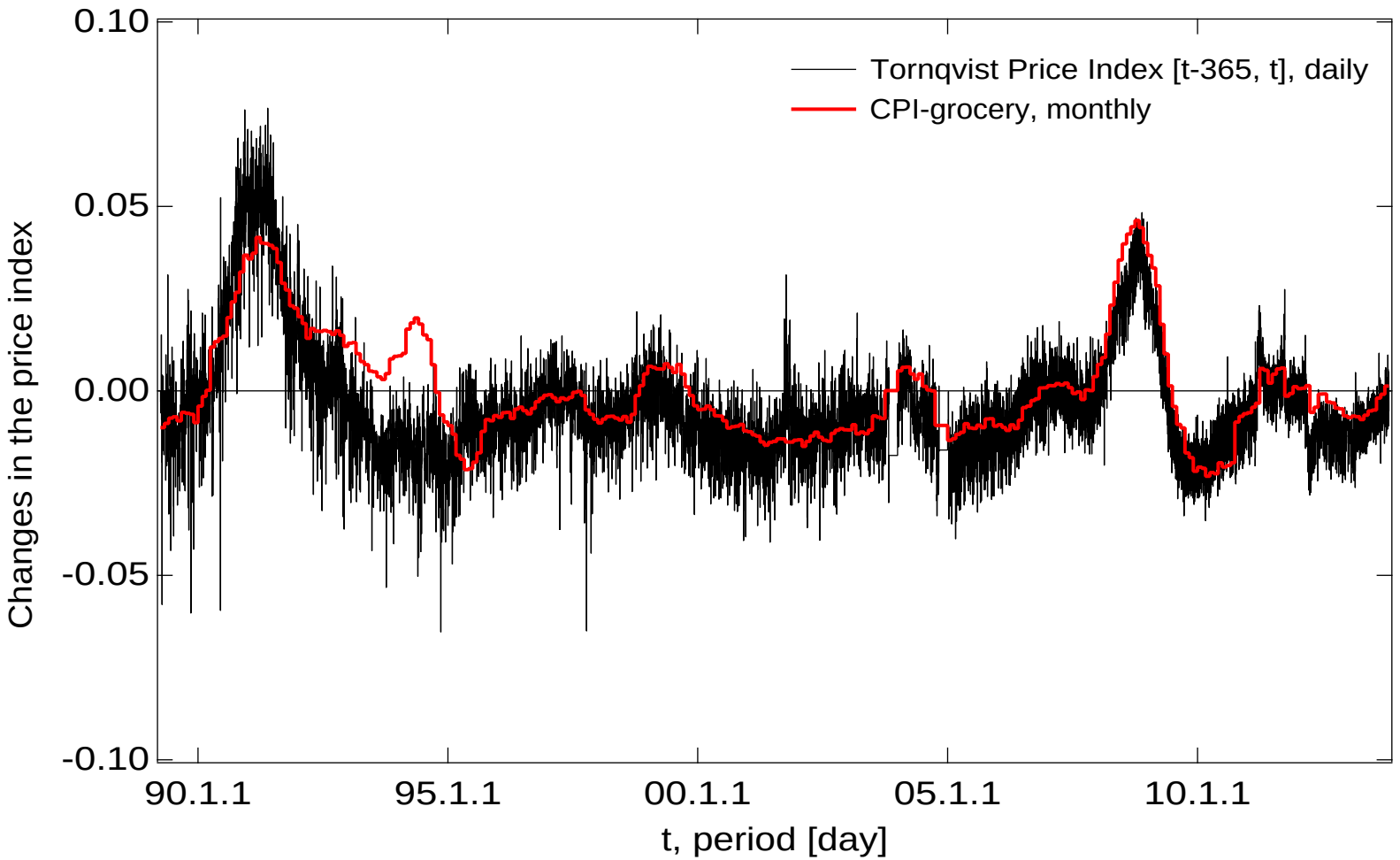
    where the weight share $W_t^k(K_{t-dt} \cap K_t) \equiv p_t^k x_t^k / \sum_{k' \in K_{t-dt} \cap K_t} p_t^{k'} x_t^{k'}$.
- Also changes in the price indices based on Logarithmic Laspeyres and Logarithmic Paasche are defined as

$$\pi_{t,dt}^{C,L} = \sum_{k \in K_{t-dt} \cap K_t} W_{t-dt}^k(K_{t-dt} \cap K_t) \log\left(\frac{p_t^k}{p_{t-dt}^k}\right), \tag{2}$$

$$\pi_{t,dt}^{C,P} = \sum_{k \in K_{t-dt} \cap K_t} W_t^k(K_{t-dt} \cap K_t) \log\left(\frac{p_t^k}{p_{t-dt}^k}\right). \tag{3}$$

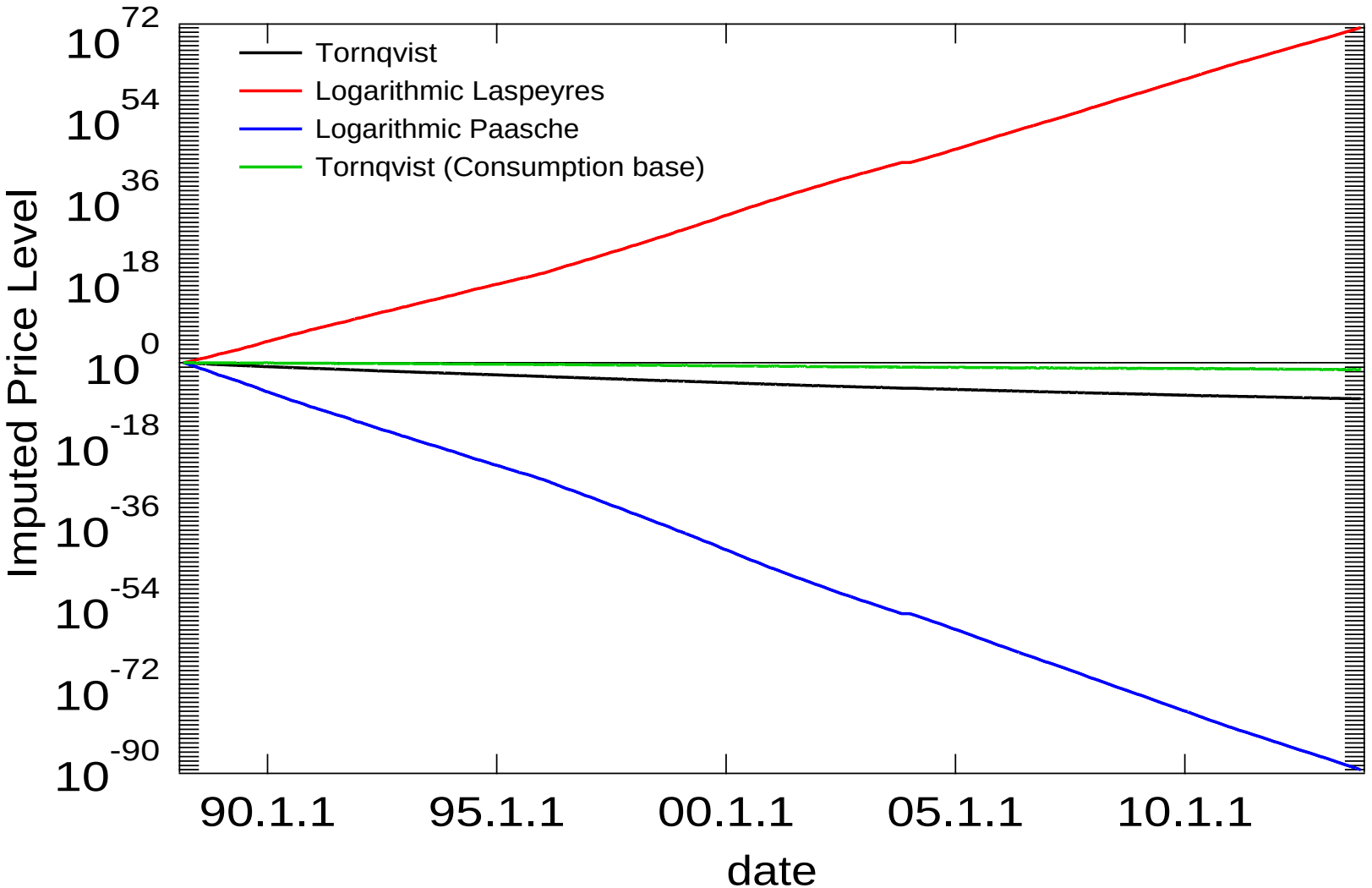
Unchained index

- Timeseries of $\pi^{C,T}_{t,dt}$, $dt = 365$days, $t \in [\text{Apr.}1, 1989, \text{Oct.}31, 2013]$



Chained index at the daily frequency

- $P_t^X = \exp\left(\sum_{s=1}^{t} \pi_{s,dt}^{C,X}\right)$, dt = 1day, X={T, L, P}.



*The missing prices are imterpolated by the estimated regular price.

Nature of drift: Simple guesstimation

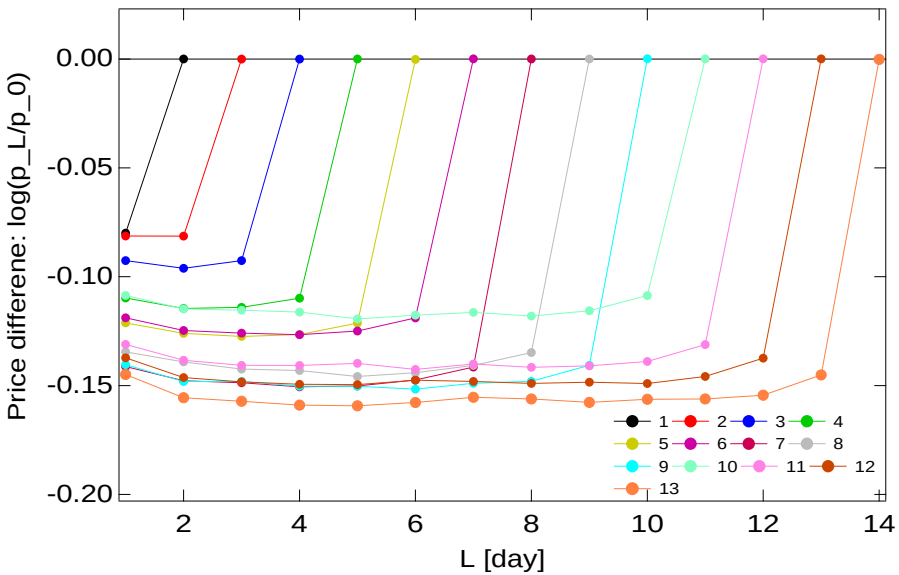
- Suggestive thought experiment by Haan and van der Grient(2011)
  - Estimate the price inflation from the following table. $0 < r < 1$

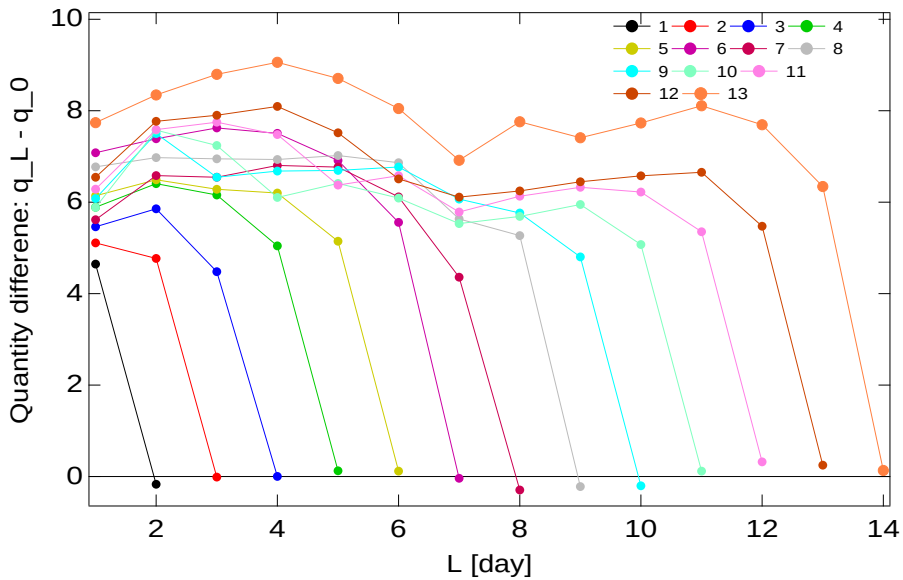
		$t=0$	$t=1$	$t=2$
Item A	Price	p_A	$(1\text{-}r)p_A$	p_A
	Share	w_0	w_1	w_2
Item B	Price	p_B	p_B	p_B
	Share	$1\text{-}w_0$	$1\text{-}w_1$	$1\text{-}w_2$

  - if $w_2 < w_0 < w_1 \rightarrow$ Paasche $<$ Törnqvist $<$ 0% $<$ Laspeyres.
  - The household have enough inventory on the day after the sale ends, then they do not buy much on that day.

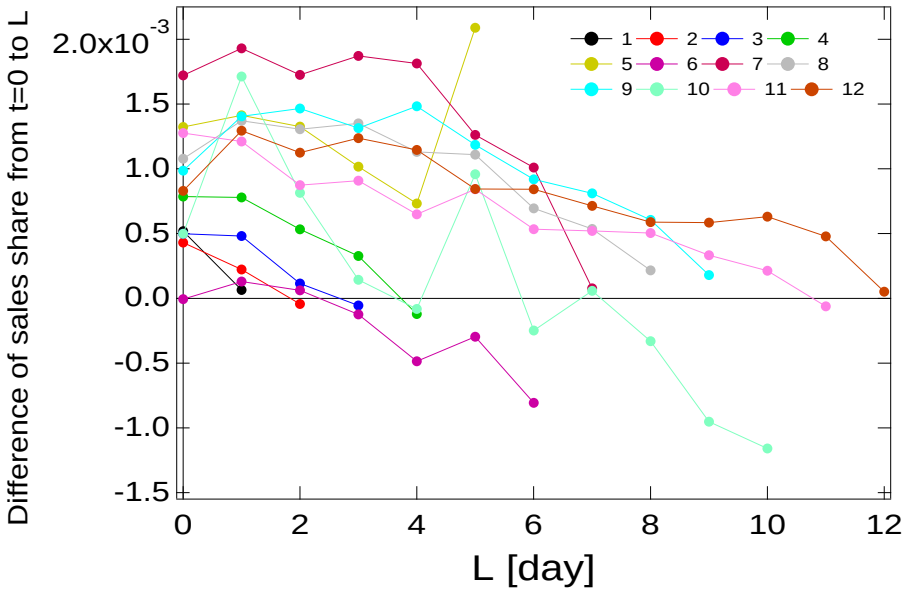
Movement of prices (left) and quantities (right) over a sales period

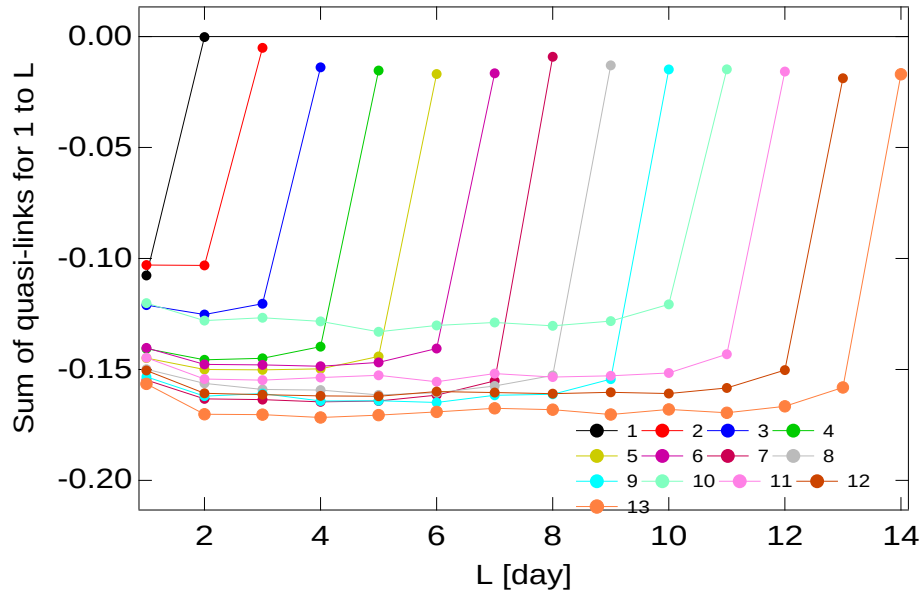
Comparison with the price/quantity just before sales($L = 0$).
(more analysis needed to test statistical significance)





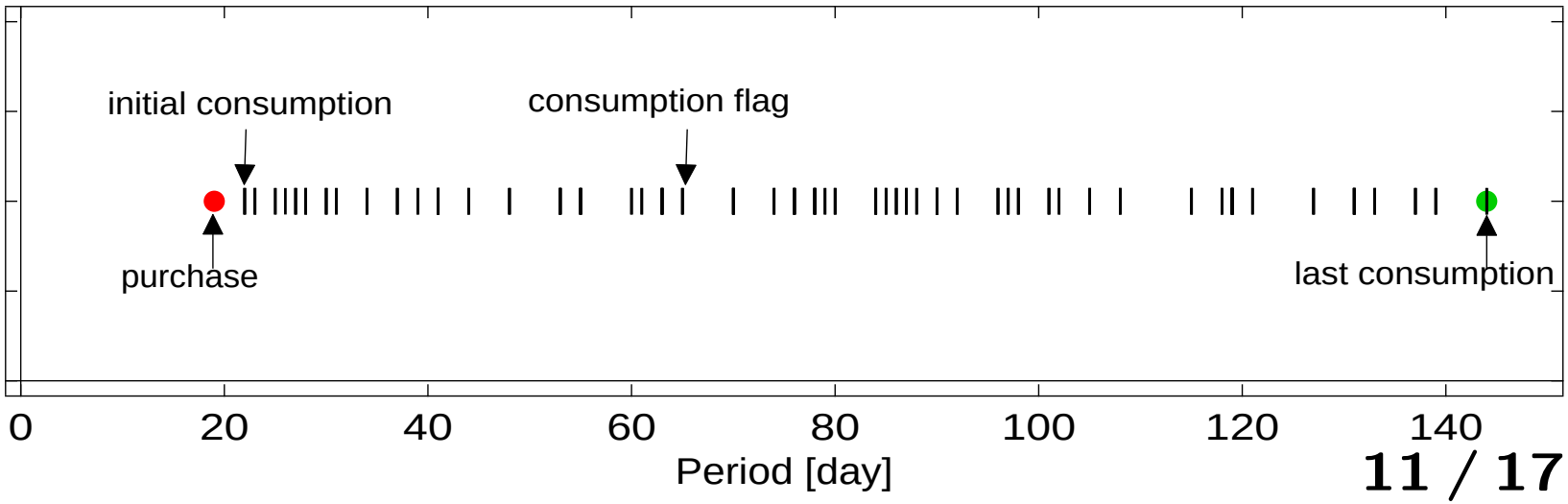
This causes the chain drift
left)Changes in sales share, right)Chained weighted changes.



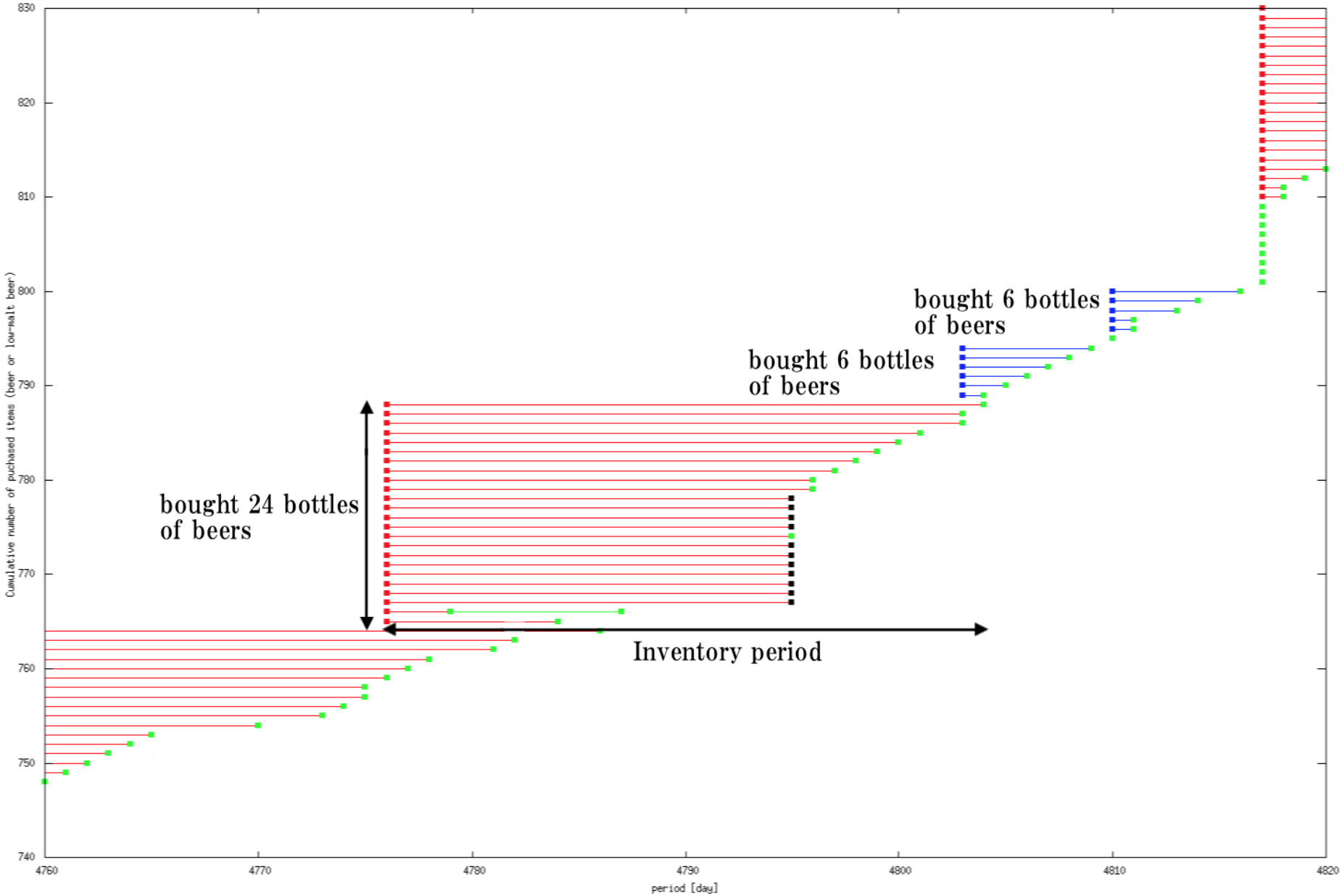


Illustrative fiure of household-side data

- About 4,000 households in total (about 400 hhs in each period).
- Daily, from 1998 to present
- Food only
- Records
  - who, what, when and where purchased, **when and who consumed, when and why consumption ends**(used up, wasted, etc.).
  - no price information
- Consumption pattern of a salt product for a household(purchased on $t = 19$, started using on $t = 22$ and finished using on $t = 144$.



Consumption pattern of items in beer category for a particular household (the last use in green).



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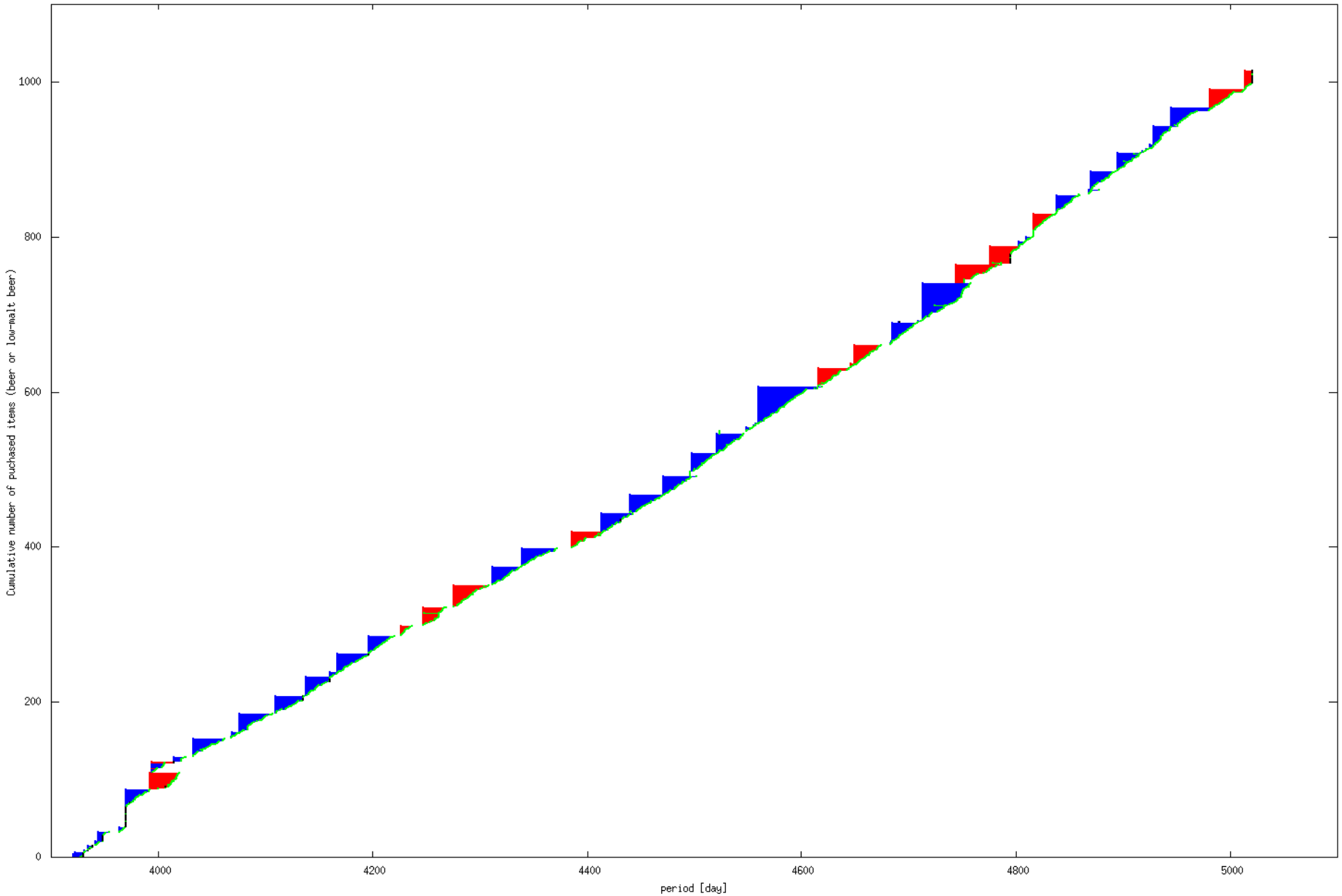
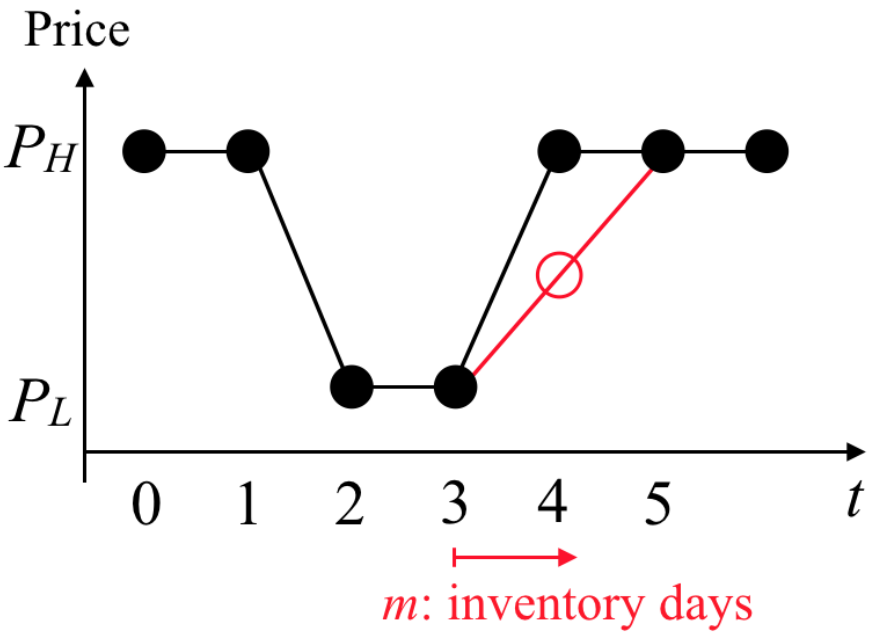
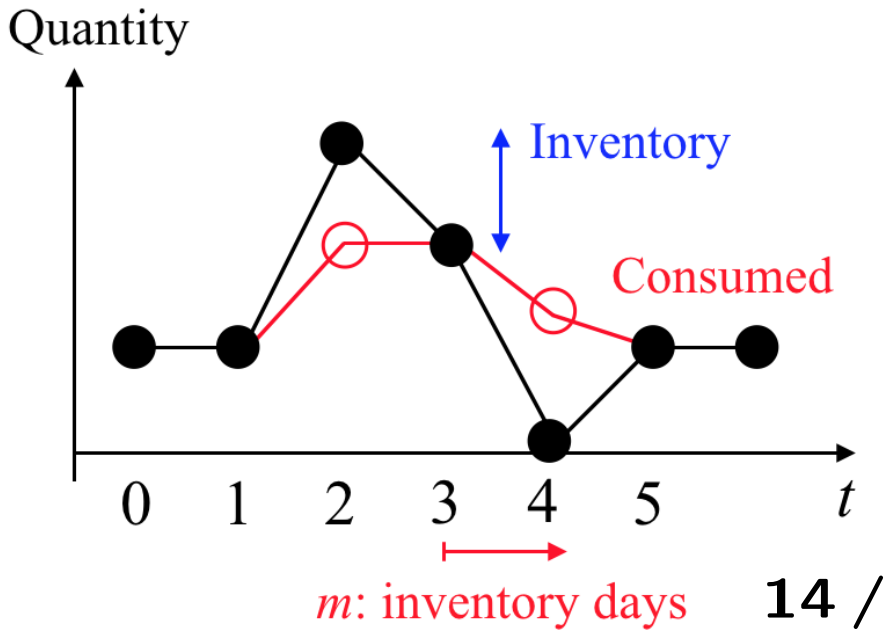


Very brief overview of the model

- Closely follow Hendel and Nevo (2006), in which goods are storable and prices change stochastically between the high level (i.e. regular price) and the low level (i.e. sale price)
  - Introduce warehouse firms in order to separate capability of inventory from the household
  - A household can purchase good from a producer or warehouse
  - Quantities consumed deviate from quantities purchased because goods are stockpiled during a sale period
  - Consumption price deviates from purchase price because the warehouse firms sell at prices between P_L and P_H during an effective sale duration

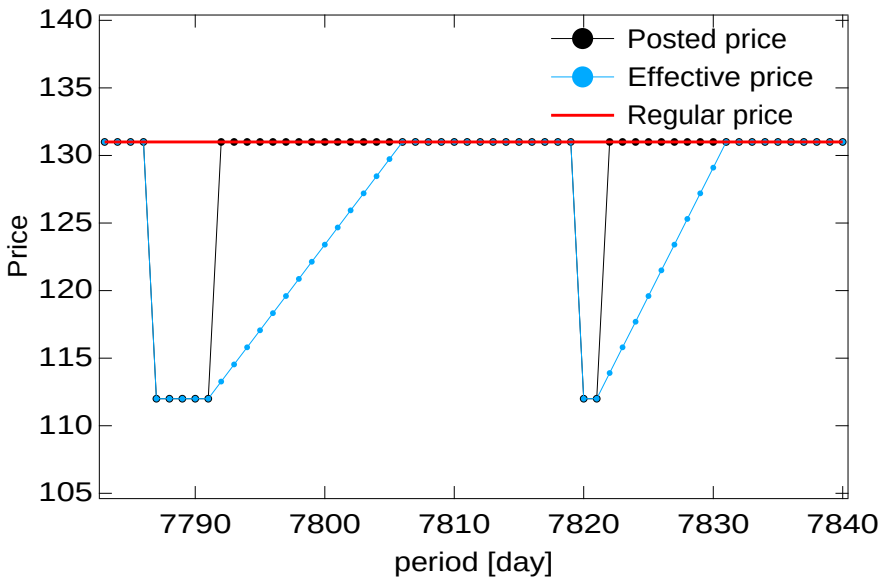


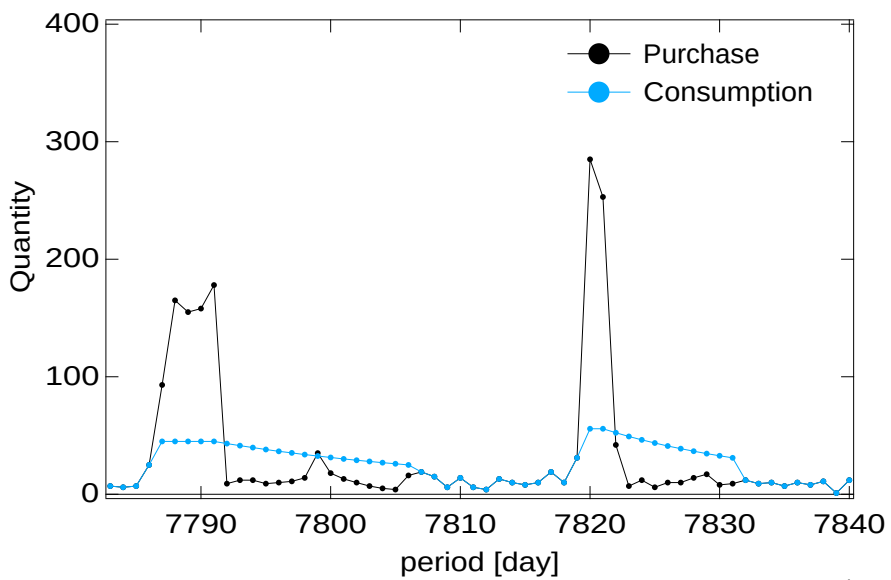


Algorithm to estimate consumption

1. Estimate the price elasticity σ for each product category.
2. Calculate m for each sale event of each product as:
$$m = \frac{P_H - P_L}{P_L} \frac{\sigma - 1}{1 - (P_H/P_L)^{-\sigma+1}} \frac{I_L}{X_L},$$
where $X_L = (P_L/P_H)^{-\sigma} X_H$ and $I_L = \sum_{j=1}^{T} X_j - T X_L$ are the quantity consumed in each day of the sale and the level of inventory on the sale ends.
3. Calculate the consumption price: $r_{H,j} = (j/m)(P_H - P_L) + P_L$, and the quantity consumed: $c_j = (r_{H,j}/P_L)^{-\sigma} X_L$ for $j \in [1, m]$

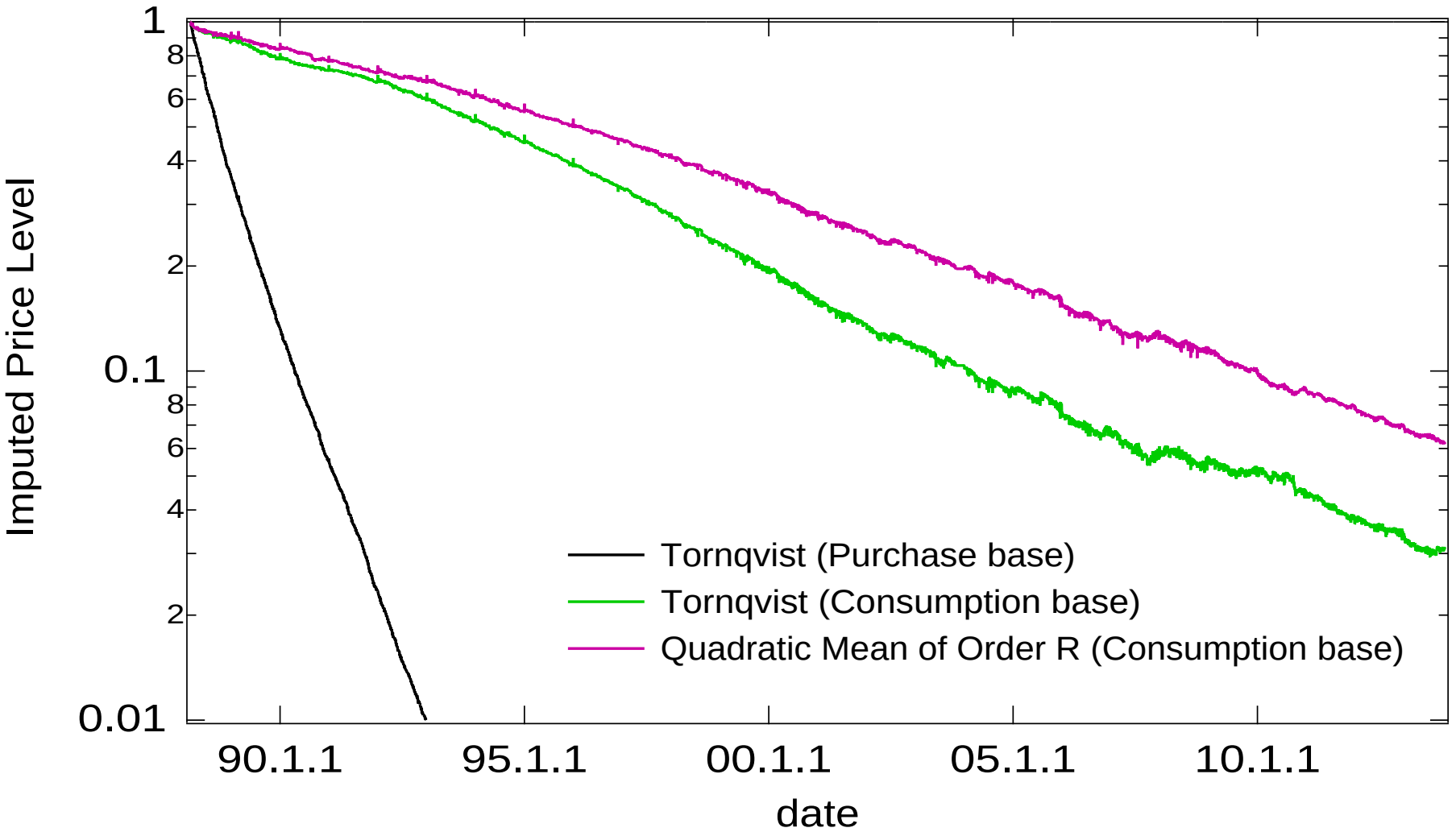
A cup noodle at a retailer





Consumption-based chained price indices

Milder chain drift, but not completely disappeared (roughly −10% annually).



Concluding remarks

- Summarize stylized facts associated with storable goods
- Construct an economic model for storable goods
- Estimate consumption from purchase data and construct the consumption-based price index.
  - Bias(Serious drift) is mitigated but not perfectly.
  - As for an asymmetric price up-and-down due to the non-negative constraint of inventory and purchase, the price index like Törnqvist is still biased even in the consumption-base.
- Things to be done in the near future
  - More careful analysis on whether implications of the model are consistent with the actual data.
  - More careful comparison of our consumption based price index with other indices including GEKS proposed by Ivanvic et al.(2011).
  - More careful treatment with things such as quality adjustment and price imputation.