Reference Prices and Nominal Rigidities

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The Bils and Klenow challenge

- The empirical plausibility of monetary business cycle models depends critically on the nature of nominal rigidities in goods markets.

- Macroeconomists are increasingly using micro data sets to measure how frequently prices change.

- The seminal article by Bils and Klenow (2004) argues that prices are quite flexible.

  - Using monthly CPI data, they find that median duration of prices is 4.3 months.

- The Bils and Klenow price duration estimate has became a litmus test for the plausibility of macro models.

Bils and Klenow challenged

- Bils and Klenow focus on raw price changes.
  - They conclude prices are *not* very inertial.

- Nakamura and Steinsson focus on non-sale prices.
  - They argue that prices *are* quite inertial.
  - When sales are excluded, prices change on average every 8 to 11 months.

- Kehoe and Midrigan examine the impact of sales on price inertia using weekly supermarket scanner data.
  - When sales observations are excluded, prices change once every 4.5 months.
  - When sales are included, prices change every 3 weeks.

The impact of sales on inference

- Excluding 'sales prices' from the data has a major impact on inference about price inertia.

- What exactly is a sale?

- Why should we treat 'regular' and 'sales' prices asymmetrically?

Motivating our analysis

- We organize our analysis around the 'reference price',
  - The price most often quoted within a given quarter.

- There *are* high frequency movements in many prices.
  - Some non-reference prices can be thought of as 'sales prices' because they are lower than the reference price.
  - Other non-reference prices can't be interpreted as 'sales prices' because they are higher than the reference price (26 percent in our data).

- We don't want to take a stand on what sales are or on whether they are special events that should be disregarded by macroeconomists.

Reference prices

Examples
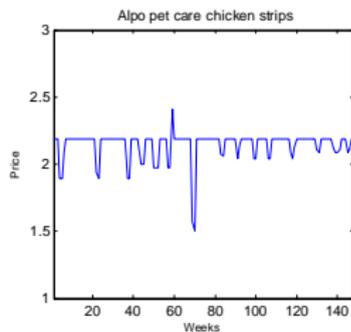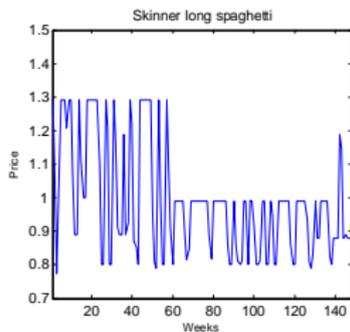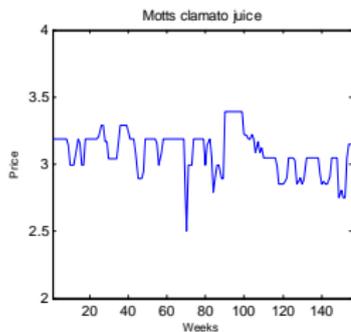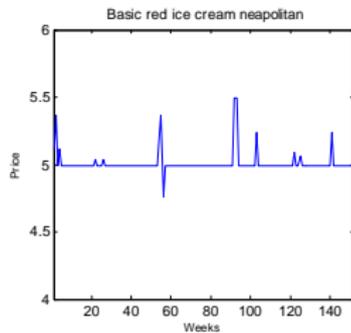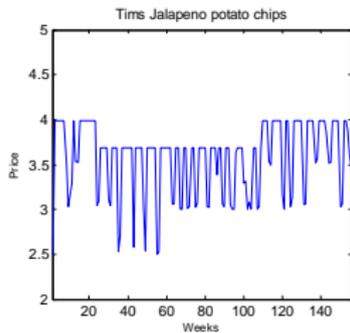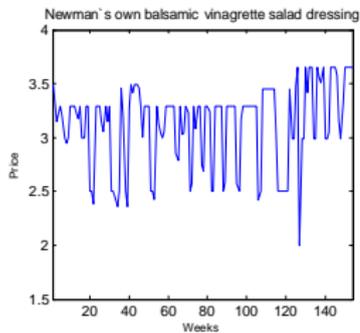
Central result of the paper

- The high frequency of price changes casts doubts about the importance of nominal rigidities.

- Reference prices are 'important' and much more inertial than raw prices.

- This inertia is very hard to reconcile with flexible price models.

- Nominal rigidities may be important even though raw prices change frequently.

Data

- From a large food and drug retailer that operates more than 1,000 stores in different U.S. states.

  - ▸ Weekly prices and sales revenue for 60,000 items.
  - ▸ High-quality weekly cost measures.
  - ▸ Sample period: 2003 to 2006.

- Our data is concentrated in the processed and unprocessed food, household furnishings, and other goods categories.

  - ▸ These categories have duration of prices roughly equal to the median duration of prices in the CPI basket.

  - ▸ Prices change more frequently in categories like vehicle fuel and less frequently in categories like services.

Cost measure

- We observe Adjusted gross profit and Sales.

$$\text{Net cost of goods} \quad = \quad \text{Cost of goods - Retail allowances,}$$
$$= \quad \text{Sales - Adjusted gross profit.}$$

- Retail Allowances are a rebate from the manufacturer or wholesaler.

- Cost of Goods = vendor cost, buying allowances, freight allowances. other allowances, unauthorized prc, overseas freight and distress.

Marginal cost

- Which costs are marginal depends on the time horizon.

  - At the weekly level it seems reasonable to assume that rent, capital, and labor are all fixed, so net cost of goods = marginal cost.
  - At lower frequencies the net cost of goods is a lower bound for both the level of marginal cost.

- Most importantly:
  - The firm's managers tell us that their pricing decisions are based on the AGP.

- For the remainder of paper we refer to net cost of goods as marginal cost.

Summarizing the data

- The retailer classifies items into 200 categories.

- We compute the median value of a statistic across the items in a category.

- Typically we report the median across categories.

Some basic facts about our data

- Average markup is 78 percent.

- Weekly prices are 27 percent more volatile than weekly marginal costs.

- The realized markup is very volatile, with a standard deviation roughly equal to that of marginal costs.

- Weekly quantities are *much more* volatile than weekly prices (5 times more volatile).

Computing reference prices and reference costs

- We compute reference prices at a quarterly frequency.

- Define a product as a UPC-store pair.

- For each product we observe weekly prices.

- Reference price: the most common price for a given good in a given quarter.

- We follow a similar procedure to compute reference costs.

Reference prices are important

- A high percentage of price observations correspond to reference prices (62 percent).

- Most quantities are sold at reference prices (54 percent).

Distribution of weeks spent and quantity sold at reference price
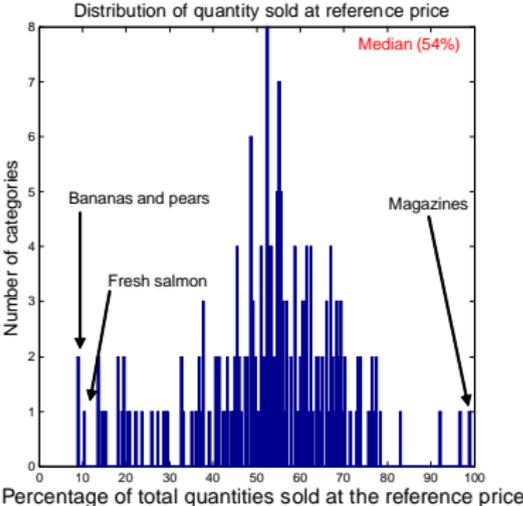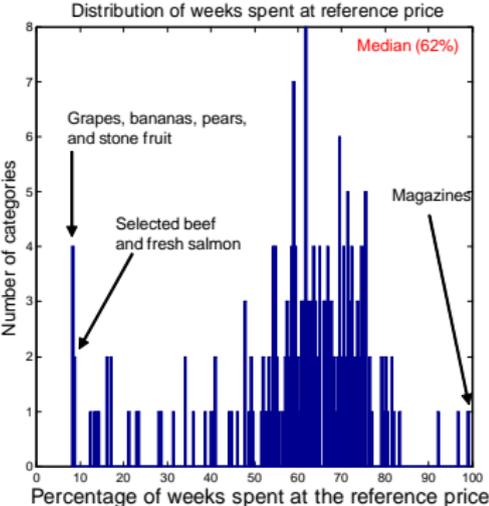
Reference prices are important

- One third of all price changes involve movements from a non-reference price to a reference price.

- The probability of going back to a reference price conditional on being at a non-reference price is high (47 percent).

- The variance of quantities sold at reference prices is the same as the variance of quantities sold at non-reference prices.

Reference prices are much more inertial than weekly prices

Implied duration of prices (quarters)
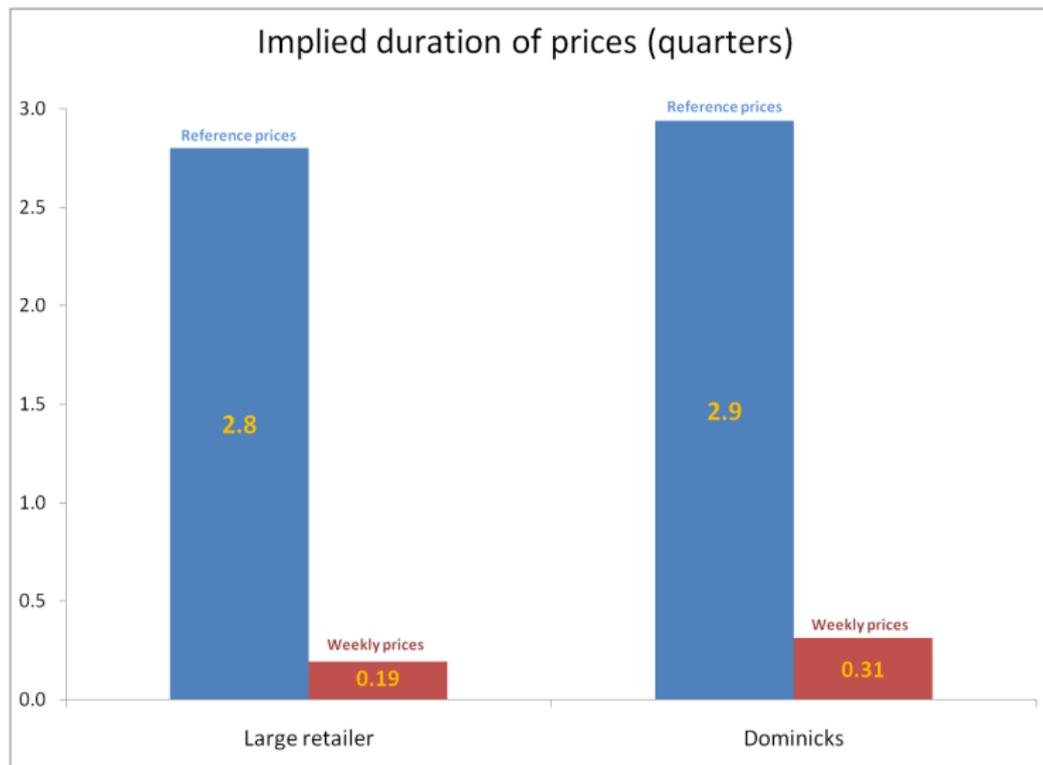
Reference prices are much more inertial than weekly prices

- The inertia of reference prices is diferent from the inertia of non-sales prices, when 'sales' are identified by the Kehoe-Midrigan algorithm.

- Duration of reference prices is roughly 9 months.

- Duration of non-sales prices, as defined by Kehoe-Midrigan, is roughly 4.5 months.

- 50 percent of this difference results from instances in which the weekly price is above the reference price.

Distribution of implied duration for reference prices and weekly prices
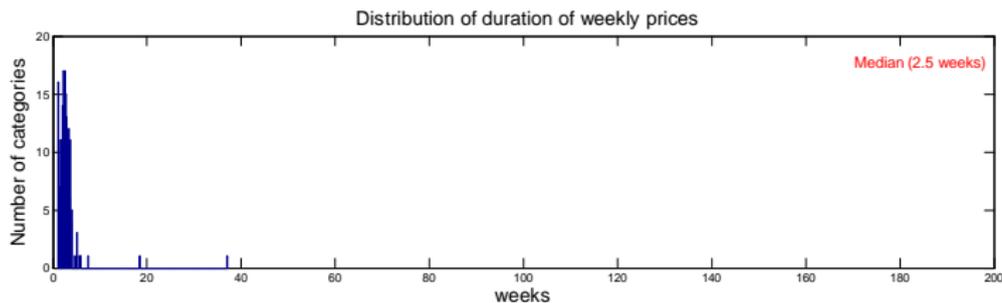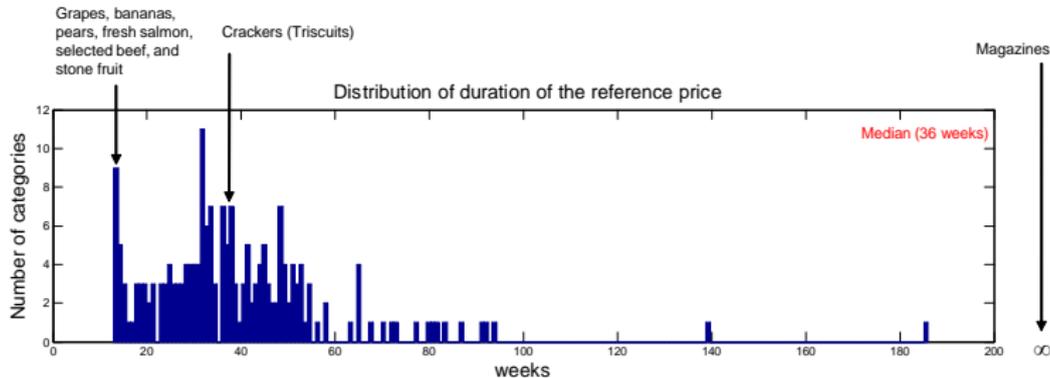
Reference costs are much more inertial than weekly costs

Implied duration of cost (quarters)

Reference cost: 2.0

Weekly cost: 0.18

Large retailer
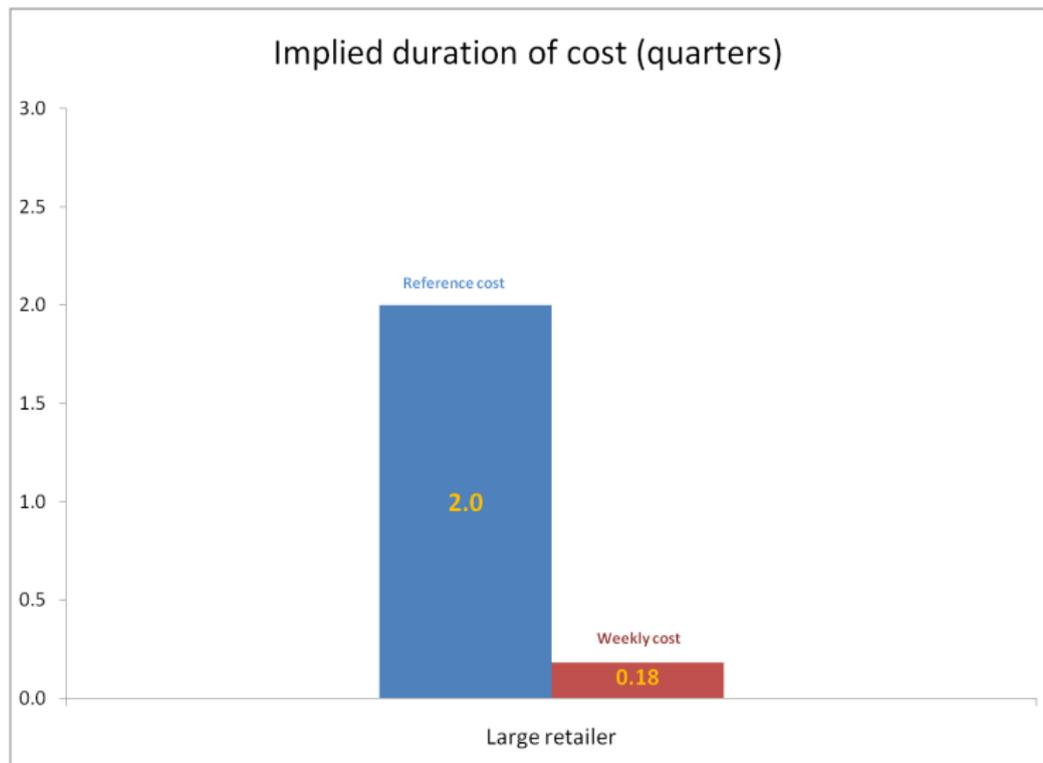
# Reference prices are systematically but imperfectly related to costs

- Probability of reference prices changing when there is no change in reference cost is low (3 percent).
  - Probability of weekly prices changing when there is no change in weekly cost is also low (10 percent).

- But, reference prices don't always change when reference costs change.
  - The probability of the reference price changing conditional on a change in marginal costs is only 50 percent.

Determinants of the probability of a reference price change

- Define the reference markup in a quarter as the ratio of the reference price to the reference cost in that quarter.

- Suppose that the reference cost in quarter t changes.

  - Other things equal this change induces a change in the value of the time t reference markup.
  - For convenience we refer to this value as the 'hypothetical reference markup'.
    - It's the reference markup that would obtain if the firm didn't change its reference price after a change in reference cost.

- We find that the probability of a change in the reference price is increasing in the deviation of the markup from its average level.

Determinants of reference price changes

- Once the firms decide to change the reference price they do so in a way that re-establishes the unconditional mean markup for the good.
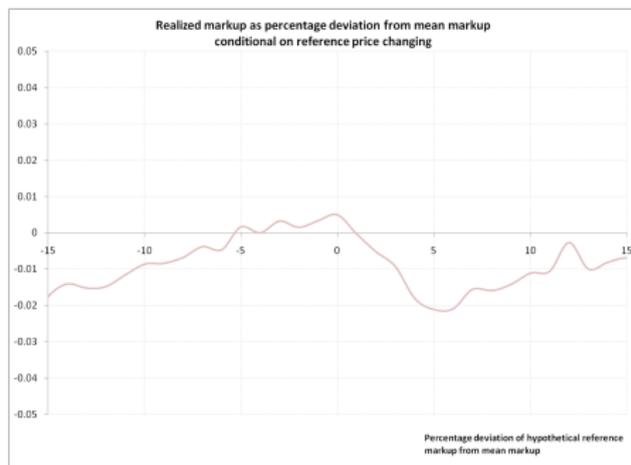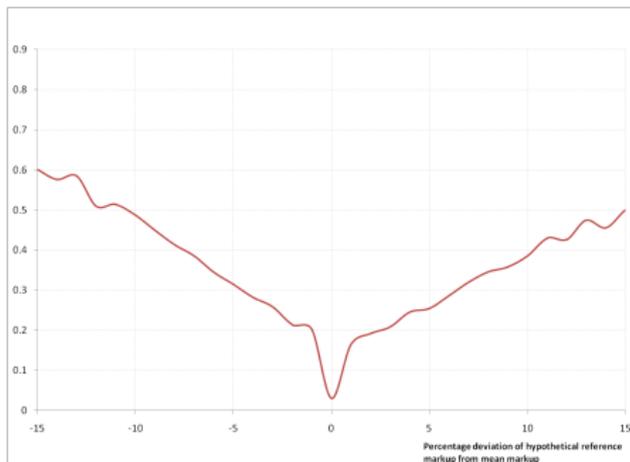
Weekly prices and marginal cost

- The contemporaneous probability of a change in the weekly price increases with the percentage deviation of the markup from its unconditional mean.

- When there is a price change the new markup is between 66 and 100 percent of the unconditional markup.
  - When costs fall the firm passes almost all of the benefits to the consumer.
  - When costs rise the firm passes only a fraction of the rise to the consumer.

# Distribution of realized markups: reference price/weekly cost

Computed for weeks in which weekly price = reference price

Percentage deviation from average markup
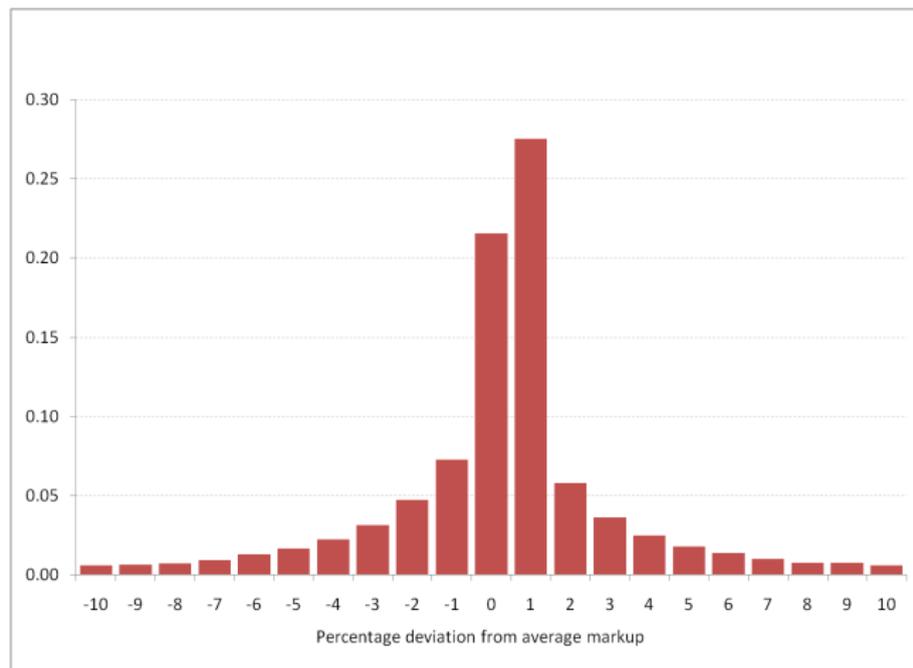
Which product categories have short price duration?

- Categories with a high probability of a reference cost change have a high probability of a reference price change.

- Categories with a high probability of weekly price change have a high probability of a weekly cost change.

Probability (p) of a change in the reference price
Cross-sectional evidence

p = 0.82c - 0.04
R^2 = 0.62

Probability (c) of a change in reference cost

Probability (p) of a change in the weekly price
Cross-sectional evidence

p = 0.91c - 0.02
R^2 = 0.81

Probability (c) of a change in weekly cost
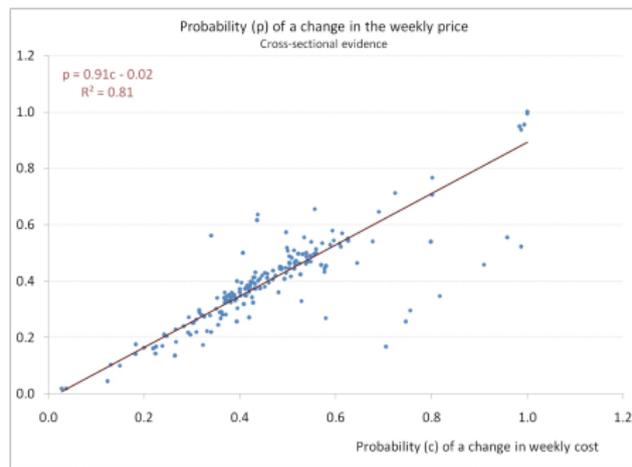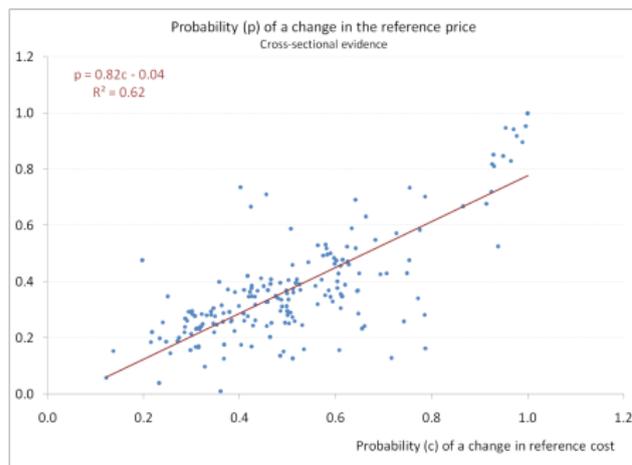
# Determinants of reference price duration

- The duration of reference prices seems to be chosen to keep the reference markup within plus or minus 10 percent of the mean markup.
  - ▸ The distribution of realized markups is very similar for goods with different reference price duration.

Distribution of weekly markups for the life of a reference prices, by duration
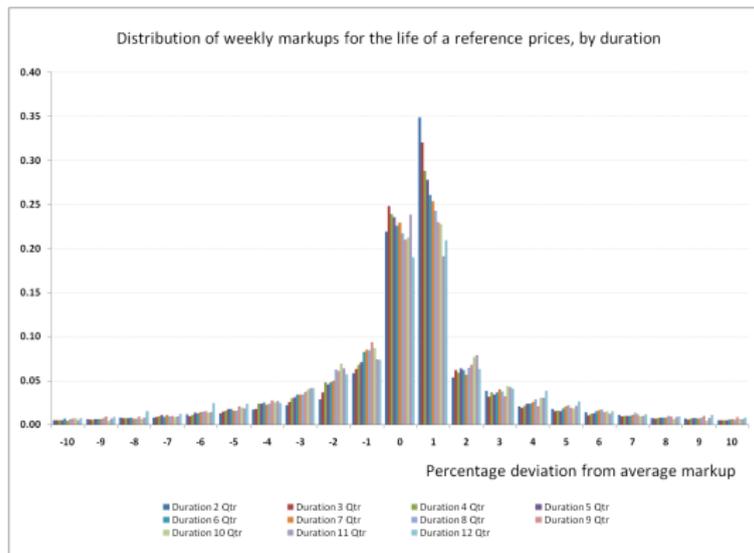
Demand shocks are important

- Conditional on the price being constant the standard deviation of quantities sold is roughly 52 percent.

Price, UA Creamy premium liquid salad dressings

Quantity sold, UA Creamy premium liquid salad dressings
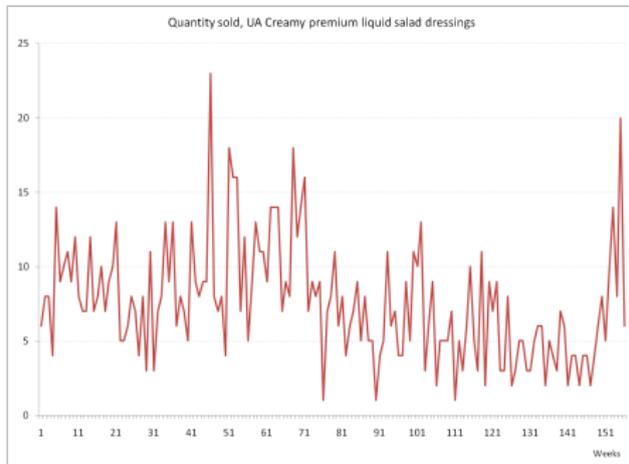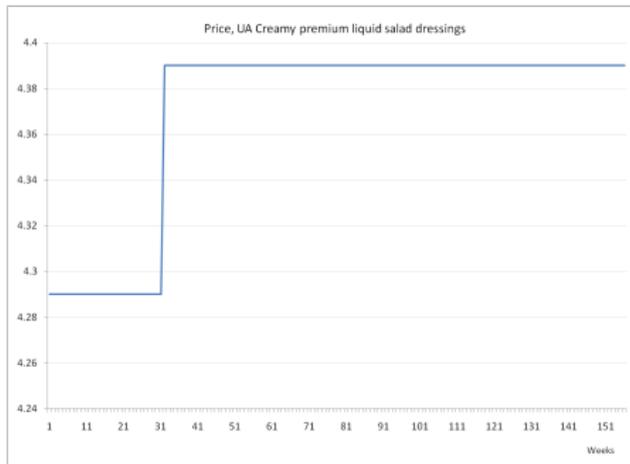
Small price changes

- There is substantial heterogeneity across categories with respect to the prevalence of small price changes.

- Many reference price changes are small.
  - Fraction of categories where 10 percent of more of the price changes are less than 1% is equal to 27 percent.

- Many weekly price changes are also small.
  - Fraction of categories where 10 percent of more of the price changes are less than 1% is equal to 13 percent.

Reconciling different pricing models with our findings

Flexible price models

- Flexible price models based on Dixit-Stiglitz specifications are inconsistent with the data.

    ▶ Roughly 50% of the variance in prices is due to the variance in markups.

- Reconciling more general flexible price models with the data, requires an *incredible* configuration of cost and demand shocks.

Flexible price models

Example

- Linear demand:

$$P_t = a_t - b_t Q_t.$$

- Profits:

$$\pi = P_t Q_t - C_t Q.$$

- $C_t =$ marginal cost.
- Optimal price and quantity:

$$P_t^* = \frac{a_t + C_t}{2},$$

$$Q_t^* = \frac{a_t - C_t}{2b_t}.$$

Flexible price models
Example

$$P_t^* = \frac{a_t + C_t}{2},$$

$$Q_t^* = \frac{a_t - C_t}{2b_t}.$$

- For every UPC we deduce the time series for a_t and b_t such that P_t^* and Q_t^* match the data exactly.

- To match the data demand shocks must be very volatile.
  - Median standard deviation of $\log(a) = 0.16$.
  - Median standard deviation of $\log(b) = 0.82$.

- 25 percent of the observations involve changes in cost but no changes in price.
  - To match these observations the change in a_t has to exactly offset the change in C_t.
  - We find this configuration of shocks to be incredible.

Standard menu cost models

- Standard menu cost models are inconsistent with the data.
  - Calibrated menu cost models imply that prices are *less* volatile than marginal cost.
    - ⋆ Golosov-Lucas: unconditional standard deviation of cost changes = 7%, unconditional standard deviation of price changes 5%.
    - ⋆ Burstein-Hellwig: unconditional standard deviation of cost changes = 10%, unconditional standard deviation of price changes 5%.
- In our data set prices are *more* volatile than marginal cost.
  - Median of the standard deviation of log(price)/standard deviation of log(cost) = 1.25.
- Many price changes are small.
- We also need an incredible configuration of cost and demand shocks to explain why firms return often to an old (reference) price.
  - In data when prices go back to the reference price, the cost does not generally go back to the old cost.

Non-standard menu cost models

- You can account for the return to reference prices by assuming that there are different menu costs for different changes in different types of prices (Kehoe and Midrigan (2007)).

- Problem 1: many reference and non-reference price changes are 'small'.
  - So you need to assume that:
    - ⋆ Once the firm pays menu cost to change one reference price, it can change some other reference price for free.
    - ⋆ Once the firm pays menu cost to change one non-reference price, it can change some other non-reference price for free. (Midrigan[2]).

- Problem 2: the standard deviation of reference prices is roughly 50 percent higher than the standard deviation of reference cost.

Calvo models

- Inconsistent with our finding the probability of a reference price change is increasing in the deviation of the realized markup from its unconditional mean.

Simple pricing rule

- Our findings can be reconciled with a relatively simple pricing rule.

- For any given good, firms set prices so that, *on average,* the nominal reference price is a particular markup over nominal cost.
  - Firms set the frequency with which they reset the reference price so as to keep the actual markup within plus/minus 10 percent of the desired markup over reference cost.

- This rule implies that the unconditional markup and the duration of the reference price is good specific.

Simple pricing rule

- Firms are more likely to change reference and non-reference prices when not doing so would imply a larger deviation between the realized markup and the unconditional markup.

- When firms change the reference price they re-establish the unconditional markup.

- When they change non-reference prices they buffer consumers from rises in marginal cost.

Implications of the pricing rule

- The simple pricing rule implies that observed prices change frequently.

- But this rule doesn't coincide with a flexible price rule and is consistent with the importance of significant nominal rigidities.

Rationalizing the pricing rule

- The simple pricing rule is consistent with our empirical findings but we didn't derive it from first principles.

- Doing so and understanding the implications for nominal shocks in a general equilibrium setting is a task we leave for future research.

Conclusion

- Reference prices are important and persistent.

- In the presence of reference prices, nominal rigidities can be important, even when prices change very frequently.

- Existing macro models cannot be easily reconciled with our empirical results.