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## ABSTRACT

We examine the frequency of price changes for 350 categories of goods and services covering about 70% of consumer spending, based on unpublished data from the BLS for 1995 to 1997. Compared with previous studies we find much more frequent price changes, with half of prices lasting less than 4.3 months. The frequency of price changes differs dramatically across categories. We exploit this variation to ask how inflation for "flexible-price goods" (goods with frequent changes in individual prices) differs from inflation for "sticky-price goods" (those displaying infrequent price changes). Compared to the predictions of popular sticky price models, actual inflation rates are far more volatile and transient, particularly for sticky-price goods.

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## 1. Introduction

The importance of price stickiness remains a central question in economics. After a ten-year period of relative quiet, sticky-price models are again at, or near, the center of analysis of business cycle fluctuations and monetary policy. Goodfriend and King (1997), Rotemberg and Woodford (1997), Clarida, Gali, and Gertler (1999), Erceg, Henderson, and Levin (2000), Chari, Kehoe, and McGrattan (2000), Christiano, Eichenbaum, and Evans (2001), and Dotsey and King (2001) are examples of recent work built on the assumptions that firms adjust prices infrequently and satisfy all demand at those posted prices.

With the exception of Dotsey and King (2001), these studies employ time-dependent pricing. Prices are maintained for a set number of periods (as in Taylor, 1999) or each period a fixed fraction of firms have an opportunity to adjust prices to new information (as in Calvo, 1983). In both the Taylor and Calvo models price changes are not synchronized across firms. In these settings monetary policy can influence economic activity for some period of time. By contrast, Caplin and Spulber (1987) illustrate that state-dependent models of price changes generate less clear predictions for the impact of monetary policy on real activity. As we discuss at length, models with staggered time-dependent pricing imply that inflation rates should be more persistent and less volatile if price changes are less frequent.

The speed with which sticky-price models were first jettisoned then retrieved partly reflects the lack of conclusive evidence on the extent and importance of sticky prices. Several papers have shown that certain wholesale and retail prices often go unchanged for many months (Carlton, 1986, Cecchetti, 1986, Kashyap, 1995, Levy, Bergen, Dutta and Venable, 1997, Blinder, Canetti, Lebow and Rudd, 1998, MacDonald and Aaronson, 2001, and Kackmeister, 2001). Compared to these studies, we obtain broader evidence on the extent of retail price rigidities and their consequences for the behavior of inflation. We employ unpublished data from the U.S. Bureau of Labor Statistics (BLS) for 1995 to 1997 on the monthly frequency of price changes for 350 categories of consumer goods and services comprising around 70% of consumer expenditures. We find that many prices seldom change.

Prices of newspapers, men's haircuts, and taxi fares change less than 5% of months. By contrast, many prices change very frequently. The prices of gasoline, tomatoes, and airfares change more than 70% of months. We exploit this diversity. We classify goods by how frequently they display monthly price changes in the 1995-1997 data, then ask how the behavior of inflation differs between goods with frequent versus infrequent price changes.

In the next section (section 2) we present the disaggregate data on the frequency of price changes for 1995 to 1997. We contrast our findings to the existing literature. We find much more frequent price changes, with half of prices lasting 4.3 months or less. We also present a number of characteristics that predict whether a good will display a flexible price. We find that variables capturing the volatility of market supply and demand can account for much of the variation in price flexibility across categories. For example, goods that exhibit frequent model changes typically exhibit flexible pricing.

In section 3 we briefly sketch a general equilibrium sticky-price model that follows work in Chari, Kehoe and McGrattan (2000). They model monopolistically competitive firms with staggered price setting of a fixed duration (a la Taylor, 1999). The wrinkle we add is multiple consumer goods with prices fixed for different durations across the goods. We simulate this model to illustrate how flexible-price goods and sticky-price goods can differ in their responses to shocks.[1]

In section 4 we analyze monthly time series on prices and consumption for 123 goods of varying price stickiness. In the workhorse Calvo and Taylor models, price stickiness dampens the initial response of a good's inflation rate to a shock, stretching the inflation impact out over time as successive cohorts of firms adjust their prices. Price stickiness thereby reduces the magnitude of innovations to a good's inflation rate while, at the same time, raising the persistence of its inflation. We do not see this in the data. For nearly all 123 categories, inflation movements are far more volatile and transient than implied by the Calvo and Taylor models given the frequency of individual price changes in the BLS data. This

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[1] Several papers have incorporated sticky-price and flexible-price sectors into model economies. Examples include Ohanian, Stockman, and Kilian (1995), Aoki (2001), and Benigno (2001).

discrepancy cannot be resolved by adding plausible measurement error or idiosyncratic shocks. Across the 123 goods, volatility and persistence of a good's inflation rate are much less related to the good's underlying frequency of price changes than predicted by these time-dependent pricing models. In other words, the popular sticky-price models fail most dramatically to predict inflation's behavior for goods with the least frequent price changes.

The final section (section 5) summarizes and discusses directions for further work.

## 2. BLS Data on the Frequency of Price Changes

For calculating the CPI, the BLS collects prices on 70,000 to 80,000 non-housing goods and services per month.[2] They collect these from around 22,000 outlets across 88 geographic areas. The BLS chooses outlets probabilistically based on household point-of-purchase surveys, and choose items within outlets based on estimates of their relative sales. The BLS divides consumption into 388 categories called Entry Level Items (ELIs).

The BLS *Commodities and Services Substitution Rate Table* gives, for each ELI, the percentage of quotes with price changes. For example, the 1997 *Table* indicates that 6,493 price quotes were collected on bananas in 1997, and that 37.8% of these quotes differed from the quote on the same type of bananas at the same outlet in the preceding month. (The *Table* does not contain information on the magnitude of price changes, just what share of price quotes involved *some* change in price.) The field agents collecting prices use a detailed checklist of item attributes to try to make sure they are pricing the same item in consecutive months. When they cannot find an item, they substitute the price of a closely-related item at the outlet. These "item substitutions" are the focus of the BLS *Table*, and we discuss them in detail later in this section. Item substitutions happen to be rare for bananas (only 1 in 1997) compared to other categories (3.1% of non-housing price quotes in 1997).

The BLS has provided us with the unpublished *Commodities and Services Substitution Rate Table* for the years 1995 through 2001. The BLS revised the ELI structure in 1998, so

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[2] The sources used for this section, unless otherwise noted, were *The Boskin Commission Report* (1986) and the *BLS Handbook of Methods* (U.S. Department of Labor, 1997, Chapter 17).

frequencies cannot be readily compared before and after 1998. For the 168 ELI definitions which remained unchanged, however, the frequencies are quite stable over the seven years. The correlation for any pair of years lies between 0.96 and 0.98. In order to maximize the number of ELIs for which there is a price index covering more than a few years, we use the 1995-1997 BLS data and its ELI structure. This data covers 350 ELIs.

In Table 1 we list, for each of the 350 ELIs, the 1995-1997 average *monthly* frequency of price changes. For food and energy ELIs, in which items are priced monthly, this is the simple average of the frequencies in the 1995, 1996, and 1997 BLS *Tables*. For the other ELIs, the frequencies in the BLS *Tables* are a mixture of one-month and two-month price change frequencies. In the five largest areas — New York City and suburbs, Chicago, Los Angeles and suburbs, San Francisco / Oakland / San Jose, and Philadelphia — the BLS collects quotes monthly for all goods and services. For the other geographic areas, the BLS collects quotes monthly only for food and energy, and bimonthly for all other goods and services. For each of 1995, 1996 and 1997, we obtained from the BLS the fraction of price quotes that were monthly vs. bimonthly.

If the monthly probability of a price change is the same across areas and from month to month for a given ELI in a given year, then we can identify the monthly frequency of price changes from the mixed frequency the BLS reports and the fraction of quotes which are monthly versus bimonthly. In doing so we assume that the probability of a price changing from $p_a$ to $p_b$ one month, then changing *back* to $p_a$ the next month, is zero. Based on scanner data for select seasonal goods at certain Chicago-area supermarkets, Chevalier, Kashyap and Rossi (2000) find that such temporary sales are actually quite common. To the extent they occur, our estimated monthly frequencies understate the true monthly frequencies. Since Chevalier et al. find that temporary sales typically last one week or less, even monthly price quotes (as for the top five areas and for food and energy) understate the true frequency of price changes. As we discuss later in this section, however, one could argue that temporary sales mask the stickiness of "regular" prices.

Let $y$ = the mixture of monthly and bimonthly frequencies (data from the BLS *Tables*), $\lambda$ = the constant monthly frequency of price changes (not directly observed), and $z$ = the fraction of quotes which are monthly (data we obtained from the BLS for each ELI for each year). Then $y = z*\lambda + (1-z)*(\lambda + (1-\lambda)*\lambda)$. Since $z \in (0, 1)$ and $\lambda \in [0,1]$, the solution for $\lambda$ is the negative root of this quadratic in $\lambda$. Table 1 reports $\lambda$ for each of the 350 ELIs. These are averages of the monthly frequencies we estimate for 1995, 1996 and 1997. They range from 1.2% for coin-operated apparel laundry and dry cleaning to 79% for regular unleaded gasoline. Figure 1 gives the histogram of frequencies for the 350 ELIs. Not all ELIs are equally important, however, as their weights in the 1995 Consumer Expenditure Survey (CEX) range from 0.001% (tools and equipment for painting) to 2.88% for electricity. Table 1 also provides the weight of each ELI and the resulting percentile of the ELI in the cumulative distribution of frequencies. Weighting the ELIs, the monthly frequency of price changes averages 26.1%. The weighted median is 20.9%. For the median category the time between price change averages 4.3 months.[3] Thus, for items comprising one half of non-housing consumption, prices change less frequently than every 4.3 months.

The 350 ELIs in Table 1 cover 68.9% of spending according to the 1995 CEX. The categories not covered are owner's equivalent rent and household insurance (20.0% weight), residential rent (6.6%), used cars (1.8%), and various unpriced items (collectively 2.7%). One question that arises is whether scanner data, which are becoming increasingly available to economists (e.g., Chevalier et al., 2000), might dominate the BLS average frequency data. Scanner data afford weekly prices and quantities for thousands of consumer items. At present, however, scanner data cannot match the category coverage of the BLS data. Hawkes and Piotrowski (2000) report that only 10% of consumer expenditures are scanned through AC Nielsen data for supermarkets, drugstores, and mass merchandisers. Categories not scanned include rent, utilities, restaurant meals (about 40% of spending on food), medical

[3] If prices can change at any moment, not just at the monthly interval, the instantaneous probability of a price change is $-\ln(1-\lambda)$ and the mean time between price changes $-1/\ln(1-\lambda)$ months. We used this formula to calculate the Mo. column from the Freq. column in Table 1. If prices instead change at most once per month, then the mean duration is simply $1/\lambda$, about half a month longer.

care, transportation, insurance, banking, and education. As noted, the 350 categories in the BLS *Table* cover 68.9% of consumer expenditures.

Table 2 reports the median frequency and duration for years 1995 through 2001. Price changes are somewhat more frequent over 1998-2001 than over the 1995-1997 period we focus on to maximize compatibility with other data.

*Comparison to Other Empirical Studies of Price Stickiness*

The BLS data suggests much more frequent price adjustment than has been found in other studies.[4] Blinder et al. (1998) surveyed 200 firms on their price setting. The median firm reported adjusting prices about once a year. Hall, Walsh and Yates (2000) surveyed 654 British companies and obtained similar results: 58% changing prices once a year or more. In contrast, the median consumer item in the 1995-1997 BLS *Tables* changes prices every 4.3 months. For 87% of consumption prices change more frequently than once a year. A possible contributor to the difference in findings is that firms in the Blinder et al. survey sell mostly intermediate goods and services (79% of their sales) rather than consumer items.

Even compared to other studies of *consumer* prices, the BLS data imply considerably more frequent price changes. Cecchetti (1986) studied newsstand prices of 38 American magazines over 1953 to 1979. The number of years since the last price change ranged from 1.8 to 14 years. In our Table 1, magazines (including subscription as well as newsstand prices) exhibit price changes 8.6% of months, implying adjustment every 11 months on average. More importantly, magazines are at the sticky end of the spectrum in Table 1; prices change more frequently than for magazines for 86% of non-housing consumption.

Kashyap (1995) studied the monthly prices of 12 mail-order catalog goods for periods as long as 1953 to 1987. Across goods and time, he found an average of 14.7 months between price changes. This contrasts with the 4.3 month median in the BLS data. Based on Table 1, prices change more frequently than every 14.7 months for 90% of non-housing

[4] The BLS data also suggest more frequent price adjustment than usually assumed in calibrated macro models. Chari et al. (2000), for instance, consider a benchmark case in which prices are set for one year.

consumption. The 12 Kashyap goods consist mostly of apparel. In the BLS data, prices actually change more frequently for clothing: the monthly hazard is 29% for apparel items, versus 26% for all items. So prices for the goods in Kashyap's sample are far stickier than the typical BLS item, apparel or otherwise. Mail-order prices may tend to be stickier than prices in retail outlets. Another factor could be that Kashyap selected "well-established, popular-selling items that have undergone minimal quality changes" (Kashyap, 1995, p. 248). As we discuss below, changing product features appear to play an important role in price changes.

MacDonald and Aaronson (2001) examine restaurant pricing (more exactly, pricing for food consumed on premises) for the years 1995 to 1997 using BLS data. They find that restaurant prices do not change very frequently, with prices displaying a median duration of about 10 months. These are close to the durations we report for breakfast (11.4 months), lunch (10.7), and dinner (10.6) prices in Table 1. This consistency is not surprising given we are using the same underlying data source. Note, however, that prices change less frequently at restaurants than for the typical good in the CPI bundle. Prices change more frequently than for restaurant foods for about 80% of non-housing consumption.

Kackmeister (2001) analyzes data on the price levels of up to 49 consumer products (depending on the period) in Los Angeles, Chicago, New York and Newark in 1889-1891, 1911-1913, and 1997-1999. The goods are at the ELI level or slightly more aggregated, and include 27 food items, 14 home furnishing items, and 8 clothing items. He finds that the frequency, size, and variability of price changes are higher in the last period than in the first period. For 1997-1999 he finds that 31% of his goods change price each month. This is higher than the mean frequency of 26% in our data; we conjecture the difference owes mostly to the composition of goods rather than the sample period or cities.

With data on price levels, Kackmeister is able to investigate how often a price is temporarily marked down from a "regular" price that is itself much stickier. He finds that 22% of prices change each month *excluding* price reductions that reverse themselves one month later. If the same fraction (9/31) of price changes arose from temporary sales in our data, then our mean frequency net of temporary sales would be 18% (vs. 26% including temporary sales). The median time between changes in *regular* prices would be 6.2 months (vs. 4.3 months with temporary sales).[5] Even 6.2 months is considerably shorter than the 12 months or more found by previous studies. Moreover, one could argue that temporary sales represent a true form of price flexibility that should not be filtered out, say because the magnitude and duration of temporary sales responds to shocks.

*Differences in Price Stickiness Across Broad Consumption Categories*

Table 3 provides price change frequencies for selected broad categories of consumption. The first row shows that the (weighted) mean frequency is 26% for all items. The next three rows provide (weighted) mean frequencies for durable goods, nondurable goods, and services, respectively, based on U.S. National Income and Product Account (NIPA) classifications. Price changes are more frequent for goods (about 30% for both durables and nondurables) than for services (21%). The lower frequency of price changes for services could reflect the lower volatility of consumer demand for them.

The next six rows in Table 3 provide frequencies for each of the six CPI Expenditure Classes defined by the BLS. At the flexible end are transportation prices (e.g., new cars, airfares), almost 40% of which change monthly. At the sticky extreme are medical care (drugs, physicians' services) and entertainment (admission prices, newspapers, magazines, and books), for whom around 10% of prices change monthly.

In the final two rows of Table 3 we draw a distinction between "raw" and "processed" goods. By raw goods we mean those with relatively little value added beyond a primary input, for instance gasoline or fresh fruits and vegetables. Because their inputs are not well-diversified, these goods may be subject to more volatile costs. Raw goods are a subset of the

[5] According to the BLS, temporary sales are more common for food and clothing, the bulk of Kackmeister's sample. For our sample, therefore, these calculations may overstate the effect of filtering out temporary sales.

food and energy items goods excluded by the BLS in its core rate of CPI inflation.[6] As expected, raw products display more frequent price changes (their prices change 54% of months) than do processed products and services (whose average is 21%). Even for processed items, the frequency of price changes remains considerably higher than values typically cited in the literature based on narrower sets of goods.

*Market Structure and Price Flexibility*

Models of price adjustment (e.g., Barro, 1972) predict greater frequency of price changes in markets with more competition because firms therein face more elastic demand. The four-firm concentration ratio is often used as an inverse measure of market competition, with a higher value expected to correlate with less elastic demand. Several papers have found an inverse relation between the concentration ratio and the frequency of price changes or price volatility in producer prices (e.g., Carlton, 1986, Caucutt, Gosh and Kelton, 1999). We examine the relationship between the share of the largest four firms in manufacturing shipments and the frequency of price change for our goods. The concentration ratio is taken from the 1997 Census of Manufactures. To exploit this measure we match the 350 consumer goods categories to manufacturing industries as classified by the North American Industrial Classification System (NAICS). This matching can be done for 231 of the goods. The categories we were unable to match are largely services.

Column A of Table 4 reports the regression of price-change frequencies on four-firm concentration ratios. (This is a weighted least squares regression with weights given by the goods' importance in 1995 consumer expenditures.) There is an economically and statistically strong negative relation. The coefficient of -0.30 implies that raising the concentration ratio from 23% (the value for pet food) to 99% (the value for cigarettes) tends to decrease the monthly frequency of price changes by more than 20 percentage points.

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[6] The set of raw goods consists of gasoline, motor oil and coolants, fuel oil and other fuels, natural gas, electricity, meats, fish, eggs, fresh fruits, fresh vegetables, and fresh milk and cream. Unlike the BLS food and energy categories, it does not include meals purchased in restaurants or foods the BLS classifies as processed.

We consider two other variables related to market competitiveness. One is the wholesale markup, defined as (wholesale sales minus cost of goods sold)/(wholesale sales). The data for wholesale markups are from the 1997 Census of Wholesale Trade. We can match 250 of the 350 consumer goods to a corresponding wholesale industry in the NAICS.

Another factor potentially related to market competition is the rate that substitute products are introduced. As mentioned above, the BLS *Commodities and Services Substitution Rate Table* actually focuses on item substitutions. When an outlet discontinues an item, the field agent collecting price quotes searches for the closest substitute at the outlet. A BLS commodity specialist later compares the attributes of the selected item and the discontinued item, and classifies the substitute as either comparable or noncomparable to the discontinued item.[7] We expect markets with greater product turnover, as measured by the rate of noncomparable substitutions, to price more flexibly. Changes in the product space may induce changes in the prices of incumbent products. Pashigian's (1988) markdown pricing model for fashion goods has this feature, as do many models in which quality improvements are introduced over time. Another hypothesis is that newer products have rapidly falling production costs as firms slide down learning curves. Finally, frequent introduction of new products may proxy for ease of market entry more generally.

Column B of Table 4 provides results relating the frequency of price changes to the three measures of market structure (concentration ratio, wholesale markup, and rate of noncomparable substitutions). Each coefficient has the anticipated sign and is economically and statistically significant. The coefficient on the concentration ratio is as large as in column A. The coefficient of –1.20 on the wholesale margin implies that increasing the margin from 12% (the value for meat products) to 35% (the value for toys and games) tends to decrease the monthly frequency of price changes by more than 25 percentage points. A 1% higher noncomparable substitution rate, meanwhile, goes along with a 1.25% higher frequency of price changes (standard error 0.3%).

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[7] Item substitutions occur for 3.4% of monthly price quotes in our sample. The BLS deemed 46% of all substitutions noncomparable over 1995-1997.

As presented earlier in Table 3, products closely linked with primary inputs (raw products) display more frequent price changes. The regression in Table 4, column C examines how the frequency of price changes covaries with the three measures of market power, but now controlling for whether a good is a raw product. The coefficient implies that price changes are 34% more common for raw products (standard error 2.7%). The four-firm concentration ratio and wholesale markup, both of which appear very important in the column B regression, become quite unimportant when controlling for whether a good is raw or processed. The rate of product turnover robustly predicts more frequent price changes. Its coefficient actually increases, with 1% more monthly substitutions associated with 2.2% more price changes (standard error 0.3%). Since the coefficient on the rate of product turnover significantly exceeds unity, price changes are more frequent in the presence of greater product turnover even aside from price changes mechanically associated with item substitutions.[8]

In column D of Table 4 we relate the frequency of price changes simply to the rate of noncomparable substitutions and the raw good dummy. These variables are available for the full set of 350 goods. The two variables explain a sizable fraction of the variation in frequencies across the 350 goods (adjusted $R^2$ of 0.56). A 1% higher rate of product substitutions is associated with a 2.9% higher rate of price changes (standard error 0.3%). Thus each product turnover is associated with nearly two price changes in addition to that directly associated with the item substitution.

We examined several other variables aimed at capturing market structure. A higher import share might be expected to raise competition and the frequency of price changes. (We obtained data on imports from the U.S. Department of Commerce.) We find a statistically insignificant correlation of 0.09 between import share and the frequency of price changes. Furthermore, import share did not help predict price flexibility after controlling for raw goods. We likewise expected higher inventory holdings in industries with market power and higher

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[8] Prices of comparable substitutes enter the CPI without adjustment, so they are associated with price changes only if the substitute's price differs from the last price collected for the discontinued item. Noncomparable substitutes enter the CPI with quality adjustments, so they are almost always associated with price changes.

markups. Therefore greater inventory holdings might be associated with less frequent price changes. The frequency of price changes was indeed very negatively correlated, -0.51, with the ratio of *wholesale* inventories to sales. But, again, this effect was not robust to controlling for the raw-good dummy. The frequency of price changes was also typically lower for goods with a high ratio of *manufacturers* inventories to shipments (correlation -0.14). This variable was also insignificant in explaining frequency of price changes controlling for whether a good was a raw good. (The data for manufacturing and wholesale inventories were taken, respectively, from the 1997 Censuses of Manufacturing and Wholesale Trade.)

## 3. A General Equilibrium Model with Goods of Varying Price Stickiness

In this section we briefly describe the implications of a general equilibrium model with Taylor-style staggered price setting. The critical feature is that firms in the respective consumer goods sectors set their prices for different durations. Our purpose is to illustrate how the flexible-price sector responds differently to shocks than the sticky-price sector does. Our model borrows heavily from a model in Chari, Kehoe and McGrattan (2000). Our only substantive deviation is in having two consumer good sectors. Within each consumer good sector, price setting is staggered evenly across monopolistically competitive firms.

Consumers have momentary utility given by

$$U(c,m,l) = \left[(\omega c^{1-1/\eta} + (1-\omega)m^{1-1/\eta})^{\frac{\eta}{\eta-1}}(1-l)^{\psi}\right]^{1-\sigma}/(1-\sigma),$$

where $c$ = a CES consumption aggregate, $m$ = real money balances, $l$ = labor supply, and 1 = the time endowment. Time subscripts are implicit. Following CKM, we set $\omega$ = 0.94 based on the empirical ratio of $m/c$ (M1 to nominal consumption), $\eta$ = 0.39 based on the interest elasticity of money demand (from regressing log $m/c$ on the nominal three-month Treasury bill rate), $\psi$ = 1.5 so that steady state $l$ is 1/4, and $\sigma$ = 1 (unit intertemporal elasticities).

The CES consumption aggregate is given by

$$c \;=\; \left[\omega_f \left(\int_0^1 c_f(i)^\theta di\right)^{\rho/\theta} + \omega_s \left(\int_0^1 c_s(j)^\theta dj\right)^{\rho/\theta}\right]^{1/\rho} \,,$$

where $c_f(i)$ = production of flexible-price good $i$ by a monopolistic competitor, $c_s(j)$ = production of sticky-price good $j$ by a monopolistic competitor. As shown, each sector has a a continuum of firms of measure 1. We set $\omega_f = \omega_s = 0.5$ so that the sticky and flexible sectors have equal weight in $c$. We assume $\theta = 0.9$ so that the elasticity of substitution between varieties within each sector is 10. This means firms desire a price markup of 10% above marginal cost, in line with Basu and Fernald's (1997) evidence. We set $\rho = 0$ (Cobb-Douglas) so that the nominal shares of the flexible and sticky sectors are constant.

Firm production technologies are linear in labor and random walk productivity $a$:

$$c_f(i) = a\, l_f(i)\ \forall i, \quad c_s(j) = a\, l_s(j)\ \forall j\,.$$

Labor is mobile across firms and sectors, so the labor market clearing condition is

$$\int_0^1 l_f(i)di \;+\; \int_0^1 l_s(j)dj \;=\; l\,.$$

The exogenous money growth process is

$$\log \mu_t \;=\; \rho_m \log \mu_{t-1} + \epsilon_t \,,$$

where $\mu_t = \frac{m_t}{m_{t-1}}$ is the gross growth rate of the money supply. For simulations, reported in the next section, we employ $\rho_m = 0.52$, the serial correlation of monthly M1 growth over 1959 to 2000. First, however, we examine responses to a 1% money impulse under the assumption that log $\mu_t$ follows a random walk ($\rho_m = 0$). This case is helpful for illustration because the ultimate price change is the same size as the money innovation.

For both sectors, any firm setting its price in period $t$ does so before observing the current period shocks.[9] After prices are set the current shock is realized and all firms produce

[9] In the next section we will compare some predictions of this model to time series data. All of the implications are robust to modeling the current shocks as observed before adjusting firms set their current prices.

to satisfy the quantity demanded of their variety at their preset price. In the flexible sector prices are preset for 2 periods (the 90th percentile of frequencies in our Table 1). In the sticky-price sector prices are preset for 15 periods (the 10th percentile of frequencies in Table 1). In each sector, price-setting is staggered evenly (1/2 the flexible sector firms set their prices before a period, the other half before the next period; 1/15th of the sticky sector firms set their prices before a period, 1/15th before the next period, and so on). Firms set their prices to maximize expected discounted profits over the period the prices will be fixed. Their information set includes the entire distribution of preset prices of other firms in their own sector and in the other sector. If prices were preset for only one period, firms would set price equal to the steady state markup over expected nominal marginal cost.

Figure 2 presents equilibrium responses to a permanent 1% increase in the money supply. Aggregate consumption and labor supply both jump 1% in the month of the shock, then decline monotonically towards zero over the next 15 months. The decline is sharpest in the first two months as the two cohorts of firms in the flexible-price sector get a chance to respond with higher prices and lower output. In contrast, in the sticky-price sector the price gradually rises and output gradually falls over the 15 months following the shock.

As illustrated by Figure 2, both inflation and output growth are more persistent in the sticky sector than in the flexible sector in response to a money shock. This reflects the greater length of time needed for all cohorts to respond in the sticky sector. The initial impact on inflation is also smaller in the sticky sector than in flexible sector, as a smaller share of firms respond in the month after the shock in the sticky sector. Thus, in this model, price stickiness dampens the initial inflation impact and spreads it across many periods, thereby lowering the volatility of inflation innovations and boosting the persistence of inflation.

We also simulated versions of the model with 4, 5, 8, 15, 20 and 30 sectors, respectively. Each time we set the stickiness and weight of sectors to approximate the empirical distribution in Table 1. Not surprisingly, the aggregate response function was smoother the greater the number of sectors. In each case we compared the aggregate responses to a monetary shock to those in a one-sector model in which all prices were fixed for the same duration. We found that a single-sector model with prices fixed for 4 months, roughly the median duration in the empirical distribution, most closely matched the aggregate response in the multi-sector models. One-sector models with durations near the reciprocal of the mean frequency (3 months) or with the mean duration (7 months) did not mimic the multi-sector model nearly as well, based on squared deviations over 20 months of impulse responses. For this reason we emphasized the median duration when summarizing the empirical distribution of price change frequencies.

Figure 3 shows model responses to a permanent 1% increase in the technology parameter $a$. In the first month, because prices do not respond, labor hours decline, with no impact on aggregate consumption. Beginning in the second month consumption rises, and then continues its rise until the higher productivity passes fully into increased consumption, with no long run impact on labor hours.

Notice from Figures 2 and 3 that, both in the aggregate and in the sticky-price sector, inflation displays high persistence regardless of whether the underlying shock is to money or to TFP. (The movements in consumption, by contrast, are persistent in response to permanent TFP shocks, but not in response to permanent money shocks.) Stickiness dampens the initial response of inflation to TFP and money shocks alike. In the next section we test these predictions for sectoral inflation with time series data on monthly inflation for sectors of varying underlying price stickiness.

## 4. Time-Series Patterns for Flexible-Price Goods vs. Sticky-Price Goods

We match our 350 categories of consumer goods to available NIPA time series on prices and consumption from the Bureau of Economic Analysis. We construct real consumption as the ratio of nominal expenditures to price deflators.[10] The data run from

[10] For the vast majority of categories, the PCE Deflators are CPI's. For the following categories in our sample the BEA puts weight on input prices as well as the CPI: (in order of their weight) hospital services, college tuition, airline fares, high school and elementary school tuition, technical and business school tuition, and nursing homes. These categories add up to 5.7% of consumption and 8.5% of our sample.

January 1959 to June 2000. Although we can match most of our 350 ELI categories to NIPA time-series, in many cases the NIPA categories are broader. The matching results in 123 categories covering 63.3% of 1995 consumer spending and most of our 350 ELIs (which made up 68.9% of spending).

Menu-cost models of price adjustment (e.g., Barro, 1972, or Caplin and Spulber, 1987) predict that price changes are more frequent in markets with high trend inflation (or deflation). Taylor (1999) cites a number of studies with empirical support for this prediction. For our sample of 123 goods we examined whether the frequency of price changes was greater for goods that display a higher absolute level of inflation. The average rate of inflation is based on the good's NIPA personal consumption deflator from 1959 to 2000. Observations are weighted by the good's relative importance in 1995 consumer expenditures. Surprisingly, we observe a negative correlation of -0.18 (s.e. 0.09, here and below) between a good's absolute average inflation rate and its frequency of price changes. Controlling for a good's rate of noncomparable substitutions, however, reduces the magnitude of this correlation to -0.11. (A good's rate of noncomparable substitutions is negatively correlated with its trend inflation rate at -0.47.) For the recent period of January 1995 to June 2000, which corresponds to the period for which we have data on the frequency of price changes, there is a small positive correlation of 0.09 between a good's absolute average inflation rate and its frequency of price changes. Controlling for the good's rate of noncomparable substitutions raises this correlation to 0.17.

In Tables 5 and 6 we examine the persistence and volatility of inflation and consumption growth for the 123 goods. We place particular emphasis on how inflation rates differ in persistence and volatility across goods in conjunction with underlying frequencies of price change as measured from the BLS panel. Table 5 restricts attention to inflation and consumption growth from January 1995 to June 2000. Table 6 repeats all statistics for the considerably longer period of January 1959 to June 2000. Implicit in examining this longer period is an assumption that the relative frequencies of price changes across goods after 1995 represent reasonably well the relative frequencies for the earlier sample period.

We first examine persistence and volatility of aggregate inflation, where the aggregation is over our 123 consumer goods. We fit this aggregate monthly inflation rate to an AR(1) process. The top panel of column A in Table 5 shows that the aggregate inflation rate is not very persistent over 1995-2000. Its serial correlation is 0.20 (standard error 0.13).

The lower panel in column A of Table 5 depicts how persistence and volatility of inflation vary across goods. For each of the 123 categories we fit the good's monthly inflation rate to an AR(1) process. This allows us to examine how inflation persistence and volatility differ across goods in relation to each good's underlying frequency of price changes over 1995 to 1997. We use the AR(1) coefficient to measure persistence. We focus on the standard deviation of innovations to a good's AR(1) process for inflation as a measure of volatility. We do so because, as discussed below, it is straightforward to depict how price stickiness dampens the volatility of innovations to inflation with Calvo and Taylor pricing.

The average serial correlation across the 123 sectors is close to zero at -0.05 (standard error 0.02). Across the 123 categories, the correlation between the frequency of price changes and the degree of serial correlation is 0.26 (s.e. 0.09). Thus, contrary to the predictions of the Calvo and Taylor models of price stickiness, goods with more frequent price changes exhibit inflation rates with *more* serial correlation. Consistent with the sticky-price models, however, goods with more frequent price changes display more volatile innovations to inflation (the correlation between the frequency of price changes and the standard deviation of inflation innovations is 0.68, s.e. 0.07).

Column B in Table 5 looks at monthly growth rates of real consumption spending. Here the predictions of sticky-price models are less clear. The models are typically written assuming that output is demand-determined in the presence of a preset price. Therefore, price rigidity tends to exaggerate sales responses to product demand shocks, but mute the impact of cost disturbances (e.g., Gali, 1999). For 1995 to 2000 aggregate real consumption growth across the 123 goods shows negative serial correlation at -0.32 (s.e. 0.12). Across the 123 categories, goods that exhibit more frequent price changes display more volatile but less persistent consumption growth rates.

Table 6 examines the patterns of persistence and volatility for the broader 1959 to 2000 period. Inflation was low and stable for the 1995 to 2000 period. The standard deviation of inflation for consumer goods was about 20% lower over 1995 to 2000 than over 1959 to 2000. Volatility of consumption growth was also lower, by about 12%. For inflation the drop in volatility reflects the fall in persistence of inflation, whereas for consumption growth it reflects a fall in the volatility of innovations.

Looking across the 123 goods, we see that inflation does show positive serial correlation over the longer period. But the magnitude of this persistence, averaging 0.26 (standard error 0.02) across goods, is fairly modest. There is a negative correlation between a good's frequency of price changes for 1995 to 1997 and its inflation persistence over 1959 to 2000, as anticipated by the sticky-price model. But it is small in magnitude and not statistically significant. The correlation between the frequency of price changes and the volatility of innovations to inflation is 0.52 (s.e. 0.08). This positive correlation is predicted by the Calvo and Taylor sticky-price models, as less frequent price changes should mute the volatility of inflation innovations. Alternatively, one could infer that sectors facing larger shocks choose to change prices more frequently.

Column B of Table 6 continues to look over 1959-2000, but at monthly growth rates of real consumption. Consumption growth rates show modestly negative serial correlation at the disaggregate level, and have more volatile innovations over this longer sample than over 1995 to 2000. Similar to the pattern for 1995 to 2000, goods with more frequent price changes have less persistent, but more volatile growth rates in consumption.

The correlations reported in Tables 5 and 6 do not convey the magnitude by which the inflation processes differ across the goods. For this reason, we regressed the estimated serial correlation and innovation standard error of inflation for each of the 123 goods on its frequency of price changes in the BLS data for 1995 to 1997. Table 7 presents the serial correlation ($\rho_i$) and volatility ($\sigma_i$) that these regressions imply for a good with monthly frequency of price changes of 48.5% (the 90th percentile of frequencies in our Table 1) versus one with frequency of 6.1% (the 10th percentile of frequencies in Table 1).

Column A of Table 7 gives results based on goods' 1995 to 2000 monthly inflation rates. Persistence is very low for both flexible-price and sticky-price goods. Persistence is actually higher for the flexible-price good ($\rho = 0.01$ versus $\rho = -0.11$). The standard deviation of inflation innovations is far higher, by a factor of eight, for the flexible-price good. Column B of Table 7 shows that consumption growth volatility is also greater for the flexible-price good. Consumption movements are more persistent for the sticky-price goods.

Results based on the broader 1959 to 2000 period appear in column C of Table 7. Now both goods show positive serial correlation in inflation and the persistence is larger, as expected, for goods with less frequent price changes. But note that persistence remains fairly modest and the greater persistence for the sticky-priced good is modest in size ($\rho = 0.28$, versus 0.24 for the flexible good) and not statistically significant. The patterns for consumption growth across flexible and sticky goods, reported in column D, largely parallel those for the shorter 1995-2000 sample period.

The results presented in Tables 5 through 7 are based on data that is *not* seasonally adjusted. We also examined the volatility and persistence of inflation with monthly seasonal dummies removed. The results for the persistence and volatility of inflation rates are remarkably similar to those presented without seasonally adjusting. Importantly, this implies that regular seasonal cycles in pricing (e.g., synchronized seasonal sales) do not generate the transience and volatility we see in goods' inflation rates.

*Inflation in the data vs. in Calvo and Taylor sticky-price models*

We argue that the workhorse models of price stickiness imply more persistent and less volatile inflation than we observe in the data. We find it is even more difficult for the models to explain the cross-good patterns we observe for persistence and variability of inflation. We illustrate these points in two ways. First, we take our staggered pricing model from section 3 and ask how goods' inflation and consumption growth respond to realistic aggregate monetary and technology shocks as well as sizable idiosyncratic technology shocks. We compare these responses to the patterns in the data described in Tables 5 through 7. Second, we focus on the pricing equation central to the Taylor and Calvo models of price stickiness. We find it is not possible to explain the volatility and transience of inflation rates for the 123 goods for reasonable depictions of time series for the marginal costs of producing. In sum, we do not see support for popular time-dependent models of price stickiness.[11]

These facts might be easier to reconcile with state-dependent models of price stickiness in which the frequency of price changes is endogenously greater in the presence of more volatile shocks. In these models, such as Willis (2000), firm price adjustments can be more synchronized in response to sectoral shocks, producing much larger inflation innovations and much less inflation persistence.

Employing the sticky-price model from section 3, we produce model statistics for persistence and volatility of inflation for goods with monthly frequencies of price change of 1/2 and 1/15. These statistics parallel those reported from the data in Table 7. For exposition, we first treat the case of only aggregate shocks to money growth and productivity. Calibrating to monthly M1 growth from 1959 to 2000, money growth exhibits a serial correlation of 0.52 with a standard deviation of innovations equal to 0.44%. We calibrate the growth rate of productivity to quarterly TFP growth for 1959 to 2000 (with parameters translated suitably to reflect an underlying monthly process). We treat the growth rate of TFP as *i.i.d.*, as this is consistent with the data. The standard deviation of its monthly innovation is 0.40%.

Results appear in column A of Table 8. The principal finding is that both the flexible and sticky good exhibit much greater inflation persistence in the model than is observed in the

[11] A number of papers discuss the difficulty faced by sticky-price models in generating persistent movements in output in response to monetary shocks (e.g., Erceg, Henderson, and Levin, 2000, Chari, Kehoe, and McGratten, 2000, Dotsey and King, 2001). This does not conflict with our statement that these models generate too much persistence in inflation. More related, Fuhrer and Moore (1995) contend that popular sticky-price models do not generate enough persistence in inflation. They focus on a setting in which firms face nominal marginal costs that are serially uncorrelated *in levels*. As we discuss below, this is highly counterfactual.

data. (The reported statistics reflect 100 separate stochastic simulations, with 480 monthly periods per simulation.) For both goods the serial correlation is approximately equal to (1–$\lambda_i$), where $\lambda_i$ is the good's monthly frequency of price changes. The mismatch with the data is particularly striking for the sticky-price good. Here the model predicts persistence of 0.91 (standard deviation 0.02 across simulations). By sharp contrast, the value for the data is only 0.28 for 1959-2000 and -0.11 for 1995-2000. The model does mimic the data in that inflation innovations are much more volatile for the flexible-price good. In fact, the model yields innovations to inflation that are six times as large (in terms of standard deviation) for the flexible good as for the sticky good. In the data this ratio is a factor of eight.

Column B of Table 8 provides similar model statistics, but for real consumption growth rates. The model predicts negative persistence in consumption growth that is fairly consistent with observed values (Table 7, columns B and D). The model does not capture, however, the much greater volatility of consumption for flexible-price goods in the data. This can potentially be solved by allowing for idiosyncratic shocks concentrated on these goods.

Column C of Table 8 allows for productivity shocks idiosyncratic to each good. These shocks are orthogonal to the aggregate shocks, as well as to shocks in the other sector. We calibrate the volatility and persistence of these shocks to the behavior of industry TFP for the 459 manufacturing industries in the NBER Productivity Database.[12] This yields an autocorrelation, in levels, of 0.98, with a standard deviation for innovations of 1.3%. Adding these idiosyncratic shocks has very little impact on inflation persistence in the model. Persistence ($\rho_i$) drops only to 0.47 from 0.48 for the flexible-price good, and only to 0.90 from 0.91 for the sticky-price good. Inflation innovations become about 50% more volatile. As a result, the variance of inflation in the model is fairly close to that observed in the data for both goods. The upshot is that the sticky-price model, calibrated to the frequency of price changes observed in the BLS panel, is not able to generate the low persistence of inflation we see in the data. This is particularly so for goods with less frequent price changes.

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[12] The NBER Productivity Database contains annual data for 1959 through 1996. We map the parameter values estimated from annual data to values for an underlying monthly process.

Column D of Table 8 considers the impact of the good-specific shocks on consumption growth rates. These real shocks particularly add volatility to consumption growth for the flexible-price good, and eliminate the negative persistence in its growth rate.

It is natural to ask if hitting the sticky-price sector with less persistent idiosyncratic shocks can enable the model to better fit the data. We explored a number of possibilities. The model's inability to capture the transience of inflation rates appears quite robust. Suppose, for instance, that sticky-price goods are subject to idiosyncratic productivity shocks with no serial correlation in levels (even though the industry TFP evidence is at odds with this assumption). Although this lowers the persistence of inflation, it also dramatically reduces the volatility of a good's inflation rate, as the sticky-price model predicts little response of prices to transitory shocks. If firms in a sector adjust their prices only every 15 months, they put little weight on shocks that are around for only a month or two. To overcome this the transitory shocks must be very large. To illustrate we chose the persistence and volatility of idiosyncratic shocks to each sector to match the persistence and volatility of inflation rates for both the flexible and sticky goods. Idiosyncratic productivity in the sticky-price sector must display serial correlation in levels of only 0.3 and must have the implausibly large monthly standard deviation of 59%.

*Inflation and realistic marginal cost processes*

The preceding exercises embedded staggered pricing in a particular general equilibrium model. The model featured money in the utility function and exogenous money supply growth, both calibrated in particular ways to the data (e.g., the latter to M1 growth). There is little consensus on how to model and calibrate money demand and monetary policy shocks, so we made these assumptions for simplicity rather than for realism. The model is special in other ways, affecting how marginal costs of production and, therefore, price changes respond to shocks. In particular, labor's share is one, with no role for capital or material inputs, and wages are assumed to be perfectly flexible.

We contend that the transience and volatility puzzles documented above are not simply a byproduct of the way we modeled money demand, shocks to monetary policy, wage setting, and so forth. Popular time-dependent models of infrequent price changes contain a strong force ratcheting up inflation persistence and holding down inflation volatility, relative to the underlying marginal cost of producing. Consider the Calvo (1983) model as outlined in Rotemberg (1987), Roberts (1995), and in many recent papers on price stickiness.[13] In each period firms in category *i* change their price with probability $\lambda_i$. This probability is fixed and therefore independent of how many periods have elapsed since a firm's last price change. Conditional on changing price in period $t$, firms set price as a markup over the average (discounted) marginal cost the firm expects to face over the duration of time the price remains in effect. The natural log of this price (minus the constant desired markup) is

$$x_{it} = [1-(1-\lambda_i\beta)] \sum_{\tau=0}^{\infty} (1-\lambda_i)^{\tau} \beta^{\tau} E_t(z_{it+\tau}) \ ,$$

where $z_{it}$ is marginal cost and $\beta$ is the discount factor. If shocks are not too large, the average price in category *i* at time $t$ is approximately

$$p_{it} = (1-\lambda_i)p_{it-1} + \lambda_i x_{it} \ ,$$

as each period $1-\lambda_i$ of the firms carry prices forward, with $\lambda_i$ setting their price at $x_{it}$.

To illustrate, suppose the log of marginal cost follows a random walk, an assumption that, as we discuss below, is roughly consistent with the evidence. In this case the model implies a process for inflation for good *i* of

[13] Although we focus on the Calvo formulation here, the discussion applies as well to Taylor models such as the one presented in section 3. The Taylor model shares critical features of the Calvo model: in any period many sellers do not adjust their prices, and those who do set their prices to reflect the expected discounted value of marginal cost viewed over a considerable time horizon. In the figures to follow we report on the ability of the Calvo model to fit the persistence and volatility of goods' inflation rates. We obtained very similar results when we conducted the same exercises with the Taylor model.

$$\pi_{it} = (1-\lambda_i)\pi_{it-1} + \lambda_i \varepsilon_{it} \ ,$$

where $\varepsilon_{it}$ is the i.i.d. growth rate of good *i*'s marginal cost. If price changes are infrequent (that is, $\lambda_i$ is well below one), the sticky-price model exerts a powerful force for creating persistence in inflation and sharply dampening its volatility. Across all consumer goods examined in section 2, the average monthly probability of price change is roughly 0.2. If, as an example, we reduce $\lambda_i$ from 1 (perfect price flexibility) to 0.2, the serial correlation in inflation implied by the model goes from zero to 0.8. At the same time, the standard deviation of innovations to the inflation process is reduced by 80% and the unconditional standard deviation of the inflation rate is reduced by two-thirds.

Figure 4 makes this point more generally. Across the 123 categories of consumer goods for which we have monthly time-series for inflation, the frequency of price changes (based on the BLS panel) varies from less than 0.05 to more than 0.70. The solid line graphs the serial correlation of monthly inflation predicted by the Calvo model as a function of this frequency of price change. Under the assumption that the growth rate of marginal cost is serially uncorrelated, this predicted serial correlation is simply one minus the frequency of price change. The figure also graphs the observed serial correlation for each of the 123 consumer goods for the shorter sample period January 1995 to June 2000. With only a few exceptions, the observed serial correlation falls far below the model's prediction. The average observed serial correlation is close to zero, whereas the average predicted value is around 0.8. For goods with frequencies of price change below the median value of 21%, no good exhibits a serial correlation in the data that is within 0.4 of the model's prediction.

Figure 5 repeats the exercise in Figure 4, except that it presents inflation's observed serial correlation over the entire 1959 to 2000 period. The goods' inflation rates are more often positively serial correlated for the longer sample period, as reported in Table 6. But, for all but a handful of goods, the observed persistence is well below that anticipated by the

Calvo model. In fact, the observed persistence is typically closer to zero than to the model's prediction, especially for goods with less frequent price changes.

Figures 4 and 5 presume a growth rate for marginal cost that is serially uncorrelated. Perhaps the failure of the Calvo model in these figures is an artifact of our assuming too much persistence in innovations to marginal cost. Addressing this question requires a measure of marginal cost, or at least its persistence. Bils (1987) creates a measure of movements of marginal cost under the assumption that output, $Y_{it}$, can be linked by a power function to at least one of its inputs, call it $N_{it}$:

$$Y_{it} = N_{it}^{\alpha} f_{it}(\text{all other inputs}) \ .$$

The Cobb-Douglas form is a special case for which any input can take the role of input *N*. Bils focuses on the case where *N* is production labor. Marginal cost can be expressed as the price of *N*, call it *W*, relative to *N*'s marginal product. For the production function above, the natural log of marginal cost is simply

$$z_{it} = ln(\alpha) + w_{it} + n_{it} - y_{it}$$

where *w*, *n*, and *y* refer to the natural logs of their upper case counterparts. Gali and Gertler (1999) and Sbordone (2002) also use this approach to construct a measure of marginal cost in order to judge the impact of price stickiness.

Suppose we treat labor as the relevant input, *n*, and measure *WN* simply as payments to labor.[14] In this case, $z_{it}$ is, up to a constant term, simply the natural log of the ratio of the wage bill to real output. The BLS publishes a quarterly time series on this ratio, labeled unit labor costs, for the aggregate business sector. We examined the persistence in the growth rate

[14] Bils (1987) argues against this assumption. If labor is quasi-fixed he shows that the marginal price of labor may be much more procyclical than the average wage rate paid to labor. We pursued the correction suggested there for calculating a marginal wage rate that reflects the marginal propensity to pay overtime premia. This does raise the volatility of innovations to marginal cost modestly. Across 459 industries, the average standard deviation of innovations to an AR(1) process for marginal cost estimated on annual data from 1959 to 1996 is increased by about 20 percent. The estimated serial correlation for marginal cost is only slightly reduced. Incorporting this adjustment alters little the results we depict in Figures 6 and 7 and describe below.

of this quarterly series. For our shorter sample period, 1995 to 2000, the growth rate of unit labor cost is actually positively serially correlated, but not significantly so. The AR(1) parameter is 0.12 with standard error 0.25. For the broader 1959 to 2000 sample the growth rate of unit labor cost is more serially correlated. The AR(1) parameter equals 0.41, with standard error 0.07. This is consistent with the observation from Tables 5 and 6 of greater serial correlation in inflation over the longer period. We obtained very similar results with the BLS series on unit labor costs for the nonfarm business sector as for the aggregate business sector. None of these estimates suggest less persistence in marginal cost than presumed by our assumption of a random walk for marginal cost. In fact, the persistence in the growth rate for this measure of marginal cost suggests the lack of persistence in inflation rates is even more problematic for the Calvo and Taylor models.

We also examined the persistence and volatility of unit labor cost as measured for 459 manufacturing industries in the *NBER Productivity Database*. The advantage of this source is that the data is much more disaggregate than the BLS measure of unit labor cost. The drawbacks are that it is only available annually and only for manufacturing. Manufacturing output is considerably more volatile than consumption. Also, average sales across the 459 manufacturing industries is an order of magnitude smaller than average consumption across the 123 categories. So there is reason to think that, if anything, marginal cost is more volatile for these manufacturing industries than for the consumption sectors.

For each of the 459 industries we estimated a separate AR(1) model for the log level of production workers' unit labor cost. Based on annual data for 1959 to 1996, the average AR(1) parameter is 0.98 (standard deviation 0.05 across industries) and the average standard error of innovations to marginal cost is 6.9% (standard deviation 3.1% across industries). This is not statistically different from a random walk.[15] If we take only the most recent third of the NBER data, years 1984 to 1996, the data show less persistence and less volatility in

[15] The implied monthly AR(1) process consistent with this annual evidence has a serial correlation of 0.997 and an innovation standard error of 2.5%. Estimates based on labor costs for all workers, not just production workers, yield almost the same results. Estimates based on unit materials cost also produce very similar results, with an average AR(1) parameter in annual data of 0.99 rather than 0.98.

unit labor cost. The average AR(1) parameter falls to 0.75 (standard deviation 0.27) and the average innovation standard error to 4.9% (standard deviation 2.6% across industries).[16]

Lastly, we compare these estimates to the behavior of marginal cost needed to explain the behavior of actual inflation rates for the 123 consumer goods. Figures 6 and 7 plot, with a point for each good, what persistence and volatility of marginal cost reconcile the Calvo model with the observed persistence and volatility of that good's inflation rate. Figure 6 is based on inflation rates for 1995 to 2000, Figure 7 on those for 1959 to 2000. The figures make clear that the popular time-dependent sticky-price models not only predict far too much persistence – they also predict far too little volatility.

Looking at Figure 6, to be consistent with observed inflation, many of the goods require little or no persistence in marginal cost in conjunction with tremendous volatility of innovations. In most cases marginal cost innovations need to exhibit a standard deviation well above 10% monthly. The figure employs three separate symbols for goods that rank among the stickiest third, middle third, and most flexible third according to their frequency of price changes in the BLS panel. The volatility required of marginal cost is enormous for goods with infrequent price changes. The figure also plots, for reference, the average persistence and volatility of marginal cost estimated for 1984 to 1996 of the *NBER Productivity Database*. Even if we move two standard deviations below the mean persistence and two standard deviations above the mean volatility, these values are far removed from what is needed for the Calvo model to fit the behavior of most goods' inflation rates.

Figure 7 shows the required marginal cost processes given goods' inflation rates over 1959 to 2000 (rather than 1995 to 2000). The figure also presents mean behavior of marginal cost based on years 1959-1996 of the *NBER Productivity Database*. Here a handful of goods do exhibit inflation rates that are consistent with the average estimated process for marginal costs. But, for the vast majority of goods, inflation is far too transient and its innovations far too volatile to be consistent with the Calvo model under plausible behavior for marginal cost.

[16] The implied monthly AR(1) process has serial correlation 0.96 and innovation standard error 2.1%.

Measurement error in the underlying BLS price quotes could conceivably explain the divergence between theory and evidence. Serially uncorrelated errors in price levels would contribute negative serial correlation to inflation, making inflation appear too transient. They would also, of course, add noise and make measured inflation more volatile. To fully reconcile the theory and evidence, however, such measurement error would have to be implausibly large. Prices are collected by different field agents at 22,000 outlets across 88 geographic areas, so measurement error is unlikely to be correlated across quotes. And given that the median number of quotes in a sector is 700 per month, uncorrelated errors should largely average out in the aggregation up to the sectoral level. To explain the low serial correlation of sectoral inflation rates (-0.05 in the data vs. 0.79 in theory), the standard deviation of measurement error at the quote level would have to be around 27% *conditional on a given price change*.[17] This is larger than the 25% average absolute size of price changes in Kackmeister's (2001) micro data. It also exceeds the "tolerances" in the BLS Data Collection Manual: field representatives must verify and explain changes in prices exceeding 20% for food items and 10% for other items.

In the above calculation, we assume measurement error only when the BLS field representative records a change from the previous price. BLS field agents must circle the previous price (shown on their collection sheets) if it is the same as the current price, presumably limiting the number of spurious price changes. When a field agent records no change in price when one has in fact occurred, however, this should contribute non-classical measurement error and mimic the predictions of the Calvo model. That is, such measurement error should affect the frequency of price changes and the sectoral inflation rates just like true price stickiness does in the Calvo model.

[17] The observed serial correlation should be a weighted average of 0.79 and -0.50, with the weights equal to the fraction of inflation variance coming from the signal and the noise, respectively. Noise would need to contribute 65.1% of the variance to drive inflation's serial correlation down from 0.79 to -0.05. In Table 6 the mean variance of inflation is 0.691%, so the standard deviation of measurement error in inflation would have to be 0.671%. Measurement error in the *level* of sectoral prices would need a standard deviation of 0.474% (= $\sqrt{0.5}$ x 0.671), and in the levels of individual prices it would need to be 12.5% (= $\sqrt{700}$ x 0.474). Finally, conditional on a price change the standard deviation would have to be 27.4% (= 12.5%/ $\sqrt{0.21}$ ).

As discussed in section 2, Kackmeister (2001) found that temporary price discounts were common for 49 food, home furnishing, and clothing items over 1997-1999. Temporary sales constituted 29% of all price changes in his data (each sale accounting for two price changes), with the average price discount equal to 30%. Temporary sales clearly work to reduce the persistence of price changes. Unless they are synchronized across sellers, however, they face the same difficulty as measurement errors in explaining the low persistence of inflation rates. We calculated the impact of temporary sales on the volatility and persistence of inflation rates based on Kackmeister's figures, which we view as a generous description of the importance of sales for our broader set of goods. Temporary sales of that magnitude would reduce the serial correlation for the median good from a model value of 0.79 to 0.57. This remains well above the average value in the data of -0.05. Furthermore, these temporary sales help much less in addressing the volatility puzzle. Eliminating the impact of these sales would reduce the standard deviation of the inflation rate by only about 11% for a good with the mean variability of inflation.

What about temporary sales that *are* synchronized across a sector? Can these address both the transience and volatility puzzles? As we noted earlier, seasonally-adjusted sectoral inflation rates show the same low persistence and high innovation volatility, so synchronized sales that reflect time-dependent pricing do not appear to explain our findings. More promising, we believe, are randomized and synchronized sales that cover a large fraction of a sector. Note, however, that such sales imply that sellers are conditioning on each other's pricing decisions; we view this as support for state-dependent pricing behavior. Importantly, synchronized sales cannot explain why the staggered-pricing model falls so far short in explaining the transience and volatility for goods that display infrequent price changes. The importance of temporary sales is limited for these goods, as otherwise they could not display such low frequency of price changes.

## 5. Conclusions

We have exploited unpublished data from the BLS for 1995 to 1997 on the monthly frequency of price changes for 350 categories of consumer goods and services. We found considerably more frequent price changes than have previous studies of producer prices or consumer prices based on narrower sets of goods. The time between price changes was 4.3 months or shorter for half of consumption. Taylor (1999, p.1020) summarized the prior literature as finding that prices typically change about once a year.

We examined whether time series for inflation are consistent with the workhorse Calvo and Taylor sticky-price models, given the frequency of price changes we observe. We found that, for nearly all consumer goods, these models predict inflation rates that are much more persistent and much less volatile than we observe. The models particularly over-predict persistence and under-predict volatility for goods with less frequent price changes.

A model with synchronized price changes within sectors might explain the volatility and transience of observed inflation rates. Synchronization might arise due to large sector-specific shocks under state-dependent pricing. Temporary price reductions could also help resolve the transience and volatility puzzles. Regular prices might behave more like the predictions of the Calvo and Taylor models. Purely seasonal sales would not do the trick, however, because seasonally-adjusted inflation rates exhibit the same low persistence and high volatility. Allowing for synchronized sales in models with state-dependent pricing appears more promising, as does variation in desired price markups more generally.

We have focused on implications of the popular Calvo and Taylor versions of sticky-price models. More elaborate sticky-price models may preserve the predictions of these models while better explaining the observed behavior of prices at the aggregate and good level. Sims (2001), for instance, models firms as actively responding to market-level information, yet choosing to largely ignore monetary policy variables. We believe that the behavior of prices we observe, particularly the volatility and transience of inflation rates for goods with infrequent price changes, should help in disciplining such models.

# Table 1

## The Frequency of Price Changes by Category

| Name | | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|---|
| Weighted Statistics: | Median | | 20.9 | 4.3 | 1.7 | 0.8 | | |
| | Mean | | 26.1 | 3.3 | 3.4 | 1.6 | | |
| Coin-operated apparel laundry and drycleaning | | 44012 | 1.2 | 79.9 | 0.53 | 0.17 | 0.148 | 0.21 |
| Vehicle inspection | | 52014 | 1.4 | 69.9 | 0.00 | 0.00 | 0.033 | 0.26 |
| Driver's license | | 52013 | 1.8 | 56.3 | 1.04 | 0.39 | 0.023 | 0.30 |
| Coin operated household laundry and drycleaning | | 34045 | 2.1 | 46.4 | 0.00 | 0.00 | 0.014 | 0.32 |
| Intracity mass transit | | 53031 | 2.5 | 40.2 | 0.66 | 0.14 | 0.223 | 0.64 |
| Local automobile registration | | 52012 | 2.8 | 34.8 | 3.26 | 0.66 | 0.019 | 0.67 |
| Legal fees | | 68011 | 2.9 | 34.3 | 0.48 | 0.37 | 0.289 | 1.09 |
| Vehicle tolls | | 52054 | 3.2 | 31.2 | 0.70 | 0.00 | 0.059 | 1.17 |
| Safe deposit box rental | | 68021 | 3.3 | 30.2 | 0.70 | 0.70 | 0.019 | 1.20 |
| Newspapers | | 59011 | 3.3 | 29.9 | 0.56 | 0.31 | 0.245 | 1.56 |
| Alterations and repairs | | 44013 | 3.3 | 29.4 | 0.36 | 0.25 | 0.022 | 1.59 |
| Automobile towing charges | | 52055 | 3.4 | 28.7 | 0.56 | 0.00 | 0.017 | 1.61 |
| Parking fees | | 52053 | 3.7 | 26.8 | 0.38 | 0.10 | 0.096 | 1.75 |
| Haircuts and other barber shop services for males | | 65021 | 3.9 | 25.5 | 0.19 | 0.11 | 0.162 | 1.99 |
| Beauty parlor services for females | | 65011 | 4.3 | 22.9 | 0.42 | 0.23 | 0.338 | 2.48 |
| State automobile registration | | 52011 | 4.3 | 22.7 | 1.00 | 0.22 | 0.278 | 2.88 |
| Services by other medical professionals | | 56041 | 4.5 | 22.0 | 0.83 | 0.62 | 0.217 | 3.19 |
| Hearing aids | | 55034 | 4.7 | 20.8 | 1.19 | 0.93 | 0.024 | 3.23 |
| Shoe repair and other shoe services | | 44011 | 4.8 | 20.4 | 0.63 | 0.57 | 0.009 | 3.24 |
| Garbage and trash collection | | 27041 | 4.9 | 20.0 | 0.89 | 0.44 | 0.249 | 3.60 |
| Pet services | | 62053 | 4.9 | 19.7 | 0.13 | 0.07 | 0.064 | 3.70 |
| Taxi fare | | 53032 | 5.0 | 19.7 | 0.33 | 0.04 | 0.045 | 3.76 |
| Care of invalids, elderly and convalescents in the home | | 34071 | 5.1 | 19.1 | 1.53 | 0.75 | 0.125 | 3.94 |
| Household laundry and drycleaning, excl coin operated | | 34044 | 5.1 | 19.0 | 0.61 | 0.54 | 0.039 | 4.00 |
| Watch and jewelry repair | | 44015 | 5.2 | 18.5 | 0.27 | 0.13 | 0.018 | 4.02 |
| Photographic and darkroom supplies | | 61022 | 5.3 | 18.4 | 2.41 | 1.71 | 0.005 | 4.03 |
| Physicians' services | | 56011 | 5.3 | 18.3 | 0.71 | 0.54 | 1.366 | 6.01 |
| Film processing | | 62052 | 5.3 | 18.2 | 1.17 | 0.87 | 0.101 | 6.16 |
| Wine away from home | | 20052 | 5.5 | 17.6 | 2.63 | 1.26 | 0.078 | 6.27 |
| Postage | | 34011 | 5.6 | 17.5 | 0.00 | 0.00 | 0.214 | 6.58 |
| Water softening service | | 34042 | 5.7 | 17.2 | 0.91 | 0.91 | 0.009 | 6.60 |
| Apparel laundry and drycleaning, excl coin operated | | 44021 | 5.7 | 17.0 | 0.21 | 0.17 | 0.269 | 6.99 |
| Plumbing supplies and equipment | | 24015 | 6.0 | 16.2 | 1.51 | 0.51 | 0.003 | 6.99 |
| Repair of television, radio and sound equipment | | 34061 | 6.1 | 16.0 | 0.39 | 0.16 | 0.026 | 7.03 |
| Dental services | | 56021 | 6.1 | 15.8 | 0.28 | 0.17 | 0.750 | 8.12 |
| Other entertainment services | | 62055 | 6.2 | 15.7 | 0.90 | 0.53 | 0.260 | 8.49 |
| Beer, ale, other alcoholic malt beverages away from home | | 20051 | 6.4 | 15.2 | 1.69 | 0.98 | 0.125 | 8.68 |
| Checking accounts and special check services | | 68022 | 6.4 | 15.2 | 1.27 | 0.56 | 0.088 | 8.80 |
| Intrastate telephone services | | 27061 | 6.4 | 15.2 | 0.16 | 0.04 | 0.460 | 9.47 |
| Veterinarian services | | 62054 | 6.5 | 14.9 | 0.66 | 0.59 | 0.182 | 9.74 |
| Domestic services | | 34031 | 6.5 | 14.9 | 0.82 | 0.60 | 0.310 | 10.19 |
| Club membership dues and fees | | 62011 | 6.7 | 14.5 | 1.23 | 0.85 | 0.340 | 10.68 |
| Elementary and high school books and supplies | | 66021 | 6.8 | 14.2 | 1.63 | 0.95 | 0.031 | 10.72 |
| Fees for lessons or instructions | | 62041 | 6.9 | 14.0 | 2.53 | 2.19 | 0.211 | 11.03 |
| Miscellaneous supplies and equipment | | 24041 | 7.1 | 13.7 | 2.26 | 0.93 | 0.044 | 11.09 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Cemetery lots and cripts | 68032 | 7.2 | 13.5 | 0.78 | 0.53 | 0.044 | 11.16 |
| Day care and nursery school | 67031 | 7.2 | 13.5 | 0.90 | 0.50 | 0.539 | 11.94 |
| Encyclopedias and other sets of reference books | 66022 | 7.5 | 12.9 | 3.70 | 0.09 | 0.005 | 11.95 |
| Technical and business school tuition and fixed fees | 67041 | 7.7 | 12.4 | 1.37 | 0.77 | 0.050 | 12.02 |
| Residential water and sewer service | 27021 | 7.9 | 12.1 | 0.86 | 0.41 | 0.663 | 12.98 |
| Distilled spirits away from home | 20053 | 7.9 | 12.1 | 1.10 | 0.58 | 0.114 | 13.15 |
| Tax return preparation and other accounting fees | 68023 | 8.3 | 11.6 | 0.76 | 0.61 | 0.147 | 13.36 |
| Breakfast or brunch | 19032 | 8.4 | 11.4 | 1.01 | 0.59 | 0.378 | 13.91 |
| Magazines | 59021 | 8.6 | 11.2 | 1.27 | 0.74 | 0.122 | 14.09 |
| Housing at school, excl board | 21031 | 8.7 | 11.0 | 0.83 | 0.45 | 0.197 | 14.37 |
| Admission to movies, theaters, and concerts | 62031 | 8.8 | 10.9 | 1.79 | 0.56 | 0.416 | 14.98 |
| Eyeglasses and eyecare | 56031 | 8.9 | 10.8 | 2.05 | 0.97 | 0.333 | 15.46 |
| Lunch | 19011 | 9.0 | 10.7 | 1.48 | 0.87 | 1.762 | 18.02 |
| Dinner | 19021 | 9.0 | 10.6 | 1.74 | 1.05 | 2.515 | 21.67 |
| Nonelectric articles for the hair | 64012 | 9.1 | 10.5 | 4.42 | 3.03 | 0.016 | 21.69 |
| Other information processing equipment | 69015 | 9.1 | 10.5 | 4.17 | 0.00 | 0.015 | 21.71 |
| Photographer fees | 62051 | 9.1 | 10.5 | 2.68 | 1.86 | 0.067 | 21.81 |
| Nursing and convalescent home care | 57022 | 9.2 | 10.4 | 1.12 | 0.72 | 0.024 | 21.85 |
| Elementary and high school tuition and fixed fees | 67021 | 9.3 | 10.2 | 0.50 | 0.17 | 0.312 | 22.30 |
| Moving, storage, freight expense | 34043 | 9.4 | 10.2 | 0.74 | 0.29 | 0.106 | 22.45 |
| Tenants' insurance | 35011 | 9.5 | 10.1 | 1.19 | 0.11 | 0.026 | 22.49 |
| Snacks and nonalcoholic beverages | 19031 | 9.5 | 10.0 | 1.87 | 1.25 | 0.414 | 23.09 |
| Tools and equipment for painting | 24012 | 9.7 | 9.8 | 4.55 | 1.81 | 0.001 | 23.09 |
| Inside home maintenance and repair services | 23011 | 9.8 | 9.7 | 0.96 | 0.60 | 0.085 | 23.21 |
| Supportive and convalescent medical equipment | 55033 | 9.8 | 9.7 | 3.14 | 1.58 | 0.013 | 23.23 |
| Medical equipment for general use | 55032 | 9.8 | 9.7 | 3.01 | 2.77 | 0.009 | 23.25 |
| Clothing rental | 44014 | 10.0 | 9.5 | 1.67 | 1.38 | 0.011 | 23.26 |
| College tuition and fixed fees | 67011 | 10.1 | 9.4 | 0.82 | 0.18 | 0.951 | 24.64 |
| Intercity train fare | 53022 | 10.2 | 9.3 | 0.07 | 0.05 | 0.068 | 24.74 |
| Plastic dinnerware | 32031 | 10.2 | 9.3 | 4.17 | 1.76 | 0.005 | 24.75 |
| College textbooks | 66011 | 10.2 | 9.3 | 2.68 | 1.55 | 0.128 | 24.93 |
| Electrical supplies, heating and cooling equipment | 24016 | 10.5 | 9.0 | 3.20 | 0.81 | 0.002 | 24.93 |
| Fees for participant sports | 62021 | 10.6 | 9.0 | 1.00 | 0.44 | 0.339 | 25.43 |
| Reupholstery of furniture | 34063 | 10.7 | 8.9 | 1.30 | 0.66 | 0.040 | 25.49 |
| Interstate telephone services | 27051 | 10.8 | 8.8 | 0.11 | 0.10 | 0.768 | 26.60 |
| Power tools | 32042 | 10.8 | 8.8 | 2.16 | 0.68 | 0.051 | 26.67 |
| Other hardware | 32043 | 10.8 | 8.7 | 2.81 | 1.30 | 0.052 | 26.75 |
| Nonpowered hand tools | 32044 | 10.9 | 8.6 | 2.84 | 1.70 | 0.030 | 26.79 |
| Cosmetics, bath/nail/make-up preparations & implements | 64031 | 11.1 | 8.5 | 2.65 | 1.47 | 0.362 | 27.32 |
| Kitchen and dining room linens | 28013 | 11.2 | 8.4 | 4.56 | 2.17 | 0.035 | 27.37 |
| Blacktop and masonry materials | 24014 | 11.2 | 8.4 | 1.36 | 0.00 | 0.001 | 27.37 |
| Stationery, stationery supplies, giftwrap | 33032 | 11.4 | 8.2 | 6.30 | 2.54 | 0.219 | 27.69 |
| Records and tapes, prerecorded and blank | 31033 | 11.4 | 8.2 | 4.95 | 1.03 | 0.179 | 27.95 |
| Hospital services | 57041 | 11.4 | 8.2 | 1.63 | 1.25 | 1.426 | 30.01 |
| Gardening and lawn care services | 34041 | 11.5 | 8.2 | 1.84 | 1.15 | 0.241 | 30.36 |
| Automotive maintenance and servicing | 49031 | 11.6 | 8.1 | 9.36 | 0.46 | 0.550 | 31.16 |
| Film | 61021 | 11.8 | 8.0 | 2.33 | 0.63 | 0.041 | 31.22 |
| Purchase of pets, pet supplies, and accessories | 61032 | 11.8 | 8.0 | 3.49 | 1.49 | 0.188 | 31.50 |
| Sewing notions and patterns | 42012 | 12.0 | 7.8 | 2.71 | 0.51 | 0.007 | 31.51 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Tableware and nonelectric kitchenware | 32038 | 12.0 | 7.8 | 5.82 | 3.02 | 0.064 | 31.60 |
| Laundry and cleaning equipment | 32014 | 12.3 | 7.6 | 5.55 | 2.44 | 0.042 | 31.66 |
| Books not purchased through book clubs | 59023 | 12.4 | 7.5 | 8.20 | 2.07 | 0.167 | 31.90 |
| Electric personal care appliances | 64017 | 12.6 | 7.4 | 6.26 | 3.39 | 0.014 | 31.92 |
| Calculators, adding machines, and typewriters | 69014 | 12.8 | 7.3 | 7.78 | 6.20 | 0.018 | 31.95 |
| Women's hosiery | 38043 | 12.9 | 7.2 | 2.78 | 0.77 | 0.082 | 32.07 |
| Clocks | 32021 | 13.0 | 7.2 | 5.92 | 2.74 | 0.012 | 32.08 |
| Videocassettes and discs, blank and prerecorded | 31022 | 13.0 | 7.2 | 6.66 | 1.68 | 0.084 | 32.21 |
| Deodorant/suntan preparations, sanitary/footcare products | 64016 | 13.2 | 7.1 | 2.39 | 1.04 | 0.090 | 32.34 |
| Coolant, brake fluid, transmission fluid, and additives | 47022 | 13.3 | 7.0 | 2.01 | 0.51 | 0.015 | 32.36 |
| Paint, wallpaper and supplies | 24011 | 13.3 | 7.0 | 1.81 | 0.61 | 0.011 | 32.37 |
| Hard surface floor covering | 24042 | 13.5 | 6.9 | 1.62 | 1.00 | 0.015 | 32.39 |
| Unpowered boats and trailers | 60012 | 13.5 | 6.9 | 4.70 | 0.44 | 0.055 | 32.47 |
| Telephone services, local charges | 27011 | 13.6 | 6.8 | 0.72 | 0.23 | 1.221 | 34.25 |
| Internal and respiratory over-the-counter drugs | 55021 | 13.7 | 6.8 | 1.82 | 1.35 | 0.257 | 34.62 |
| Dental products, nonelectric dental articles | 64014 | 13.8 | 6.7 | 2.30 | 1.24 | 0.078 | 34.73 |
| Toys, games and hobbies | 61011 | 13.9 | 6.7 | 6.58 | 2.67 | 0.403 | 35.32 |
| Infants' and toddlers' underwear | 41013 | 14.0 | 6.6 | 4.00 | 1.57 | 0.158 | 35.55 |
| Topicals and dressings | 55031 | 14.2 | 6.6 | 2.40 | 1.65 | 0.071 | 35.65 |
| Slipcovers and decorative pillows | 28015 | 14.2 | 6.5 | 7.69 | 2.28 | 0.015 | 35.67 |
| Distilled spirits at home (excl whiskey) | 20022 | 14.2 | 6.5 | 0.61 | 0.27 | 0.056 | 35.75 |
| Replacement of installed wall to wall carpet | 23013 | 14.3 | 6.5 | 5.61 | 4.48 | 0.024 | 35.79 |
| Floor coverings | 32011 | 14.4 | 6.4 | 4.19 | 2.17 | 0.057 | 35.87 |
| Funeral expenses | 68031 | 14.5 | 6.4 | 2.56 | 1.47 | 0.261 | 36.25 |
| Landscaping items | 24043 | 14.9 | 6.2 | 2.47 | 1.53 | 0.005 | 36.26 |
| Shaving products, nonelectric shaving articles | 64015 | 15.0 | 6.1 | 2.76 | 1.52 | 0.041 | 36.32 |
| Products for the hair | 64011 | 15.0 | 6.1 | 1.94 | 1.13 | 0.131 | 36.51 |
| Whiskey at home | 20021 | 15.3 | 6.0 | 0.54 | 0.25 | 0.050 | 36.58 |
| Automobile insurance | 50011 | 15.5 | 5.9 | 1.51 | 0.12 | 2.460 | 40.15 |
| Lawn and garden supplies | 33052 | 15.5 | 5.9 | 3.54 | 1.68 | 0.200 | 40.44 |
| Vehicle parts and equipment other than tires | 48021 | 15.8 | 5.8 | 3.84 | 1.02 | 0.260 | 40.82 |
| Other laundry and cleaning products | 33012 | 15.9 | 5.8 | 1.81 | 0.99 | 0.145 | 41.03 |
| Infants' equipment | 32013 | 15.9 | 5.8 | 5.32 | 2.48 | 0.013 | 41.04 |
| Nonelectric cookingware | 32037 | 16.1 | 5.7 | 5.28 | 2.30 | 0.034 | 41.09 |
| Music instruments and accessories | 61013 | 16.2 | 5.7 | 3.06 | 1.12 | 0.064 | 41.19 |
| Photographic equipment | 61023 | 16.4 | 5.6 | 4.47 | 1.58 | 0.042 | 41.25 |
| Candy and chewing gum | 15011 | 16.4 | 5.6 | 2.10 | 1.03 | 0.237 | 41.59 |
| Computer software and accessories | 69012 | 16.5 | 5.5 | 5.53 | 2.57 | 0.067 | 41.69 |
| Household decorative items | 32023 | 16.6 | 5.5 | 8.12 | 4.24 | 0.213 | 42.00 |
| Indoor, warm weather and winter sports equipment | 60021 | 16.6 | 5.5 | 5.01 | 2.12 | 0.255 | 42.37 |
| Tobacco products other than cigarettes | 63012 | 16.7 | 5.5 | 0.96 | 0.75 | 0.063 | 42.46 |
| Prescription drugs and medical supplies | 54011 | 16.8 | 5.4 | 1.22 | 0.62 | 0.648 | 43.40 |
| Miscellaneous household products | 33051 | 16.8 | 5.4 | 2.21 | 1.01 | 0.272 | 43.80 |
| Repair of household appliances | 34062 | 16.9 | 5.4 | 0.60 | 0.29 | 0.014 | 43.82 |
| Fabric for making clothes | 42011 | 17.0 | 5.4 | 3.96 | 0.86 | 0.018 | 43.84 |
| Boys' underwear, nightwear and hosiery | 37014 | 17.1 | 5.3 | 3.20 | 0.42 | 0.034 | 43.89 |
| Hunting, fishing, and camping equipment | 60022 | 17.1 | 5.3 | 4.27 | 1.66 | 0.064 | 43.98 |
| Boys' accessories | 37015 | 17.2 | 5.3 | 5.33 | 1.54 | 0.020 | 44.01 |
| Infants' furniture | 29042 | 17.5 | 5.2 | 4.76 | 1.60 | 0.025 | 44.05 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Pet food | 61031 | 17.5 | 5.2 | 2.13 | 0.80 | 0.251 | 44.41 |
| Men's underwear and hosiery | 36031 | 17.6 | 5.2 | 2.31 | 0.40 | 0.114 | 44.58 |
| Salt and other seasonings and spices | 18041 | 17.6 | 5.2 | 1.41 | 0.64 | 0.070 | 44.68 |
| Sewing materials for household items | 28016 | 17.7 | 5.1 | 2.45 | 0.71 | 0.036 | 44.73 |
| Men's nightwear | 36032 | 17.8 | 5.1 | 5.37 | 0.70 | 0.013 | 44.75 |
| Telephone, peripheral equipment and accessories | 69013 | 17.8 | 5.1 | 4.79 | 3.24 | 0.065 | 44.84 |
| Books purchased through book clubs | 59022 | 17.9 | 5.1 | 7.56 | 3.12 | 0.031 | 44.89 |
| Indoor plants and fresh cut flowers | 32061 | 18.0 | 5.0 | 4.88 | 3.07 | 0.164 | 45.13 |
| Flatware | 32033 | 18.3 | 4.9 | 3.91 | 1.93 | 0.014 | 45.15 |
| Glassware | 32034 | 18.4 | 4.9 | 5.12 | 2.44 | 0.014 | 45.17 |
| Automotive brake work | 49022 | 18.5 | 4.9 | 9.94 | 1.25 | 0.141 | 45.37 |
| Automotive drive train repair | 49021 | 18.5 | 4.9 | 9.65 | 1.13 | 0.178 | 45.63 |
| Men's accessories | 36033 | 18.7 | 4.8 | 4.62 | 0.78 | 0.130 | 45.82 |
| Watches | 43011 | 18.8 | 4.8 | 5.08 | 1.32 | 0.069 | 45.92 |
| Living room tables | 29032 | 18.8 | 4.8 | 4.13 | 2.55 | 0.063 | 46.01 |
| Portable cool/heat equip., small electric kitchen appliances | 32052 | 19.0 | 4.8 | 5.15 | 2.02 | 0.078 | 46.13 |
| Soaps and detergents | 33011 | 19.2 | 4.7 | 3.16 | 2.05 | 0.214 | 46.44 |
| Wine at home | 20031 | 19.3 | 4.7 | 3.24 | 0.84 | 0.187 | 46.71 |
| Lamps and lighting fixtures | 32022 | 19.4 | 4.6 | 6.26 | 2.61 | 0.035 | 46.76 |
| Repair to steering, front end, cooling system and A/C | 49023 | 19.5 | 4.6 | 10.18 | 1.26 | 0.154 | 46.98 |
| Community antenna or cable TV | 27031 | 19.6 | 4.6 | 1.91 | 0.20 | 0.784 | 48.12 |
| Bicycles | 60013 | 19.6 | 4.6 | 6.94 | 1.10 | 0.047 | 48.19 |
| Automotive body work | 49011 | 19.7 | 4.6 | 10.11 | 1.45 | 0.098 | 48.33 |
| Window coverings | 32012 | 19.9 | 4.5 | 2.13 | 0.71 | 0.038 | 48.39 |
| Other condiments (excl olives, pickles, relishes) | 18044 | 20.1 | 4.5 | 0.95 | 0.51 | 0.054 | 48.46 |
| Rolls, biscuits, muffins (excl frozen) | 2022 | 20.1 | 4.5 | 2.48 | 1.35 | 0.135 | 48.66 |
| Intercity bus fare | 53021 | 20.3 | 4.4 | 1.31 | 0.09 | 0.051 | 48.73 |
| China and other dinnerware | 32032 | 20.4 | 4.4 | 5.19 | 2.34 | 0.042 | 48.79 |
| Outboard motors and powered sports vehicles | 60011 | 20.5 | 4.3 | 6.98 | 0.96 | 0.176 | 49.05 |
| Sweet rolls, coffee cake and doughnuts (excl frozen) | 2063 | 20.6 | 4.3 | 4.06 | 2.68 | 0.073 | 49.16 |
| Canned ham | 4032 | 20.7 | 4.3 | 3.45 | 2.06 | 0.007 | 49.17 |
| Bedroom furniture other than mattress and springs | 29012 | 20.8 | 4.3 | 4.35 | 2.30 | 0.193 | 49.45 |
| Occasional furniture | 29044 | 20.9 | 4.3 | 4.92 | 3.25 | 0.125 | 49.63 |
| Beer, ale, and other alcoholic malt | 20011 | 20.9 | 4.3 | 1.03 | 0.36 | 0.308 | 50.07 |
| Baby food | 18062 | 20.9 | 4.3 | 1.03 | 0.33 | 0.088 | 50.20 |
| Cakes and cupcakes (excl frozen) | 2041 | 21.0 | 4.3 | 3.49 | 2.12 | 0.119 | 50.37 |
| Nondairy cream substitutes | 16013 | 21.0 | 4.2 | 1.11 | 0.57 | 0.024 | 50.41 |
| Tea | 17052 | 21.0 | 4.2 | 1.09 | 0.53 | 0.057 | 50.49 |
| Automotive power plant repair | 49041 | 21.1 | 4.2 | 10.09 | 1.75 | 0.404 | 51.08 |
| Other noncarbonated drinks | 17053 | 21.1 | 4.2 | 2.21 | 0.88 | 0.069 | 51.18 |
| Lumber, paneling, wall and ceiling tile, awnings, glass | 24013 | 21.6 | 4.1 | 1.68 | 0.67 | 0.006 | 51.19 |
| Nuts | 18032 | 21.6 | 4.1 | 2.28 | 1.23 | 0.062 | 51.28 |
| Cigarettes | 63011 | 21.6 | 4.1 | 0.35 | 0.22 | 0.801 | 52.44 |
| Mattress and springs | 29011 | 21.9 | 4.1 | 5.44 | 2.36 | 0.146 | 52.65 |
| Smoking accessories | 63013 | 21.9 | 4.0 | 3.83 | 0.00 | 0.004 | 52.66 |
| Women's underwear | 38042 | 22.1 | 4.0 | 3.28 | 0.77 | 0.108 | 52.81 |
| Men's footwear | 40011 | 22.2 | 4.0 | 4.84 | 0.79 | 0.348 | 53.32 |
| Other sweets (excl candy and gum) | 15012 | 22.5 | 3.9 | 1.95 | 1.16 | 0.075 | 53.43 |
| Admission to sporting events | 62032 | 22.6 | 3.9 | 4.80 | 3.64 | 0.155 | 53.65 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Bathroom linens | 28011 | 22.6 | 3.9 | 3.40 | 1.10 | 0.055 | 53.73 |
| Serving pieces other than silver or glass | 32036 | 22.9 | 3.9 | 5.30 | 3.98 | 0.005 | 53.74 |
| Sugar and artificial sweeteners | 15021 | 22.9 | 3.8 | 1.30 | 0.70 | 0.073 | 53.84 |
| Girls' hosiery and accessories | 39017 | 23.0 | 3.8 | 7.01 | 2.17 | 0.030 | 53.89 |
| Lawn and garden equipment | 32041 | 23.1 | 3.8 | 5.92 | 1.02 | 0.131 | 54.08 |
| Video game hardware, software and accessories | 31023 | 23.4 | 3.8 | 10.15 | 5.65 | 0.051 | 54.15 |
| Jewelry | 43021 | 23.4 | 3.7 | 4.86 | 1.76 | 0.401 | 54.73 |
| Curtains and drapes | 28014 | 24.0 | 3.6 | 3.25 | 1.08 | 0.057 | 54.81 |
| Kitchen and dining room furniture | 29041 | 24.1 | 3.6 | 5.47 | 3.40 | 0.163 | 55.05 |
| Cleansing and toilet tissue, paper towels, napkins | 33031 | 24.2 | 3.6 | 3.37 | 2.25 | 0.208 | 55.35 |
| Girls' footwear | 40022 | 24.2 | 3.6 | 7.43 | 1.27 | 0.119 | 55.52 |
| Sofas | 29021 | 24.2 | 3.6 | 6.73 | 3.50 | 0.277 | 55.93 |
| New motorcycles | 45031 | 24.3 | 3.6 | 9.30 | 1.31 | 0.082 | 56.04 |
| Instant and freeze dried coffee | 17032 | 24.3 | 3.6 | 1.17 | 0.67 | 0.056 | 56.13 |
| Girls' underwear and nightwear | 39016 | 24.4 | 3.6 | 6.80 | 1.77 | 0.026 | 56.16 |
| Other processed vegetables | 14023 | 24.6 | 3.5 | 2.04 | 0.40 | 0.113 | 56.33 |
| Other fuels | 25023 | 24.8 | 3.5 | 0.71 | 0.29 | 0.014 | 56.35 |
| Canned and dried fruits | 13031 | 24.9 | 3.5 | 2.10 | 0.68 | 0.068 | 56.45 |
| Noncarbonated fruit flavored drinks | 17051 | 25.0 | 3.5 | 2.20 | 0.92 | 0.088 | 56.58 |
| Other fats and oils | 16012 | 25.3 | 3.4 | 1.16 | 0.46 | 0.172 | 56.83 |
| Outdoor equipment | 32015 | 25.3 | 3.4 | 8.33 | 6.19 | 0.014 | 56.85 |
| Macaroni and cornmeal | 1032 | 25.5 | 3.4 | 1.22 | 0.65 | 0.094 | 56.98 |
| Cereal | 1021 | 25.5 | 3.4 | 1.69 | 0.87 | 0.333 | 57.47 |
| Radio, phonographs and taperecorders/players | 31031 | 25.5 | 3.4 | 7.80 | 4.96 | 0.030 | 57.51 |
| Pies, tarts, turnovers (excl frozen) | 2065 | 25.6 | 3.4 | 5.47 | 2.05 | 0.044 | 57.57 |
| White bread | 2011 | 25.7 | 3.4 | 1.48 | 0.83 | 0.124 | 57.75 |
| Truck rental | 52052 | 25.7 | 3.4 | 1.60 | 0.25 | 0.287 | 58.17 |
| Canned beans other than lima beans | 14021 | 25.8 | 3.3 | 1.79 | 0.37 | 0.037 | 58.22 |
| Boys' suits, sportcoats, and pants | 37016 | 25.9 | 3.3 | 4.82 | 1.22 | 0.119 | 58.40 |
| Men's suits | 36011 | 26.0 | 3.3 | 3.27 | 1.03 | 0.126 | 58.58 |
| Canned and packaged soup | 18011 | 26.3 | 3.3 | 1.48 | 0.69 | 0.108 | 58.73 |
| Lamb, organ meats, and game | 5014 | 26.4 | 3.3 | 1.88 | 0.82 | 0.044 | 58.80 |
| Men's pants and shorts | 36051 | 26.4 | 3.3 | 3.39 | 0.84 | 0.242 | 59.15 |
| Women's accessories | 38044 | 26.4 | 3.3 | 11.10 | 2.02 | 0.057 | 59.23 |
| Rice | 1031 | 26.5 | 3.2 | 1.10 | 0.58 | 0.073 | 59.34 |
| Canned or packaged salads and desserts | 18061 | 26.6 | 3.2 | 2.12 | 1.05 | 0.079 | 59.45 |
| Living room chairs | 29031 | 26.7 | 3.2 | 7.05 | 3.17 | 0.136 | 59.65 |
| Infants' and toddlers' sleepwear | 41014 | 26.9 | 3.2 | 7.37 | 1.42 | 0.014 | 59.67 |
| Other dairy products | 10012 | 26.9 | 3.2 | 1.48 | 0.58 | 0.077 | 59.78 |
| Bedroom linens | 28012 | 27.0 | 3.2 | 5.02 | 1.60 | 0.170 | 60.03 |
| Prepared Flour Mixes | 1012 | 27.1 | 3.2 | 2.14 | 0.85 | 0.043 | 60.09 |
| Other frozen fruits and fruit juices | 13012 | 27.1 | 3.2 | 1.28 | 0.55 | 0.025 | 60.13 |
| Canned fish or seafood | 7011 | 27.4 | 3.1 | 1.80 | 0.75 | 0.058 | 60.21 |
| Sauces and gravies | 18043 | 27.6 | 3.1 | 1.01 | 0.55 | 0.134 | 60.41 |
| Margarine | 16011 | 27.9 | 3.1 | 1.48 | 0.39 | 0.043 | 60.47 |
| Bologna, liverwurst, salami | 5012 | 28.0 | 3.0 | 2.02 | 1.22 | 0.085 | 60.59 |
| Ship fares | 53023 | 28.0 | 3.0 | 4.78 | 1.10 | 0.101 | 60.74 |
| Women's footwear | 40031 | 28.0 | 3.0 | 6.80 | 1.62 | 0.424 | 61.35 |
| Other canned or packaged foods | 18063 | 28.1 | 3.0 | 1.80 | 0.76 | 0.223 | 61.68 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Olives, pickles, relishes | 18042 | 28.1 | 3.0 | 1.50 | 0.71 | 0.035 | 61.73 |
| Dryers | 30022 | 28.5 | 3.0 | 5.43 | 0.21 | 0.042 | 61.79 |
| Automobile finance charges | 51011 | 28.6 | 3.0 | 1.84 | 0.04 | 0.493 | 62.50 |
| Lunchmeats | 5013 | 28.7 | 3.0 | 2.79 | 1.08 | 0.150 | 62.72 |
| Microwave ovens | 30032 | 29.0 | 2.9 | 8.16 | 1.39 | 0.030 | 62.77 |
| Potato chips and other snacks | 18031 | 29.1 | 2.9 | 2.62 | 1.57 | 0.212 | 63.07 |
| Boys' footwear | 40021 | 29.7 | 2.8 | 9.51 | 1.26 | 0.094 | 63.21 |
| Bread other than white | 2021 | 29.7 | 2.8 | 2.07 | 1.27 | 0.137 | 63.41 |
| Outdoor furniture | 29043 | 29.8 | 2.8 | 9.88 | 4.63 | 0.040 | 63.47 |
| Window air conditioners | 30034 | 29.9 | 2.8 | 7.22 | 2.00 | 0.039 | 63.52 |
| Men's sportcoats and tailored jackets | 36012 | 30.1 | 2.8 | 4.47 | 1.39 | 0.030 | 63.57 |
| Frozen bakery products | 2064 | 30.3 | 2.8 | 2.68 | 1.22 | 0.076 | 63.68 |
| Tires | 48011 | 30.5 | 2.7 | 2.72 | 0.58 | 0.290 | 64.10 |
| Men's coats and jackets | 36013 | 30.9 | 2.7 | 8.28 | 2.51 | 0.116 | 64.27 |
| Frozen vegetables | 14011 | 31.0 | 2.7 | 1.95 | 0.79 | 0.099 | 64.41 |
| Peanut butter | 16014 | 31.0 | 2.7 | 1.10 | 0.48 | 0.040 | 64.47 |
| Televisions | 31011 | 31.0 | 2.7 | 9.03 | 3.61 | 0.269 | 64.86 |
| Floor covering equipment and sewing machines | 32051 | 31.1 | 2.7 | 7.45 | 1.56 | 0.060 | 64.94 |
| Video cassette recorders, disc players, cameras | 31021 | 31.2 | 2.7 | 10.70 | 4.09 | 0.095 | 65.08 |
| Portable dishwashers | 30033 | 31.2 | 2.7 | 3.65 | 2.50 | 0.002 | 65.08 |
| Ice cream and related products | 10041 | 31.4 | 2.7 | 1.96 | 0.96 | 0.178 | 65.34 |
| Bread and cracker products | 2062 | 31.5 | 2.6 | 1.99 | 1.99 | 0.014 | 65.36 |
| Women's pants and shorts | 38033 | 31.5 | 2.6 | 7.71 | 2.44 | 0.345 | 65.86 |
| Other fresh milk and cream | 9021 | 31.6 | 2.6 | 1.08 | 0.22 | 0.222 | 66.19 |
| Flour | 1011 | 31.7 | 2.6 | 0.75 | 0.38 | 0.029 | 66.23 |
| Bottled or tank gas | 25021 | 31.7 | 2.6 | 0.69 | 0.38 | 0.055 | 66.31 |
| Canned cut corn | 14022 | 31.9 | 2.6 | 0.91 | 0.29 | 0.023 | 66.34 |
| Luggage | 42013 | 31.9 | 2.6 | 6.21 | 2.62 | 0.034 | 66.39 |
| Carbonated drinks other than cola | 17012 | 32.4 | 2.6 | 1.99 | 0.91 | 0.146 | 66.60 |
| Motor oil | 47021 | 32.7 | 2.5 | 1.00 | 0.33 | 0.045 | 66.67 |
| Men's shirts | 36041 | 32.7 | 2.5 | 6.20 | 1.55 | 0.270 | 67.06 |
| Cheese | 10021 | 32.9 | 2.5 | 1.82 | 0.85 | 0.307 | 67.50 |
| Stoves and ovens excluding microwave ovens | 30031 | 33.0 | 2.5 | 7.45 | 1.09 | 0.037 | 67.56 |
| Girls' skirts and pants | 39014 | 33.2 | 2.5 | 10.10 | 3.28 | 0.076 | 67.67 |
| Refrigerators and home freezers | 30011 | 33.5 | 2.5 | 7.14 | 0.85 | 0.106 | 67.82 |
| Cookies | 2042 | 33.7 | 2.4 | 2.27 | 1.51 | 0.157 | 68.05 |
| Fresh, canned, or bottled fruit juices | 13013 | 33.7 | 2.4 | 2.28 | 1.03 | 0.210 | 68.35 |
| Playground equipment | 61012 | 33.8 | 2.4 | 12.07 | 8.25 | 0.007 | 68.36 |
| Components and other sound equipment | 31032 | 34.1 | 2.4 | 9.25 | 5.42 | 0.132 | 68.56 |
| Frozen orange juice | 13011 | 34.4 | 2.4 | 0.95 | 0.43 | 0.030 | 68.60 |
| Fresh whole milk | 9011 | 34.4 | 2.4 | 0.79 | 0.12 | 0.201 | 68.89 |
| Washers | 30021 | 35.4 | 2.3 | 6.80 | 0.65 | 0.057 | 68.97 |
| Other poultry | 6031 | 36.0 | 2.2 | 5.38 | 0.96 | 0.129 | 69.16 |
| Frankfurters | 5011 | 36.1 | 2.2 | 2.22 | 0.92 | 0.077 | 69.27 |
| Boys' shirts | 37013 | 36.2 | 2.2 | 10.17 | 3.24 | 0.063 | 69.36 |
| Infants' and toddlers' play and dresswear | 41012 | 36.3 | 2.2 | 14.68 | 4.60 | 0.049 | 69.43 |
| Other beef | 3043 | 36.4 | 2.2 | 0.94 | 0.75 | 0.053 | 69.51 |
| Frozen prepared foods other than meals | 18022 | 36.5 | 2.2 | 2.24 | 1.15 | 0.158 | 69.74 |
| Shellfish (excl canned) | 7021 | 37.0 | 2.2 | 2.39 | 1.22 | 0.124 | 69.92 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Roasted coffee | 17031 | 37.1 | 2.2 | 1.36 | 0.68 | 0.103 | 70.07 |
| Frozen prepared meals | 18021 | 37.4 | 2.1 | 3.53 | 1.72 | 0.072 | 70.17 |
| New trucks | 45021 | 37.7 | 2.1 | 10.80 | 9.04 | 1.953 | 73.01 |
| Men's active sportswear | 36035 | 37.8 | 2.1 | 10.80 | 2.14 | 0.061 | 73.10 |
| Pork sausage | 4042 | 37.9 | 2.1 | 1.40 | 0.63 | 0.077 | 73.21 |
| Lodging while out of town | 21021 | 38.1 | 2.1 | 1.80 | 0.52 | 1.571 | 75.49 |
| Personal computers and peripheral equipment | 69011 | 38.4 | 2.1 | 16.12 | 7.79 | 0.488 | 76.19 |
| Infants' and toddlers' outerwear | 41011 | 38.6 | 2.1 | 19.32 | 7.70 | 0.011 | 76.21 |
| Cola drinks | 17011 | 38.8 | 2.0 | 0.91 | 0.42 | 0.306 | 76.66 |
| New cars | 45011 | 39.1 | 2.0 | 10.26 | 8.11 | 2.747 | 80.64 |
| Women's coats and jackets | 38011 | 39.2 | 2.0 | 14.86 | 6.93 | 0.155 | 80.87 |
| Fresh whole chicken | 6011 | 39.4 | 2.0 | 2.12 | 0.14 | 0.088 | 80.99 |
| Women's nightwear | 38041 | 40.6 | 1.9 | 15.50 | 3.04 | 0.088 | 81.12 |
| Fresh or frozen chicken parts | 6021 | 40.7 | 1.9 | 1.39 | 0.38 | 0.273 | 81.52 |
| Apples | 11011 | 41.4 | 1.9 | 0.18 | 0.04 | 0.102 | 81.67 |
| Other roast (excl chuck and round) | 3041 | 42.2 | 1.8 | 0.93 | 0.75 | 0.050 | 81.74 |
| Fish (excl canned) | 7022 | 42.4 | 1.8 | 2.55 | 1.42 | 0.167 | 81.98 |
| Crackers | 2061 | 42.5 | 1.8 | 1.53 | 0.91 | 0.075 | 82.09 |
| Girls' tops | 39013 | 42.7 | 1.8 | 17.00 | 5.47 | 0.070 | 82.19 |
| Women's skirts | 38032 | 42.9 | 1.8 | 16.69 | 7.81 | 0.071 | 82.30 |
| Bananas | 11021 | 43.0 | 1.8 | 0.07 | 0.03 | 0.106 | 82.45 |
| Electricity | 26011 | 43.4 | 1.8 | 0.64 | 0.08 | 2.884 | 86.63 |
| Bacon | 4011 | 43.5 | 1.7 | 1.51 | 0.74 | 0.071 | 86.74 |
| Girls' active sportswear | 39015 | 43.6 | 1.7 | 18.93 | 5.51 | 0.033 | 86.78 |
| Girls' coats and jackets | 39011 | 43.8 | 1.7 | 19.43 | 6.02 | 0.023 | 86.82 |
| Women's active sportswear | 38034 | 44.6 | 1.7 | 17.26 | 3.43 | 0.092 | 86.95 |
| Women's tops | 38031 | 45.0 | 1.7 | 17.94 | 6.93 | 0.471 | 87.63 |
| Men's sweaters | 36034 | 45.3 | 1.7 | 13.53 | 4.85 | 0.046 | 87.70 |
| Butter | 10011 | 45.5 | 1.6 | 0.90 | 0.24 | 0.042 | 87.76 |
| Boys' coats and jackets | 37011 | 45.7 | 1.6 | 15.27 | 5.81 | 0.024 | 87.80 |
| Ground beef | 3011 | 46.1 | 1.6 | 0.67 | 0.32 | 0.288 | 88.21 |
| Boys' active sportswear | 37017 | 46.6 | 1.6 | 19.12 | 3.96 | 0.027 | 88.25 |
| Pork roast, picnics, other pork | 4041 | 46.8 | 1.6 | 1.44 | 0.75 | 0.131 | 88.44 |
| Other steak (excl round and sirloin) | 3042 | 46.8 | 1.6 | 0.72 | 0.53 | 0.156 | 88.67 |
| Diesel | 47017 | 47.2 | 1.6 | 0.70 | 0.03 | 0.254 | 89.04 |
| Potatoes | 12011 | 47.3 | 1.6 | 0.41 | 0.13 | 0.098 | 89.18 |
| Women's suits | 38051 | 47.3 | 1.6 | 19.45 | 8.45 | 0.123 | 89.36 |
| Pork chops | 4021 | 47.9 | 1.5 | 0.35 | 0.19 | 0.138 | 89.56 |
| Round steak | 3051 | 48.2 | 1.5 | 0.62 | 0.46 | 0.060 | 89.65 |
| Sirloin steak | 3061 | 48.4 | 1.5 | 0.65 | 0.48 | 0.084 | 89.77 |
| Boys' sweaters | 37012 | 48.4 | 1.5 | 17.18 | 5.47 | 0.007 | 89.78 |
| Women's dresses | 38021 | 48.5 | 1.5 | 25.44 | 11.08 | 0.296 | 90.21 |
| Ham (excl canned) | 4031 | 50.4 | 1.4 | 4.00 | 2.03 | 0.118 | 90.38 |
| Fuel oil | 25011 | 52.5 | 1.3 | 0.40 | 0.18 | 0.169 | 90.63 |
| Other fresh vegetables | 12041 | 52.8 | 1.3 | 0.17 | 0.07 | 0.250 | 90.99 |
| Round roast | 3031 | 53.1 | 1.3 | 0.48 | 0.40 | 0.045 | 91.05 |
| Chuck roast | 3021 | 54.3 | 1.3 | 0.76 | 0.65 | 0.043 | 91.12 |
| Oranges | 11031 | 54.7 | 1.3 | 0.45 | 0.11 | 0.057 | 91.20 |
| Girls' dresses and suits | 39012 | 55.1 | 1.2 | 28.49 | 12.80 | 0.045 | 91.26 |

# Table 1

## The Frequency of Price Changes by Category

| Name | ELI | Freq | Mo | Subs | NSub | Wgt | CDF |
|---|---|---|---|---|---|---|---|
| Automobile rental | 52051 | 56.8 | 1.2 | 2.86 | 0.40 | 0.758 | 92.36 |
| Other fresh fruits | 11041 | 59.7 | 1.1 | 0.24 | 0.08 | 0.247 | 92.72 |
| Other motor fuel | 47018 | 61.8 | 1.0 | 4.46 | 1.80 | 0.032 | 92.77 |
| Eggs | 8011 | 61.8 | 1.0 | 0.64 | 0.26 | 0.107 | 92.92 |
| Lettuce | 12021 | 62.4 | 1.0 | 0.06 | 0.05 | 0.064 | 93.02 |
| Utility natural gas service | 26021 | 64.2 | 1.0 | 0.34 | 0.08 | 1.012 | 94.48 |
| Airline fares | 53011 | 69.1 | 0.9 | 0.45 | 0.25 | 0.829 | 95.69 |
| Tomatoes | 12031 | 71.0 | 0.8 | 0.22 | 0.03 | 0.078 | 95.80 |
| Premium unleaded gasoline | 47016 | 76.2 | 0.7 | 2.81 | 0.89 | 0.998 | 97.25 |
| Mid-grade unleaded gasoline | 47015 | 77.5 | 0.7 | 2.55 | 0.82 | 0.865 | 98.50 |
| Regular unleaded gasoline | 47014 | 78.9 | 0.6 | 2.56 | 0.83 | 1.031 | 100.00 |

**ELI** = Entry Level Item in the CPI (around 4-5 items priced each month in each geographic area).

**Freq** = the estimated average monthly frequency of price changes over 1995-1997 ($\lambda$ in the text).

**Mo** = the mean duration between price changes implied by $\lambda$ [$= -1/\ln(1-\lambda)$].

**Subs** = the average item substitution rate in the ELI over 1995-1997.

**NSub** = the average *noncomparable* item substitution rate in the ELI over 1995-1997.

**Wgt** = Share of the ELI in the 1995 Consumer Expenditure Survey (these sum to 68.9).

**CDF** = cumulative distribution function of Freq within the share of the CPI covered.

All data are from the U.S. Department of Labor.

## Table 2

Monthly Frequency of Price Changes By Year, 1995 to 2002

| Year | Median Frequency | Median Duration |
|---|---|---|
| **1995** | 21.3 % | 4.2 months |
| **1996** | 20.8 | 4.3 |
| **1997** | 19.9 | 4.5 |
| **1998** | 20.7 | 4.3 |
| **1999** | 22.4 | 3.9 |
| **2000** | 24.0 | 3.6 |
| **2001-02** | 23.1 | 3.8 |

Notes: The medians are across 350 expenditure-weighted categories (ELIs). 2001-02 refers to the 15-month period from January 2001 through March 2002.

Data Source: U.S. Department of Labor, *Commodities and Services Substitution Rate Table*, various years.

# Table 3

Monthly Frequency of Price Changes for Selected Categories

| | **% of Price Quotes with Price Changes** | **% of Price Quotes with Price Changes *Net* of the Item Substitution %** |
|---|---|---|
| **All goods and services** | 26.1 (1.0) | 22.7 (1.0) |
| | | |
| **Durable Goods** | 29.8 (2.5) | 21.5 (2.5) |
| **Nondurable Goods** | 29.9 (1.5) | 26.6 (1.5) |
| **Services** | 20.7 (1.5) | 19.1 (1.5) |
| | | |
| **Food** | 25.3 (1.9) | 23.7 (1.9) |
| **Home Furnishings** | 26.4 (1.8) | 23.7 (1.8) |
| **Apparel** | 29.2 (3.0) | 20.2 (3.0) |
| **Transportation** | 39.4 (1.8) | 34.2 (1.8) |
| **Medical Care** | 9.4 (3.2) | 8.2 (3.2) |
| **Entertainment** | 11.3 (3.5) | 8.2 (3.5) |
| **Other** | 11.0 (3.3) | 9.9 (3.3) |
| | | |
| **Raw Goods** | 54.3 (1.9) | 52.9 (1.7) |
| **Processed Goods** | 20.5 (0.8) | 16.7 (0.7) |

Notes: Frequencies are weighted means of category components. Standard errors are in parentheses. Durables, Nondurables and Services coincide with U.S. National Income and Product Account classifications. Housing (reduced to home furnishings in our data), apparel, transportation, medical care, entertainment, and other are BLS Expenditure Classes for the CPI. Raw goods include gasoline, motor oil and coolants, fuel oil and other fuels, electricity, natural gas, meats, fish, eggs, fresh fruits, fresh vegetables, and fresh milk and cream.

Data Source: U.S. Department of Labor (1997).

# Table 4

## Predicting Price Changes Across Goods

Dependent Variable = Frequency of Price Changes across ELIs

| **Regressors** ↓ | **(A)** | **(B)** | **(C)** | **(D)** |
|---|---|---|---|---|
| 4-firm Concentration Ratio | -0.30<br>(0.05) | -0.30<br>(0.04) | -0.002<br>(0.04) | |
| Wholesale Markup | | -1.20<br>(0.12) | -0.10<br>(0.13) | |
| Noncomparable Substitution Rate | | 1.25<br>(0.33) | 2.17<br>(0.26) | 2.86<br>(0.29) |
| Raw Good | | | 34.1<br>(2.7) | 37.7<br>(1.8) |
| Adjusted $R^2$ | 0.15 | 0.36 | 0.63 | 0.56 |
| Number of goods (ELIs) | 231 | 221 | 221 | 350 |

Notes: Each regression is weighted by the importance of the ELI in 1995 Consumer Expenditures. Standard errors are in parentheses.

# Table 5

## Aggregate and Sectoral Inflation Rates (Short Sample)

| **Variable** ↓ | **(A) Monthly Inflation** | **(B) Monthly Growth of Real Consumption** |
|---|---|---|
| **Aggregate of 123 Sectors** | | |
| $\rho$ | 0.20 (0.13) | –0.32 (0.12) |
| $\sigma_{\varepsilon}$ | 0.22 | 0.57 |
| **Across $i$ = 1, ..., 123 sectors** | | |
| Mean $\rho_i$ | –0.05 (0.02) | –0.08 (0.03) |
| Mean $\sigma_{\varepsilon,i}$ | 0.83 (0.08) | 1.66 (0.17) |
| Correlation between $\rho_i$ and $\lambda_i$ | 0.26 (0.09) | –0.56 (0.08) |
| Correlation between $\sigma_{\varepsilon,i}$ and $\lambda_i$ | 0.68 (0.07) | 0.45 (0.08) |

*Notes:*

Define $dx_t$ = first difference of $x_t$, where $x_t$ is the log of the price or real consumption.

For the aggregate: $dx_t = \rho\, dx_{t-1} + \varepsilon_t$, where $\varepsilon_t$ is i.i.d. with standard deviation $\sigma_{\varepsilon}$.

For sector $i$: $dx_{i,t} = \rho_i\, dx_{i,t-1} + \varepsilon_{i,t}$, where $\varepsilon_{i,t}$ is i.i.d. with standard deviation $\sigma_{\varepsilon,i}$.

The sample is 1995:M1 to 2000:M6. The 123 sectors represent 63.3% of 1995 Consumer Expenditures, and each sector is weighted by its expenditure share. Standard errors are in parentheses.

# Table 6

## Aggregate and Sectoral Inflation Rates (Longer Sample)

| Variable ↓ | (A) Monthly Inflation | (B) Monthly Growth of Real Consumption |
|---|---|---|
| **Aggregate of 123 Sectors** | | |
| $\rho$ | 0.63 (0.03) | –0.14 (0.04) |
| $\sigma_{\varepsilon}$ | 0.22 | 0.79 |
| **Across *i* = 1, ..., 123 sectors** | | |
| Mean $\rho_i$ | 0.26 (0.02) | –0.11 (0.02) |
| Mean $\sigma_{\varepsilon,i}$ | 0.91 (0.07) | 2.43 (0.19) |
| Correlation between $\rho_i$ and $\lambda_i$ | –0.06 (0.09) | –0.40 (0.08) |
| Correlation between $\sigma_{\varepsilon,i}$ and $\lambda_i$ | 0.52 (0.08) | 0.35 (0.08) |

*Notes:*

Define $dx_t$ = first difference of $x_t$ , where $x_t$ is the log of the price or real consumption.

For the aggregate: $dx_t = \rho\, dx_{t-1} + \varepsilon_t$, where $\varepsilon_t$ is i.i.d. with standard deviation $\sigma_\varepsilon$.

For sector $i$: $dx_{i,t} = \rho_i\, dx_{i,t-1} + \varepsilon_{i,t}$, where $\varepsilon_{i,t}$ is i.i.d. with standard deviation $\sigma_{\varepsilon,i}$.

The sample is 1959:M1 to 2000:M6. The 123 sectors represent 63.3% of 1995 Consumer Expenditures, and each sector is weighted by its expenditure share. Standard errors are in parentheses.

# Table 7

## Observed Inflation for Flexible-Price and Sticky-Price Goods

| Variable ↓ | From 1995-2000 data (A) Price Inflation | (B) Growth of Real Consumption | From 1959-2000 data (C) Price Inflation | (D) Growth of Real Consumption |
|---|---|---|---|---|
| **Flexible-price good** | | | | |
| $\rho$ | 0.01 | –0.34 | 0.24 | –0.22 |
| $\sigma_\varepsilon$ | 1.54 | 2.63 | 1.37 | 3.29 |
| **Sticky-price good** | | | | |
| $\rho$ | –0.11 | 0.15 | 0.28 | –0.02 |
| $\sigma_\varepsilon$ | 0.19 | 0.78 | 0.50 | 1.65 |
| **Flexible versus sticky** | | | | |
| $\rho_{flexible} - \rho_{sticky}$ | 0.12 (0.04) | –0.49 (0.07) | –0.04 (0.05) | –0.21 (0.04) |
| $\sigma_{\varepsilon, flexible} - \sigma_{\varepsilon, sticky}$ | 1.35 (0.13) | 1.85 (0.33) | 0.87 (0.13) | 1.63 (0.40) |

*Notes:*

Define $dx_{it}$ = first difference of $x_{it}$ , where $x_{it}$ is the log of the price or real consumption.

$dx_{i,t} = \rho_i \, dx_{i,t-1} + \varepsilon_{i,t}$, where $\varepsilon_{i,t}$ is i.i.d. with S.D. $\sigma_{\varepsilon,i}$ .

$\rho_{flexible}$ and $\sigma_{\varepsilon, flexible}$ refer to the serial correlation and volatility fitted for a good with monthly frequency of price changes of 48.5% (the 90th percentile of frequency in Table 1); $\rho_{sticky}$ and $\sigma_{\varepsilon, sticky}$ refer to those fitted for a good with monthly frequency of price changes of 6.5% (the 10th percentile).

# Table 8

## Inflation from a Staggered Pricing Model

| Variable ↓ | Only Aggregate Shocks (A) Price Inflation | (B) Growth of Real Consumption | Aggregate and Sector Shocks (C) Price Inflation | (D) Growth of Real Consumption |
|---|---|---|---|---|
| **Flexible-price good** | | | | |
| $\rho$ | 0.48 (0.03) | –0.30 (0.04) | 0.47 (0.03) | 0.16 (0.04) |
| $\sigma_\varepsilon$ | 0.68 (0.02) | 0.67 (0.02) | 1.01 (0.04) | 1.08 (0.04) |
| **Sticky-price good** | | | | |
| $\rho$ | 0.91 (0.02) | 0.01 (0.05) | 0.90 (0.02) | 0.10 (0.05) |
| $\sigma_\varepsilon$ | 0.11 (0.01) | 0.86 (0.03) | 0.17 (0.01) | 0.91 (0.03) |

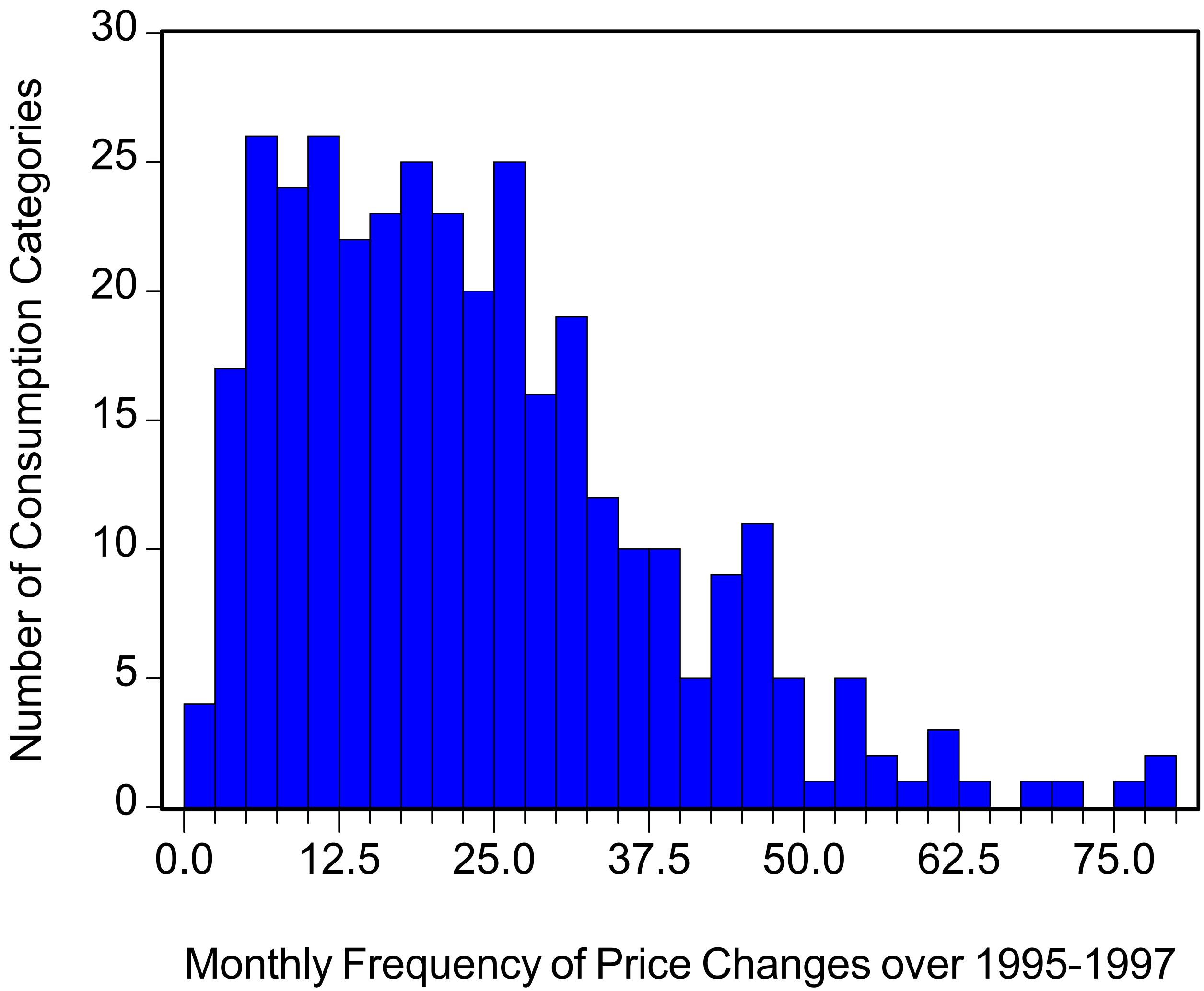
*Notes:*

$dx_{it}$ = first difference of $x_{it}$ , where $x_{it}$ is the log of the price or real consumption.

$dx_{i,t} = \rho_i\, dx_{i,t-1} + \varepsilon_{i,t}$, where $\varepsilon_{i,t}$ is i.i.d. with S.D. $\sigma_{\varepsilon,i}$ and $\sigma_i$ = S.D.( $dx_{i,t}$) = $[\sigma_{\varepsilon,i}^2/(1-\rho_i^2)]^{½}$.

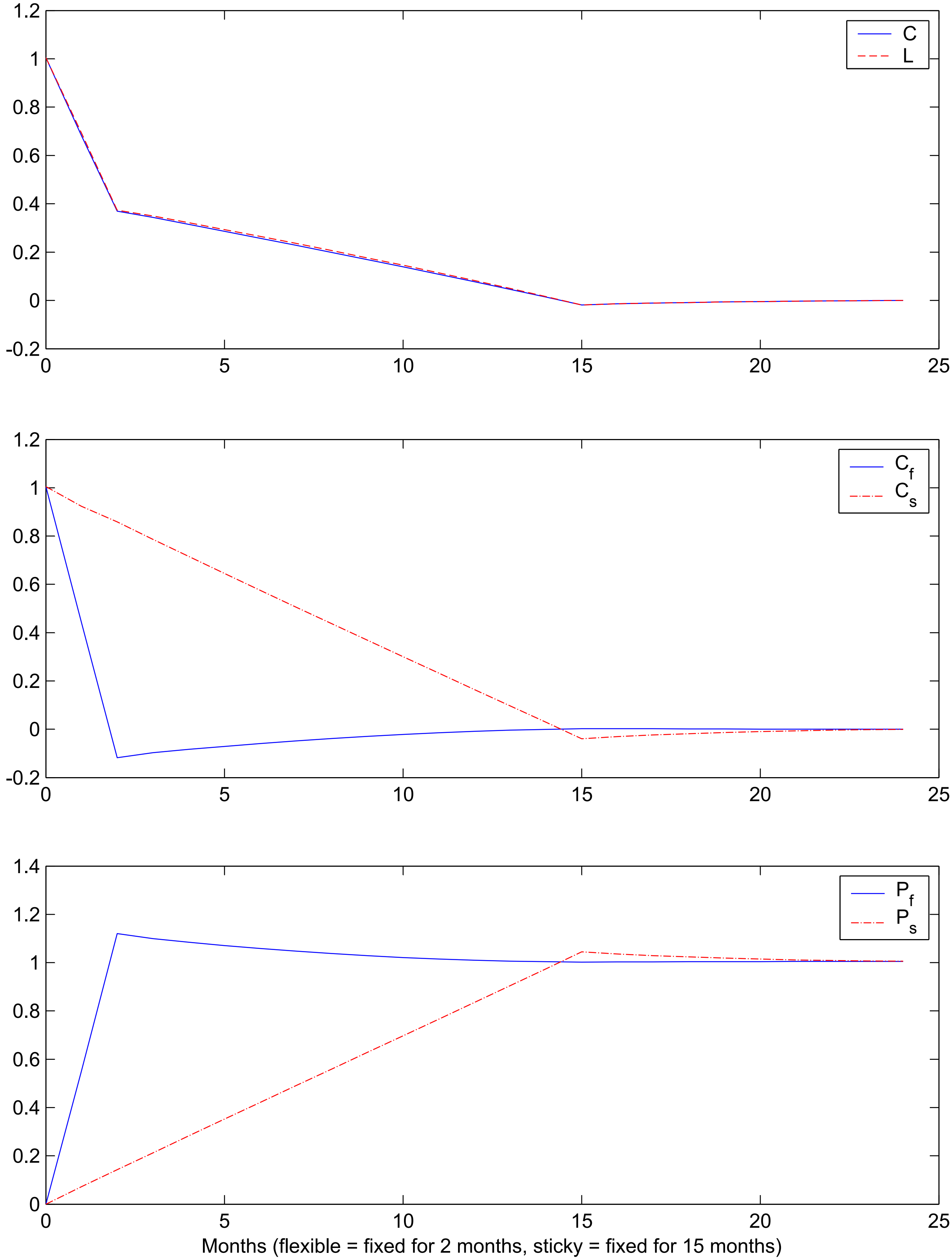
$\rho_{flexible}$ and $\sigma_{\varepsilon, flexible}$ refer to the serial correlation and volatility predicted by the staggered-pricing model for a good with monthly frequency of price changes of 1/2 (near the 90th percentile of frequency in Table 1); $\rho_{sticky}$ and $\sigma_{\varepsilon, sticky}$ refer to those predicted by the model for a good with monthly frequency of price changes of 1/15 (near the 10th percentile).

# Figure 1


30
25
20
15
10
5
0
Number of Consumption Categories
0.0
12.5
25.0
37.5
50.0
62.5
75.0
Monthly Frequency of Price Changes over 1995-1997

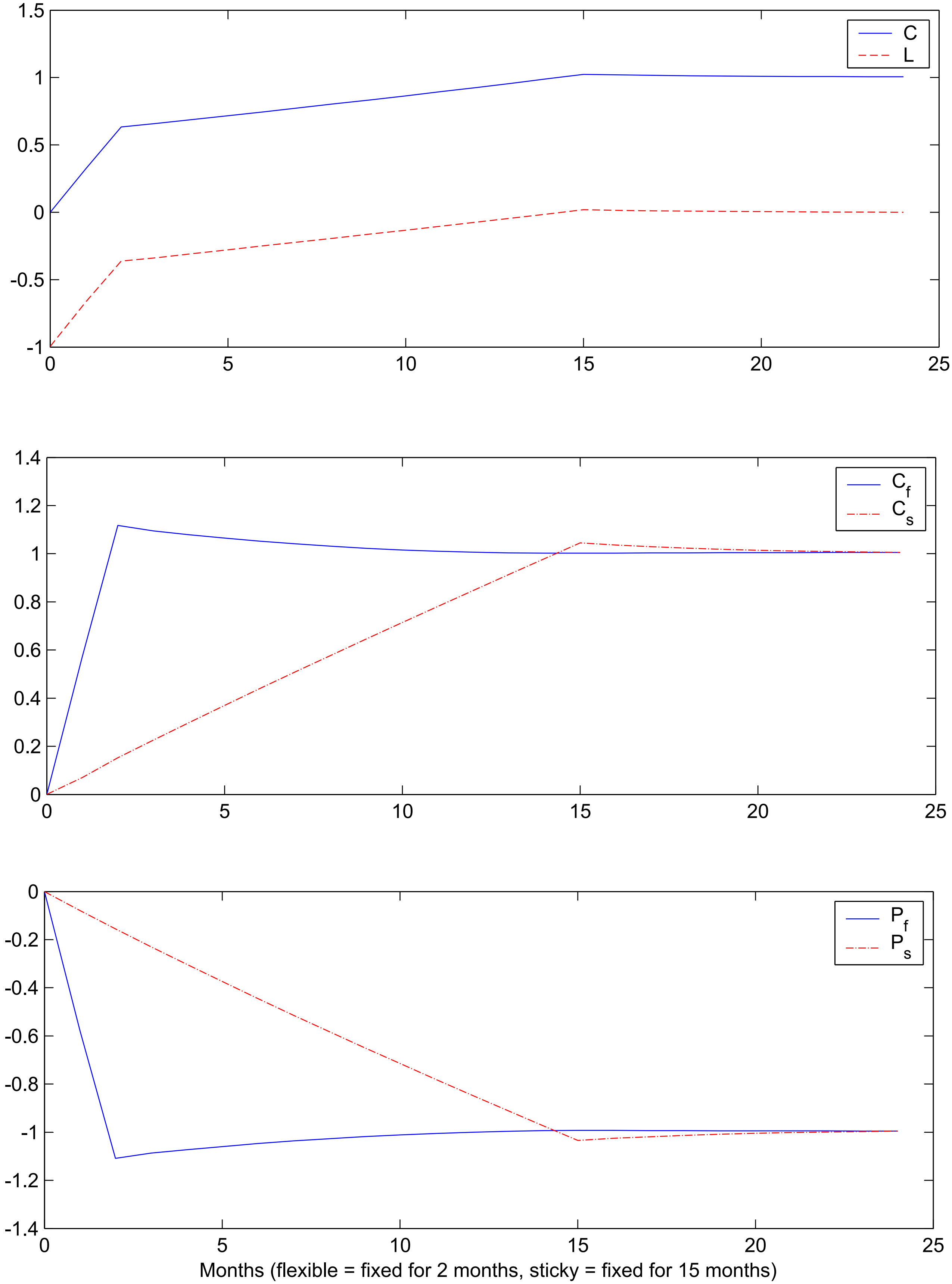
## Figure 2

**% responses to a 1% money supply shock (persistence of money growth is $\rho_m = 0$)**



## Figure 3

### % responses to a 1% productivity shock (persistence is $\rho_a = 1$)



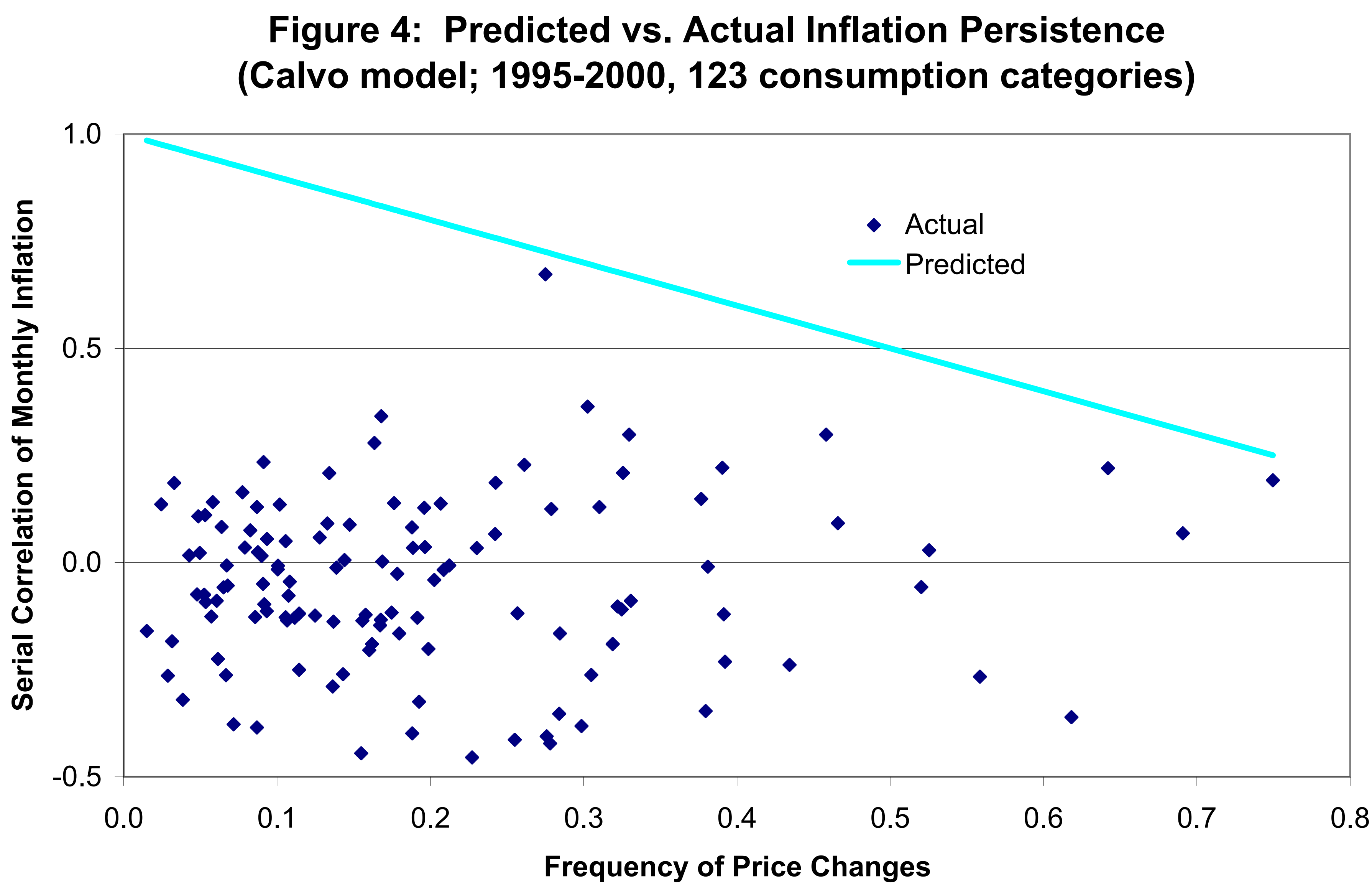


Figure 4: Predicted vs. Actual Inflation Persistence
(Calvo model; 1995-2000, 123 consumption categories)
Actual
Predicted
Serial Correlation of Monthly Inflation
Frequency of Price Changes
1.0
0.5
0.0
-0.5
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

**Figure 5: Predicted vs. Actual Inflation Persistence**
**(Calvo model; 1959-2000, 123 consumption categories)**

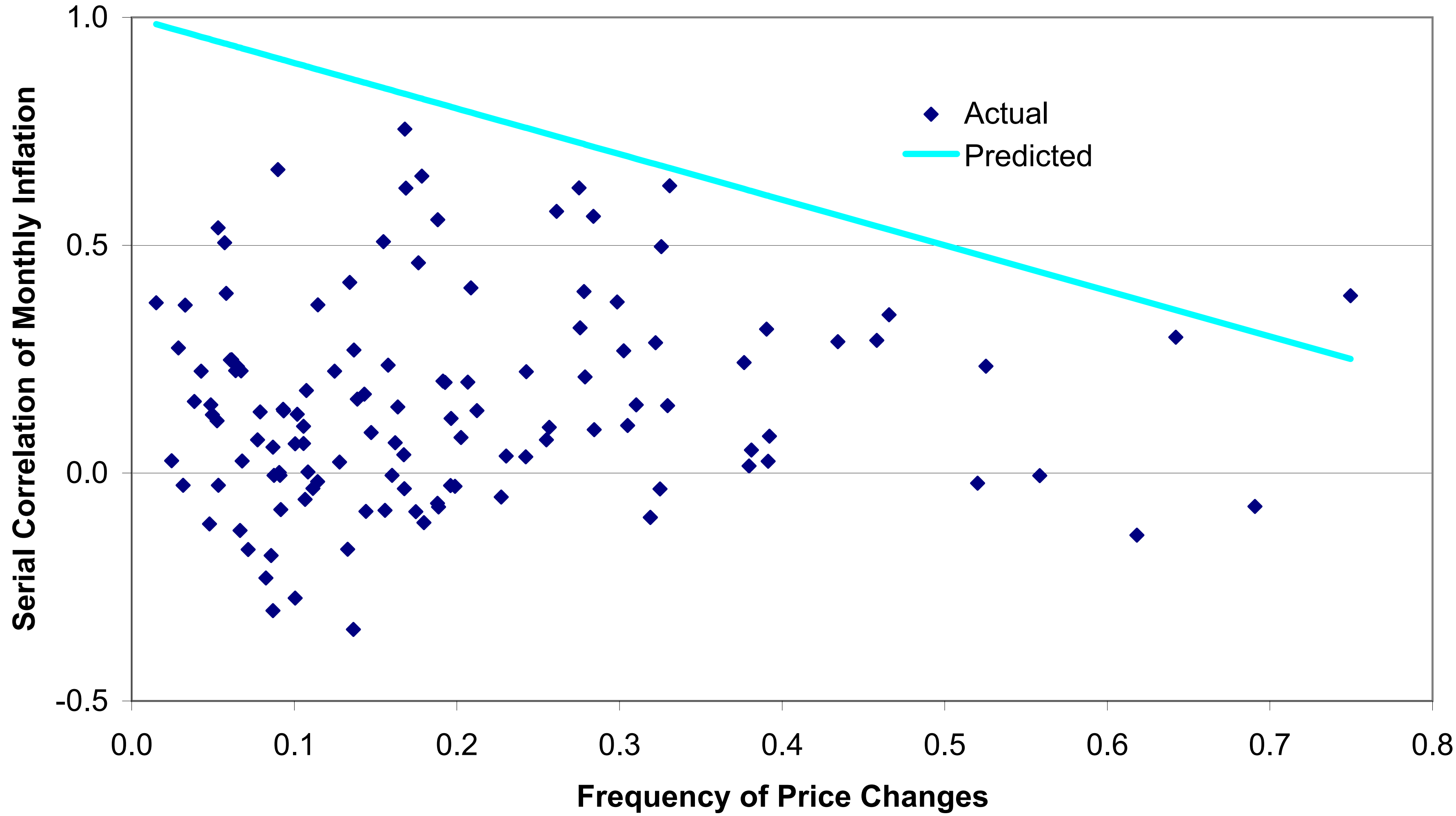


**Figure 6: Marginal Cost Needed to Generate Sectoral Inflation (Calvo model; 1995-2000 data for 123 categories)**

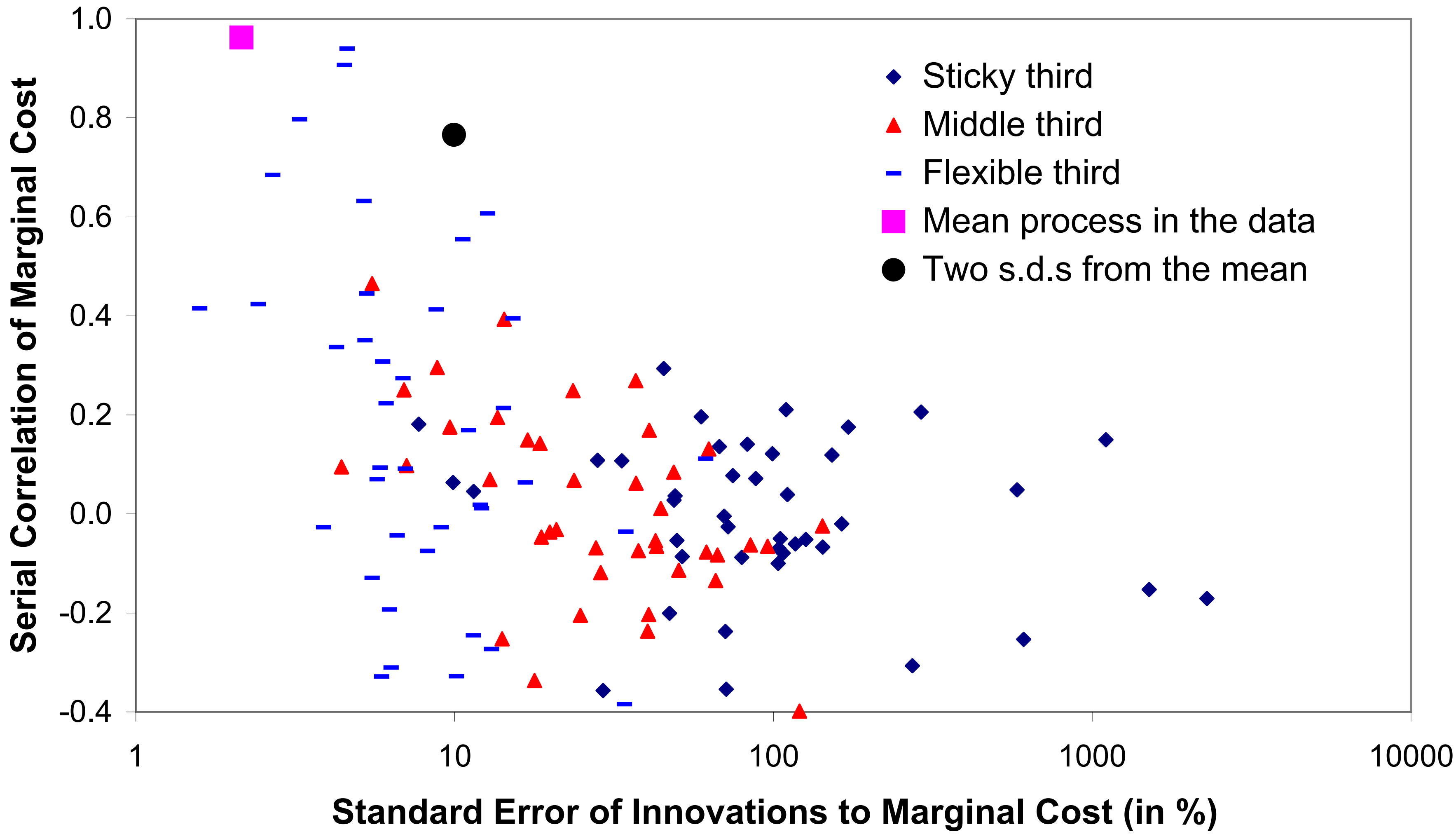
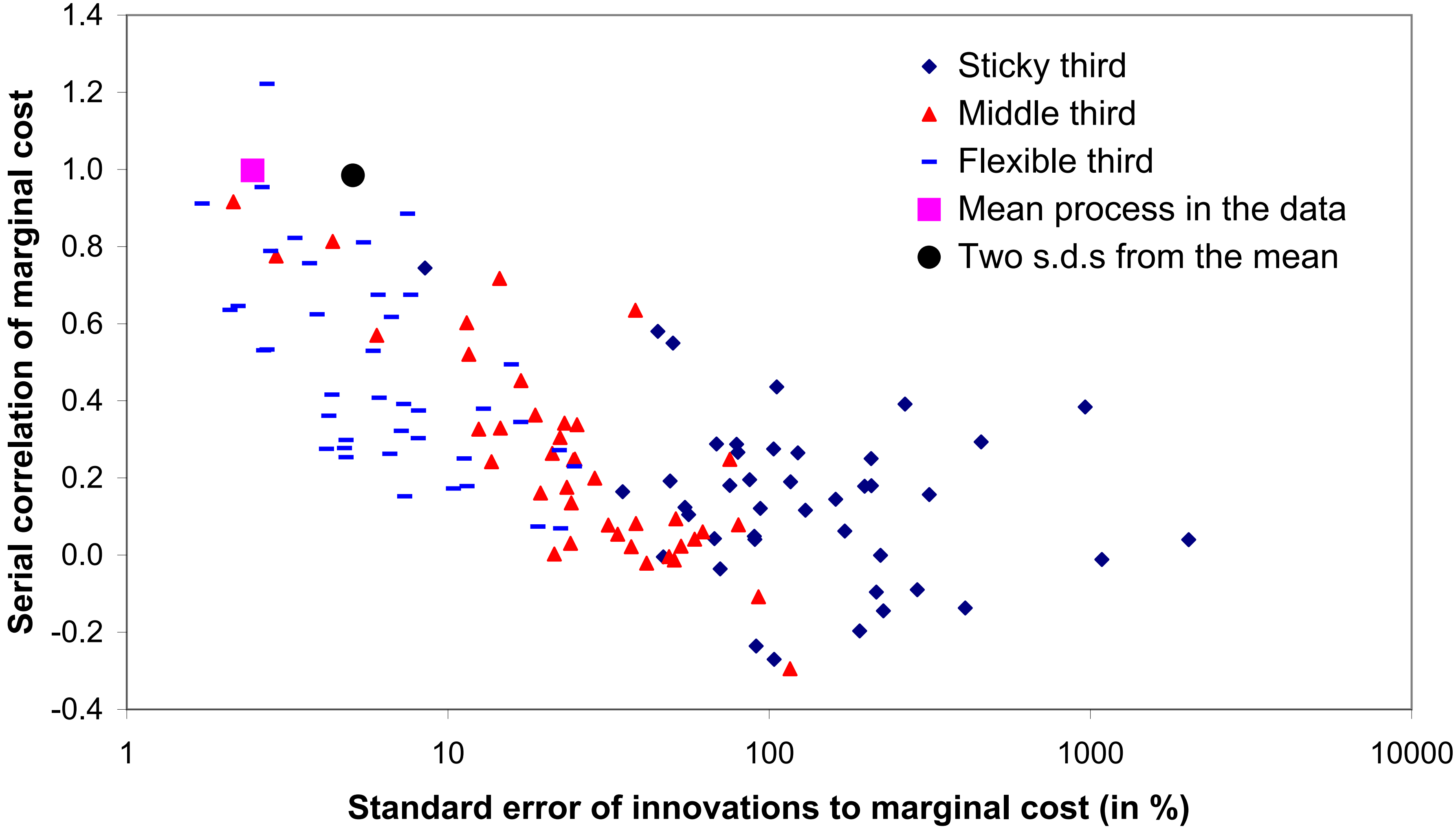


**Figure 7: Marginal Cost Needed to Generate Sectoral Inflation (Calvo model; 1959-2000 data for 123 categories)**



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