Storable Goods, Chain Drifts, and the Cost of Living Index

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What we do in this paper

Chain drift is one of the most serious issues in constructing price indexes based on scanner data. Previous studies, argue that the emergence of chain drifts is associated with household stockpiling when goods are on sale (Ivancic et al 2011; de Haan 2011; Feenstra and Shapiro 2003; Betancourt and Gautschi 1992). Household inventory behavior is key to understand the mechanism through which chain drifts occur. To the best of our knowledge, however, there is no research on the link between household inventory behavior and chain drifts. In this paper, we conduct empirical and theoretical analysis to fill this gap.

The purpose of this paper:

❶ We present new empirical evidence to test the hypothesis that chain drifts are mainly driven by household inventory behavior, especially by households' inventory buildup when products are on sale.

❷ We present new empirical results on the effectiveness of the remedies to chain drifts proposed by the previous studies. Specifically, we check the effectiveness of the "smoothing of quantity sold" approach proposed by Feenstra and Shapiro (2003) and the "quantity purchased per person" approach proposed by Watanabe and Watanabe (2014).

❸ We construct a model in which goods are storable and sometimes on sale, and households make decisions on inventory so as to maximize their intertemporal utility. We use this model to show that chain drift occurs in the model, and to propose a new methodology to construct a cost of living index consistent with the theory.

Our tentative conclusions:

❶ Our analysis based on scanner data (store scanner data, home scanner data, and receipt level data) shows that some statistics, such as the probability of purchase conditional on the elapsed time since the last purchase, are consistent with theoretical predictions from models on household inventory behavior in an economy with temporary sale, such as Hendel and Nevo (2006) and Boizot et al (2001), suggesting that volatility in household purchase mostly stems from household stockpiling when goods are on sale.

❷ The "smoothing of quantity sold" approach reduces chain drift substantially as far as the data frequency is more than 100 days. The "quantity purchased per person" approach also performs well.

❸ We show using a model with storable goods and stochastic temporary sale that chained Tornqvist has a downward drift since (1) households purchase less on the day immediately after a sale period than on the day immediately before the sale period and (2) they purchase less on the last day of a sale period than on the first. [This part is not included in this poster due to space limitation. Please ask the authors for more details.]

High frequency chaining

Fig 1 shows the result of high frequency chaining. It compares the Tornqvist index obtained by daily chaining (dt=1 day) and the same index obtained by annual chaining (dt=365 days). It shows that when dt = 1, the chained index has a substantial downward trend, which is equal to 60 percent per year. Fig 2 checks how the magnitude of chain drifts differs depending on the data frequency, with the data frequency (dt) on the horizontal axis and the magnitude of chain drifts on the vertical axis. It shows that the rate of deflation falls rapidly until dt=100 days, but once dt becomes greater than 100 days, the inflation rate converges to around -0.3 percent, suggesting that chain drift is a serious problem at frequencies of less than a quarter year, but for longer frequencies it is small enough to be ignored from a practical perspective.

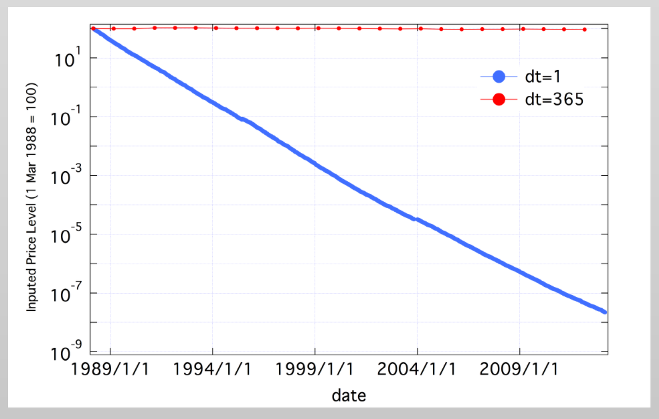

Fig 1

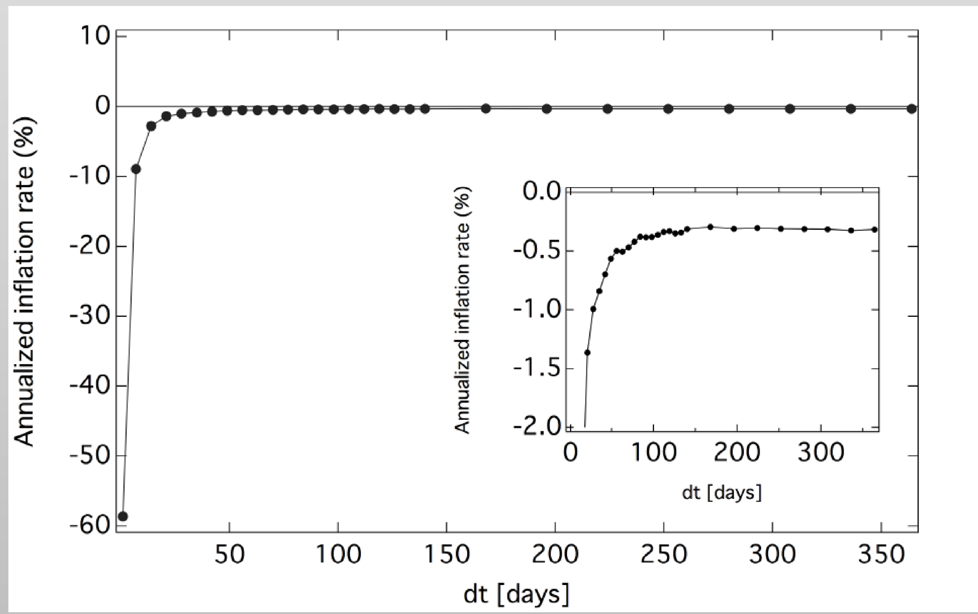

Fig 2

What account for the difference in the magnitude of chain drift across product categories?

Dependent variable: the magnitude of chain drift for each product category (# of product categories is 214)	
Independent variables	
Frequency of price adjustments for each product category	-0.24* (0.12)
Average size of price adjustments for each product category	-1.38*** (0.25)
Frequency of missing values for each product category	-0.12 (0.08)
Price elasticity of demand for each product category	-0.00 (0.01)
Trend growth in quantity sold for each product category	13.52*** (1.88)

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Chain drift driven by temporary sale

We conduct two experiments to check whether chain drift is driven by fluctuations in the Tornqvist weight associated with temporary sales. The first experiment we conduct is to identify sale periods using the Eichenbaum et al (2011) sale filter and then to replace the quantity sold in each day during a particular sale period by the average of quantities sold over the sale period. The result presented in Fig 3 indicates that the Tornqvist index constructed in this was is very close to the unweighted index, suggesting that chain drift mainly stems from fluctuations in quantity sold associated with temporary sales. The second experiment is to classify sale periods according to their lengths (1 day to 6 days), and then to examine the movement of prices over the sale period (Fig 4.1), the movement of quantity sold (Fig 4.2), and the movement of Tornqvist price index (Fig 4.3). Although the price returns to the original level immediately after the sale period, the quantity sold on the day immediately after the sale period tends to be slightly below the quantity sold on the day before the sale period, creating a downward chain drift.

Fig 3

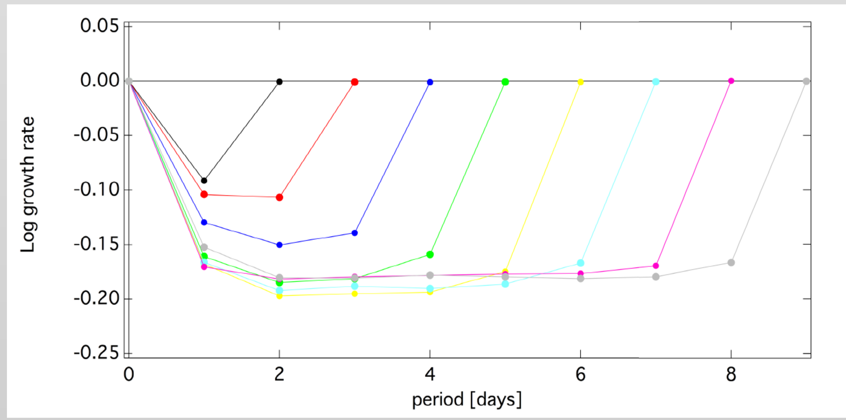

Fig 4.1

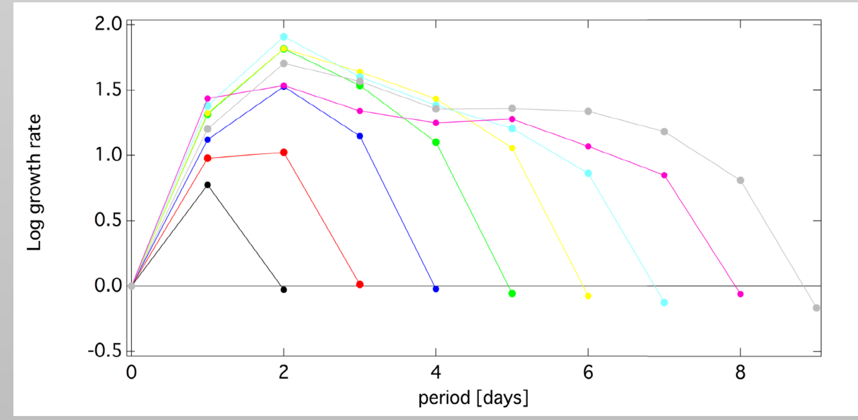

Fig 4.2

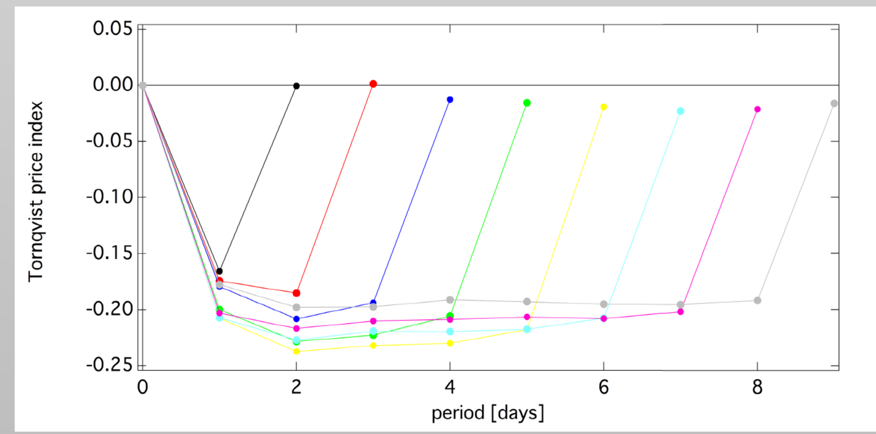

Fig 4.3

Stylized facts about households' purchase behavior

We observe the following facts about households' purchase behavior, all of which suggest that (1) inventory quantity is an important state variable which governs households' decision on when to buy, and (2) household inventory behavior is influenced considerably by temporary sales. They are consistent with theoretical predictions from models on household inventory behavior in an economy with temporary sale, such as Hendel and Nevo (2006) and Boizot et al (2001),

❶ The probability of purchase for a particular product tends to increase with the time elapsed since the last purchase of that product (Figs 5.1) and it tends to be higher when the product is sold at the sale price than when the product is sold at the regular price (Fig 5.2).

❷ The time interval between today and the next purchase tends to be longer when a product is purchased today at the sale price than it is purchased at the regular price (Fig 5.3).

❸ The time interval between today and the day when the last purchase occurred tends to be shorter when the purchased today is at the sale price than when it is at the regular price (Fig 5.4).

❹ The probability that the purchase today is at the sale price tends to be higher when the purchase last time was at the sale price than when it was at the regular price (Fig 5.5).

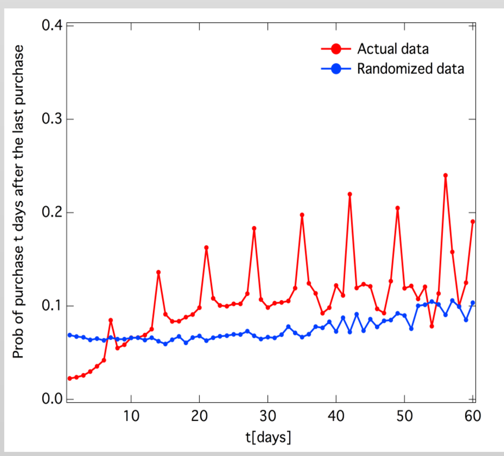

Fig 5.1

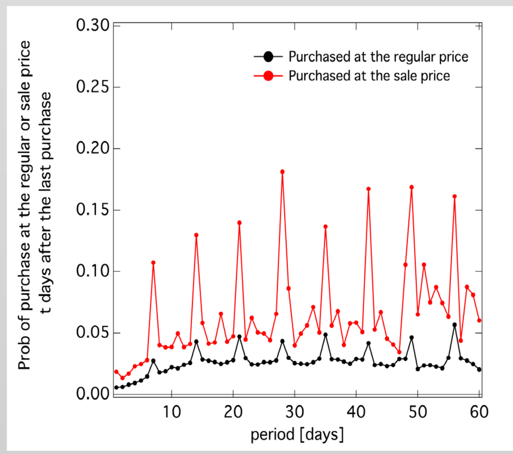

Fig 5.2

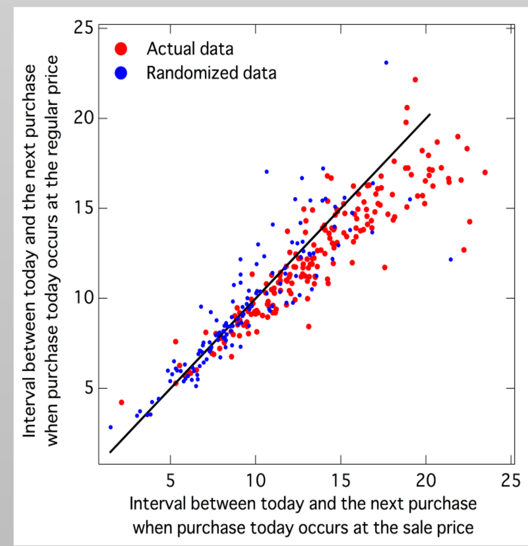

Fig 5.3

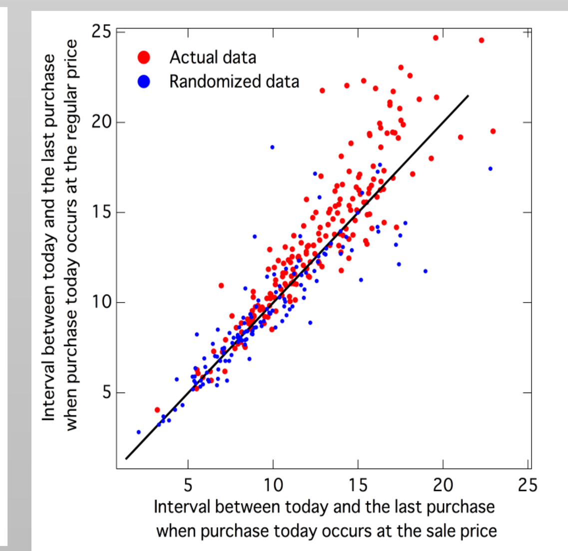

Fig 5.4

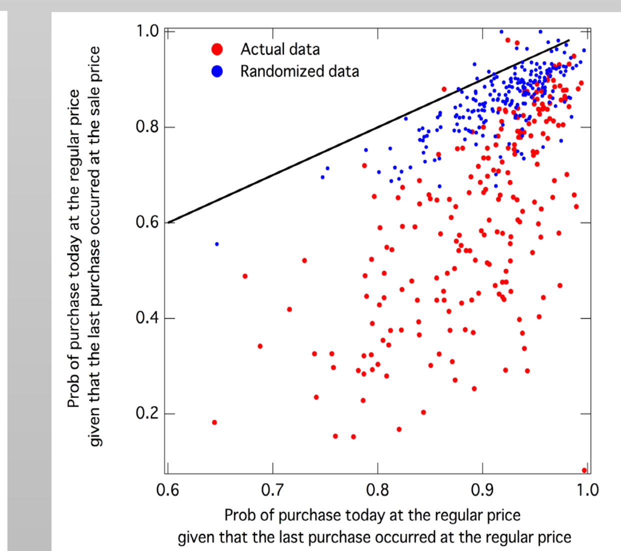

Fig 5.5

Remedies to chain drifts

Feenstra and Shapiro (2003) argues that chain drift arises because household purchase is more volatile than consumption due to household stockpiling, proposing to use the moving average of purchase as a proxy of consumption. Fig 6 shows that the Tornqvist price indexes based on the moving average of purchase almost coincides with the unweighted price index when the data frequency is 100 days or longer than that, but otherwise there remains non trivial deviation. On the other hand, Watanabe and Watanabe (2014) argues that the volatility of household purchase mainly stems from the volatility of the number of buyers (i.e., extensive margin) rather than from the volatility of the quantity purchased by a single buyer (i.e., intensive margin), proposing to calculate the Tornqvist weight based on the quantity purchased per person. Fig 7.1 shows that the quantity purchased exhibits substantial fluctuation in response to price changes, while the quantity purchased per person does not. Fig 7.2 shows that the Tornqvist index based on the quantity purchased per person is fairly close to the unweighted price index.

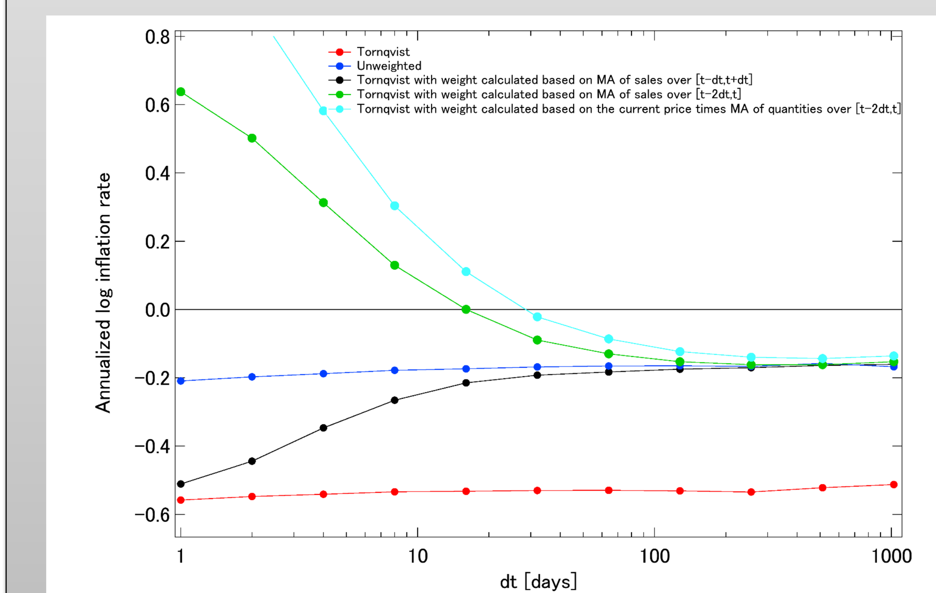

Fig 6

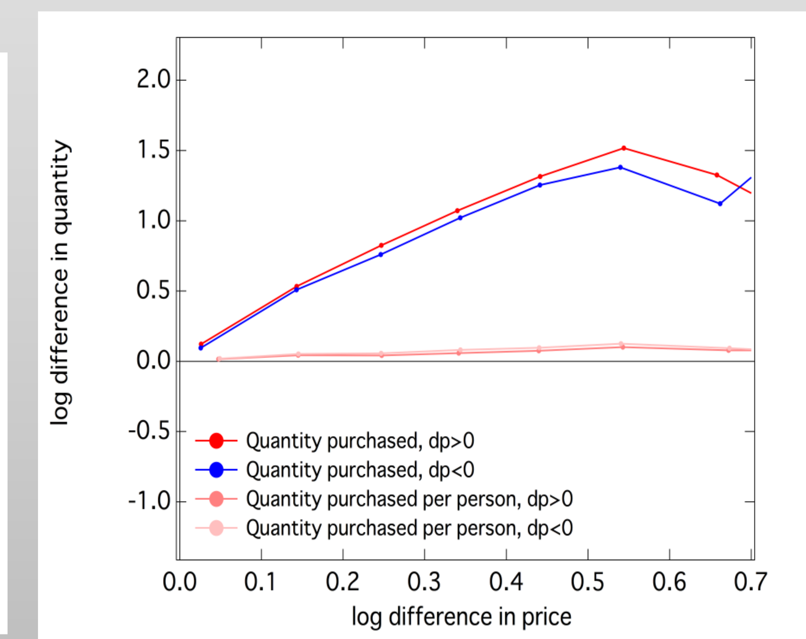

Fig 7.1

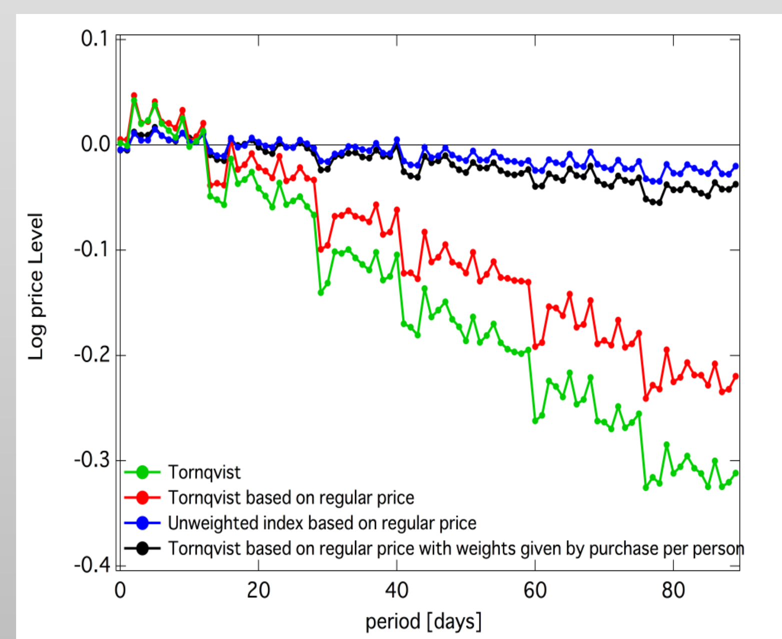

Fig 7.2