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# IMF Working Paper

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## Why Do Prices in Sierra Leone Change So Often? A Case Study Using Micro-level Price Data

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**IMF Working Paper**

African Department

**Why Do Prices in Sierra Leone Change So Often? A Case Study  
Using Micro-level Price Data**

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**Abstract**

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We use cross-section and time-series techniques to analyze pricing behavior in Sierra Leone. In cross-sectional data, we find that inflation volatility and product diversification are the main factors explaining differences in the frequency of price adjustments. We show that variance in the fraction of prices subject to change is a key determinant of inflation volatility in Sierra Leone, indicating that retail prices are sensitive to economic events. We explain variations in this fraction over time with past inflation and monetary growth, which are important policy variables.

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## I. Introduction

Understanding the causes and consequences of nominal and real rigidities in an economy is essential for studying business cycles or assessing the impact of macroeconomic policies on that economy. In this literature, a distinction is typically made between time-dependent and state-dependent price-setting behavior. In time-dependent pricing models, it is assumed that enterprises alter their output prices on the basis of a time-contingent pricing mechanism. This model, based on Taylor (1980) and Calvo (1983), provides a core theoretical foundation for the analysis of modern inflation dynamics. A key conclusion of this branch of pricing models is that the fraction of prices changing at a given time is determined exogenously and remains constant over time.

However, time-dependent pricing models lack proper microeconomic foundation. Nor do these models do a good job of explaining empirical regularities of inflation dynamics (Ball, 1994; Fuhrer and Moore, 1995; and Mankiw, 2001). To overcome these shortcomings, other types of expectation formations have been proposed. For example, Mankiw and Reis (2002) have developed a sticky information model, in which future price expectations are updated gradually as new information becomes available. Their model generates a gradual output response, which is positively correlated with money and demand shocks as suggested by empirical evidence (see Christiano, Eichenbaum, and Evans, 2004).

In state-dependent pricing models, enterprises choose when to change their prices subject to “menu costs.” That is, they will adjust their prices when specific events occur. Assuming that enterprises’ costs are fixed regardless of changes in prices (for example, the cost of printing a new schedule of prices), the timing and magnitude of enterprises’ price adjustments depend on the state of the economy (see, for example, Dotsey, King, and Wolman, 1999). Because of the explicit cost of changing prices, it is profitable for enterprises to change prices only if the higher price covers the cost of price change.

In this study, we conduct an empirical analysis of pricing behavior at the microlevel, taking advantage of price-level data for Sierra Leone. Compared to aggregated consumer price data, which are typically reported in the form of an index, the unindexed price-level data used for this study comprise all items included in the official consumer price index. Therefore, it will offer a unique opportunity to analyze disaggregated pricing behavior at the retail level for a developing country.<sup>2</sup>

One of the questions we pose is why prices in Sierra Leone change so frequently. We analyze the question using micro-level price data from two different perspectives: cross-sectional and over time. Regarding cross-sectional analysis, we show that the different frequencies with which retailers change prices may be explained by two variables: inflation volatility and the

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<sup>2</sup> Virtually all empirical studies on pricing behavior are conducted on developed economies. The price-level data for this study were provided by Statistics Sierra Leone (SSL).

extent to which an item is considered processed (that is, has a high value added). Uncertainty about inflation, as measured by inflation volatility, helps to explain why retailers change their prices more frequently. In an environment where future inflation is subject to uncertainty, enterprises have to be responsive to economic conditions in their pricing decisions. Their ability to absorb costs is also important. Food items, such as rice, are typically unprocessed and comprise mainly the cost of growing the item and the costs of distribution (labor and transportation) and storage. Changes in these costs are likely to be passed on to customers quickly because retailers wish to avoid pricing their products below their marginal costs. For services and products that are processed, it may be easier for retailers to absorb some of the increases in the production costs, at least in the short run, while avoiding adjusting the retail prices frequently. Therefore, the prices of these items are usually changed less frequently.

Furthermore, we examine the frequency with which retail prices are adjusted over time by constructing a time series that measures the fraction of prices changing each month.<sup>3</sup> The key contribution of this analysis is that the volatility of inflation in Sierra Leone can be explained, by and large, by the volatility in the frequency of monthly price changes. This is an important observation because, in industrial countries, the volatility of inflation is typically associated with the volatility of the average size of monthly price changes, whereas the frequency of price changes each month remains relatively stable (Box 1). This implies that firms in industrial countries rely mostly on time-dependent pricing rules when adjusting their output prices.<sup>4</sup> In Sierra Leone, in contrast, retail prices appear to be much more responsive to “events”—for example, driven by inflation and the growth rate of the broad money supply—reflecting, in part, economic uncertainties.

In light of the above, another policy question we explore in this study is to what extent policy authorities are able to reduce both the fraction of prices subject to change each month and, more important, the volatility in that fraction, as these would reduce inflation volatility. By estimating a statistical equation for the fraction of prices subject to change each month and linking this fraction to variables that proxy “events,” we find that bringing inflation and money growth to more moderate levels over time would also reduce the proportion of prices changing each month and would contribute to lower inflation volatility.

Sierra Leone, a small, open economy in West Africa, has a rich resource base as well as a diversified agricultural sector. Key exports include diamonds and agricultural crops (coffee and cocoa). However, the long civil conflict had a devastating social and economic impact on the infrastructure and institutions, and resulted in widespread poverty. The signing of a peace accord in July 1999 in Lomé and the cessation of hostilities, followed by concentrated efforts to resettle displaced people, have facilitated the normalization of economic conditions. They

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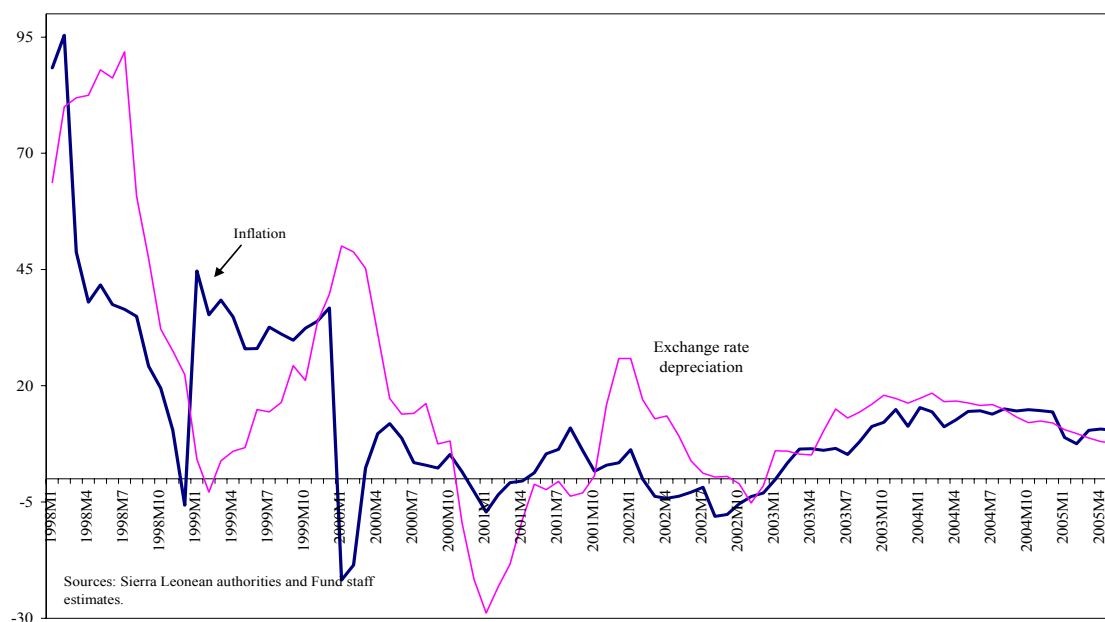
<sup>3</sup> If all prices are changed in a given month, this variable will have a value of 1. If all prices remain unchanged, the variable will have a value of 0.

<sup>4</sup> For example, enterprises may review their output prices every six months.

have also reinforced confidence in the economy and thus enhanced macroeconomic stability. Inflation, as a result, has come down to more moderate levels. (Figure 1).

Box 1. Selected Research Findings on Pricing Behavior					
Study	Country	Average Duration 1/	Price-Setting Strategy (percent)		
			Time Dependent	State Dependent	Mixed
Aucremanne and Druant (2005)	Belgium	10.2	25.7	34.3	40.0
Fabiani, Gattulli, and Sabbatini (2004)	Italy	12.0	5.4	27.0	62.8
Dias, Dias, and Neves (2004)	Portugal	8.5	...	...	...
Apel, Friberg, and Hallsten (2001)	Sweden	...	18.2	33.8	48.0
Hall, Walsh, and Yates (2000)	United Kingdom	6.0	79.0	11.0	10.0
Klenow and Kryvtsov (2005)	United States	...	91.0	9.0	...
Bils and Klenow (2002)	United States	4.3	...	...	...
This study 2/	Sierra Leone	2.6	3.1	96.9	...
Sources: Sierra Leonean authorities; and Fund staff estimates.					
1/ In months.					
2/ Using methodology of Klenow and Kryvtsov (2005).					

Figure 1. Inflation and Exchange Rate Depreciation (January 1998–May 2005)  
(Annual percentage change)



Most retail prices in Sierra Leone change frequently, compared with industrial countries where retail prices generally display considerable “stickiness” (Box 1). In contrast with more complex and advanced developing economies, the structure of the economy in Sierra Leone is rather basic. Retail markets in the country are dominated by small-scale enterprises and individual sellers who offer mainly primary goods for sale. Further, reflecting the structure of consumption and low levels of income, more than one-half of the goods included in the consumer price index are food items. The prices of food items, by their very nature, are typically more volatile than the prices of nonfood items, which in part explains the relatively high frequency of price changes in the retail sector.

In this study, we use price data comprising monthly retail prices (unindexed) for 251 items included in the official consumer price index. The data were collected by Statistical Sierra Leone and cover the period from November 1999 to April 2003. The data set forms the basis for the published monthly consumer price index.<sup>5</sup> The items included in the consumer basket are allocated among 13 expenditure groups. For each item, a monthly retail price is derived as an unweighted average price based on surveys at different collection points in Freetown during each month. Food items represent about 60 percent of the index and comprise food, drinks, and tobacco. This data set allows us to measure directly how frequently and by how much individual retail prices change (on average) each month.

The paper is organized as follows. Section II reviews relevant empirical research on pricing behavior. Section III analyzes cross-sectional data and presents some stylized facts about retail prices in Sierra Leone for the period under study. In Section IV, we analyze the underlying causes of frequent price changes in cross-sectional data. The behavior of prices over time will be examined in Section V, and Section VI concludes the paper.

## **II. Empirical Studies on Pricing Behavior**

Empirical research using micro-level pricing data has grown rapidly in recent years, in part, because of the growing need to understand the price rigidities prevailing in an economy. In turn, the price rigidities provide valuable insight into the dynamic reactions of output and inflation to shocks and the transmission mechanism of monetary policy. Studies by Klenow and Kryvtsov (2005) and Bils and Klenow (2002) analyzed price data collected by the U.S. Bureau of Labor Statistics. Klenow and Kryvtsov (2005) found that, during 1988–2003, the variance of monthly inflation in the United States could be explained by fluctuations in the average size of price changes rather than by the frequency of prices changing each month, suggesting that pricing behavior in the United States is consistent with the assumptions of time-dependent pricing models. Bils and Klenow (2002) showed that prices in the United States changed relatively frequently, with about half of the prices remaining unchanged for

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<sup>5</sup> In Sierra Leone, the official price index covers only the capital city, Freetown (a number of separate indexes are produced from other larger cities). Appendix Table 1 provides a detailed list of the items in the index.



less than 4.3 months. However, the frequency of price changes varied considerably from sector to sector.

A number of studies have examined pricing behavior in European countries. Dias, Dias, and Neves (2004) found that the prices of food items are changed more frequently than the prices of nonfood items in Portugal, reflecting the nature of these items (typically unprocessed), and that the prices of goods were adjusted more frequently than the prices of services. They also reported that economic conditions can have an impact on pricing behavior: during periods of higher inflation, prices are adjusted more frequently. Fabiani, Gattulli, and Sabbatini (2004) found that the majority of Italian firms use both time-and-state-dependent pricing strategies (see Aucremanne and Druant, 2005; Apel, Friberg, and Hallsten, 2001; and Hall, Walsh, and Yates, 2000).

Several studies on wholesale and retail prices have suggested that these prices often remain unchanged for months. Levy, Dutta, and Bergen (2002) examined the heterogeneity of price rigidity using weekly retail, wholesale, and spot prices for 12 orange juice producers in the United States. They found that prices were more rigid in response to small changes in cost shocks than to large shocks, as well as in response to temporary cost shocks in comparison with permanent shocks. Prices were also more rigid when producers had less information about the cost shocks. By examining spot-wholesale price spreads, the authors concluded that firms were more likely to absorb temporary cost increases, possibly because of concern over losing customers, which contributes to price rigidities at the retail level. The findings are consistent with the menu-cost models. MacDonald and Aaronson (2000) studied restaurant prices in the United States and found that these prices were often adjusted less frequently than the prices of consumer goods in the basket of the consumer price index.

Blinder and others (1998) found, based on a survey of 200 firms selling intermediate goods in the United States, that firms adjusted median prices about once a year. Hall, Walsh, and Yates (2000) made a similar conclusion for U.K. companies. Borenstein and Shepard (1996) found that firms with market power adjusted wholesale prices less than fully in response to cost shocks in U.S. gasoline markets (see also Davis and Hamilton, 2003).

Campbell and Malley (2003) studied price stickiness in the U.S. manufacturing sector and estimated industry-specific Phillips curves. They found that inflation inertia was higher in durable goods industries than in nondurable goods industries. Furthermore, they concluded that the majority of industries tend to set their prices in a forward-looking manner, but that industries also used a backward-looking price-setting strategy, particularly industries that are characterized by higher average markups.

### III. Some Stylized Facts—Cross-Sectional Evidence

In this section, we will summarize the key features of price movements in Sierra Leone. We begin by defining a measure for price change,  $I_{it}$ , which indicates whether or not the price of item  $i$  has changed in month  $t$ .

Let  $p_{it}$  represent the log price of item  $i$  in month  $t$ . The indicator can be defined as follows:

$$\begin{aligned} I_{it} &= 1 \text{ if } p_{it} \neq p_{i,t-1} \quad i = 1, \dots, k \text{ (number of items)} \\ &= 0 \text{ if } p_{it} = p_{i,t-1} \quad t = 1, \dots, n \text{ (number of periods).} \end{aligned} \quad (1)$$

The average monthly frequency of a change in the price of item  $i$  can be defined using equation (1) as follows:

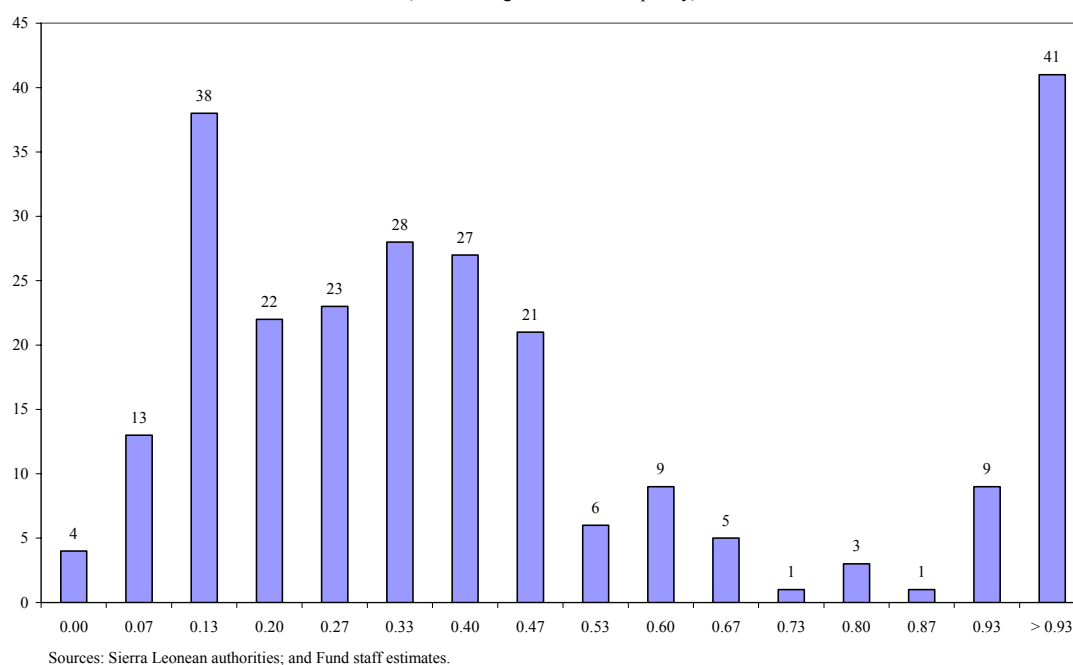
$$I_i = (1/n) \sum_{t=1}^n I_{it} \text{ for all } i = 1, \dots, k. \quad (2)$$

Estimated monthly frequencies range from zero for four items whose prices were unchanged<sup>6</sup> during the sample period to close to one for 41 items whose prices were adjusted virtually every month (Figure 2). The median frequency is about one-third, which means that the price of a typical item in the consumer price index is adjusted once every three months during the 3½-year period under study. Virtually all high-frequency items were food products, except for a small number of nonfood items (such as soap and firewood).

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<sup>6</sup> These were subsidized house rents; rental value of rent-free housing; city rates for rents, rates, and repairs; and the price of matches.

Figure 2. Average Monthly Frequency of Price Change by Product  
(Number of goods at each frequency)



Duration measures the length of the interval during which the price of an item remains constant. It is related to the frequency of price change and may be defined as follows:<sup>7</sup>

$$\text{Duration}_i = - [1/\ln(1 - I_i)] \text{ for all } i = 1, \dots, k, \quad (3)$$

where  $\text{Duration}_i = \infty$  for  $I_i = 0$  and

$$\text{Duration}_i = 0 \text{ for } I_i = 1.$$

The prices of food items were adjusted, on average, virtually every month, whereas the prices of items included in the category rents, rates, and repairs and in the category transportation and communication were adjusted infrequently (Figure 3). One reason for the frequent price changes in the food category is that food items are typically unprocessed goods and therefore have little value added beyond their primary input costs to absorb cost shocks. Since primary inputs are undiversified, their prices are likely to change more frequently in response to cost changes because enterprises want to ensure that retail prices don't fall below their marginal costs.

Furthermore, we can extrapolate from these facts to the case of Sierra Leone, where food represents about 60 percent of the consumer basket. Changes in food prices therefore have a significant impact on the overall price index, which explains, in part, the volatility of

<sup>7</sup> As in Bils and Klenow (2002).

inflation in the country. These findings are comparable to those from research for industrial countries, where changes in food prices were found to be more frequent than changes in the prices of nonfood items (Bils and Klenow, 2002; and Dias, Dias, and Neves, 2004).

Moreover, the bulk of items whose prices were adjusted less frequently could be subject to administrative pricing, including rental rates, the cost of transportation and communication, fees for medicines and medical care, and the cost of education (Appendix Table 1 lists the goods included in Sierra Leone's consumer price index). We also find that the prices of foods eaten in restaurants (included in the food category) have changed less frequently, on average, than retail prices of food items. This may be due, in part, to the fact that restaurants can more easily absorb cost shocks.<sup>8</sup> Significant costs could also be associated with frequent changes in menu prices. This outcome is in line with MacDonald and Aaronson (2000) for the U.S. markets. Hence, the median length of time that prices remain unchanged in Sierra Leone is considerably shorter than, for instance, in the U.S. markets (see Bils and Klenow, 2002).

Next we examine whether the frequency of price changes could explain the level of average monthly price change. Let  $\pi_{it}$  represent the log difference in the price of item  $i$  between periods  $t$  and  $t-1$ :

$$\pi_{it} = p_{it} - p_{it-1} \quad \text{for all } i = 1, \dots, k. \quad (4)$$

The average monthly inflation of item  $i$  is defined as

$$\pi_i = (1/n) \sum_{t=[1,n]} \pi_{it} \quad \text{for all } i = 1, \dots, k. \quad (5)$$

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<sup>8</sup> In developing countries where goods (such as restaurant items and cooked foods) often are subject to variable standards, changes may be reflected in the quantity, size, or quality rather than in the retail prices.

Figure 3. Duration of Price Changes by Product Category  
(In months)

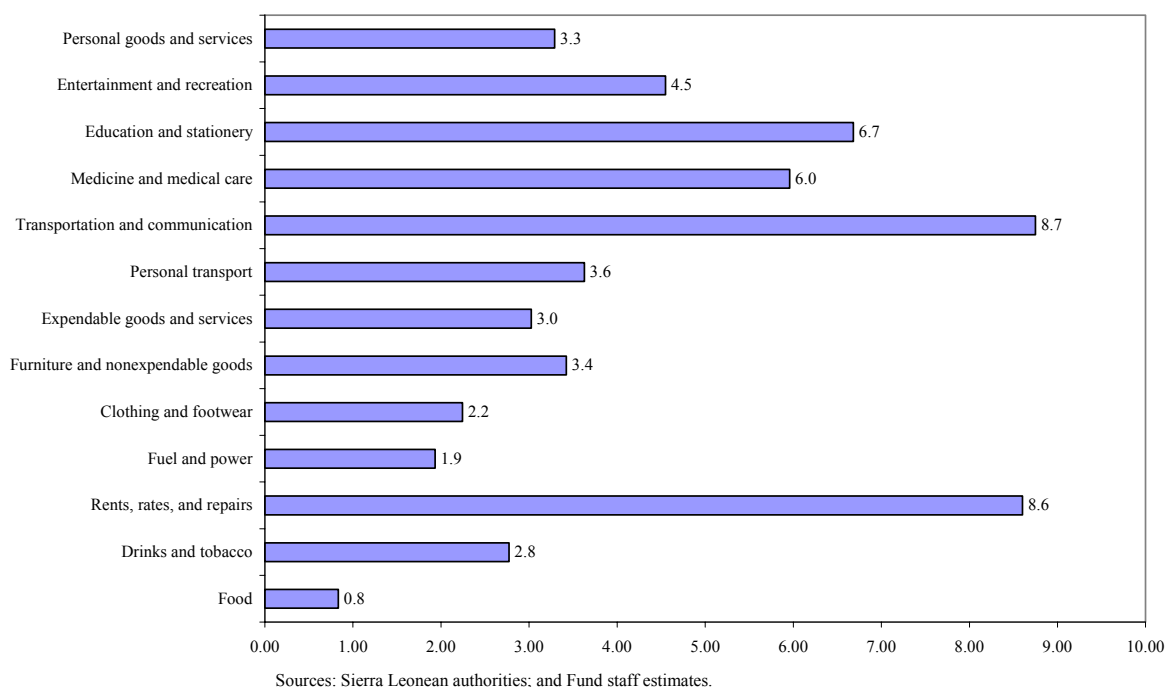
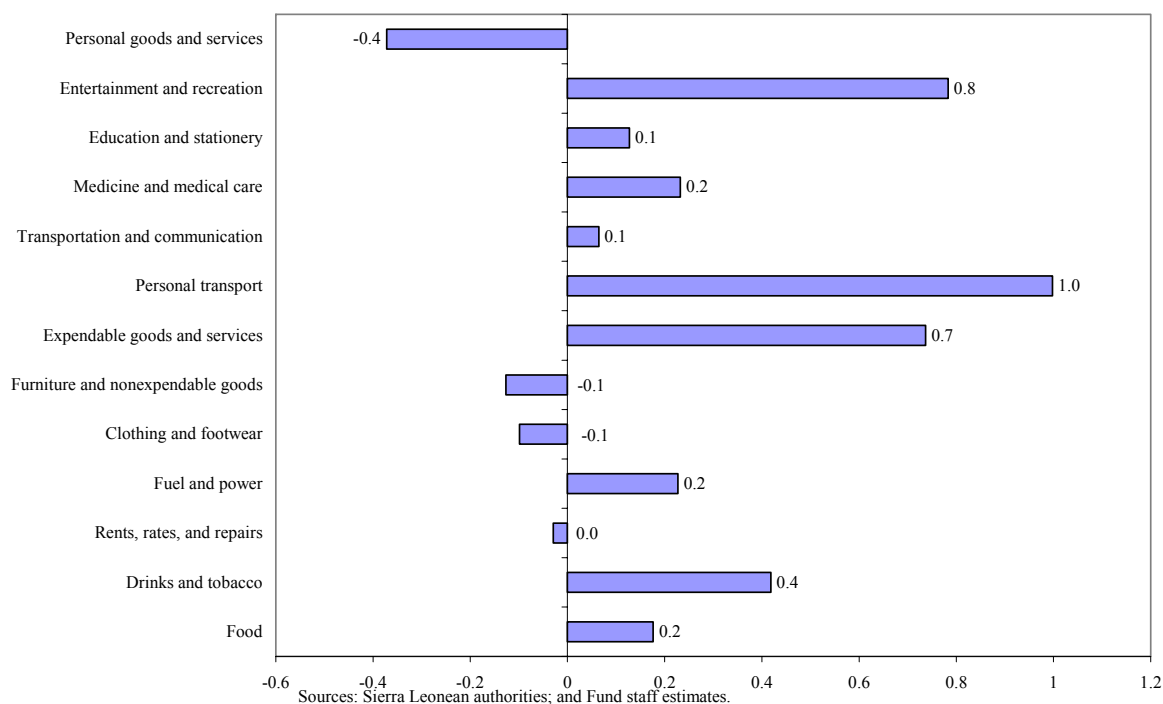


Figure 4 displays the average monthly price change for each category, which varies substantially across the expenditure groups. However, a high (low) frequency of price changes does not indicate high (low) inflation. The monthly average rate of price change is very low for food items (0.2 percent) and transportation and communication (0.1), but the duration of any given price for food items is very low (0.8 months), whereas the duration of prices for transportation and communication is very high (8.7 months). Moreover, the increased availability of goods and services in Sierra Leone since the end of the civil conflict has increased imports as well as local trade, thereby resulting in lower costs.<sup>9</sup> Therefore, the prices of certain goods and services fell during the sample period.

<sup>9</sup> This is highly probable for items in the categories of personal goods and services, clothing and footwear, and furniture and nonexpendables.

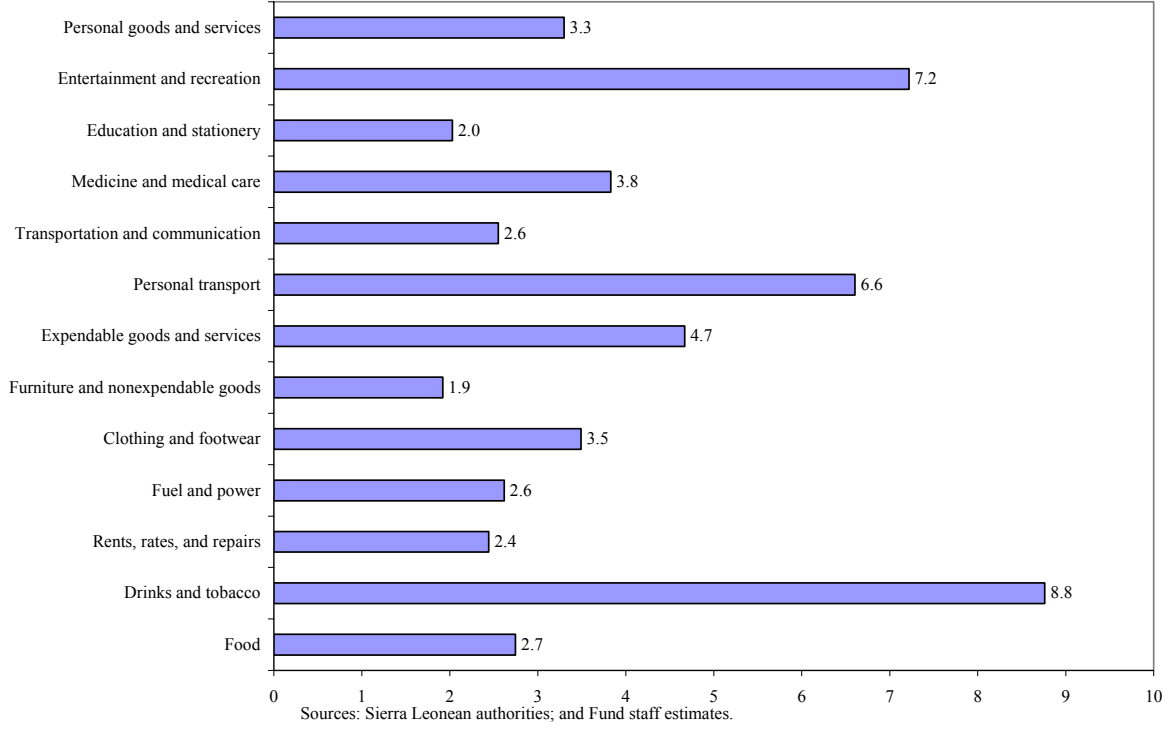
Figure 4. Average Monthly Price Change by Product Category  
(In percent per month)



The volatility of price change in Sierra Leone varies a lot across different expenditure groups (Figure 5). The volatility of food prices, reflecting their significant weight in the consumer price index, has been an important factor in explaining the volatility of the overall price index in Sierra Leone.<sup>10</sup>

<sup>10</sup> Volatility is measured by the standard deviation of monthly price changes.

Figure 5. Estimated Volatility of Price Change by Product Category



Are monthly price changes correlated in Sierra Leone? Given the high frequency of monthly price changes, one would expect that monthly price changes are not significantly correlated (i.e., inflation persistence is rather low). Let us assume that the price of commodity  $i$  in Sierra Leone's consumption basket follows the following stochastic process:

$$p_{it} = p_{it-1} + v_{it}, \quad (6)$$

where  $v_{it} = \rho_i v_{it-1} + \xi_{it}$  (stability requires that  $|\rho_i| < 1$ ) and the random shock,  $\xi_{it}$ , is a normally distributed disturbance with zero mean and constant variance. The price of item  $i$  changes in response to random shocks, which tend to persist. Using equation (6), monthly inflation becomes

$$\pi_{it} = \rho_i \pi_{it-1} + \xi_{it}, \quad (7)$$

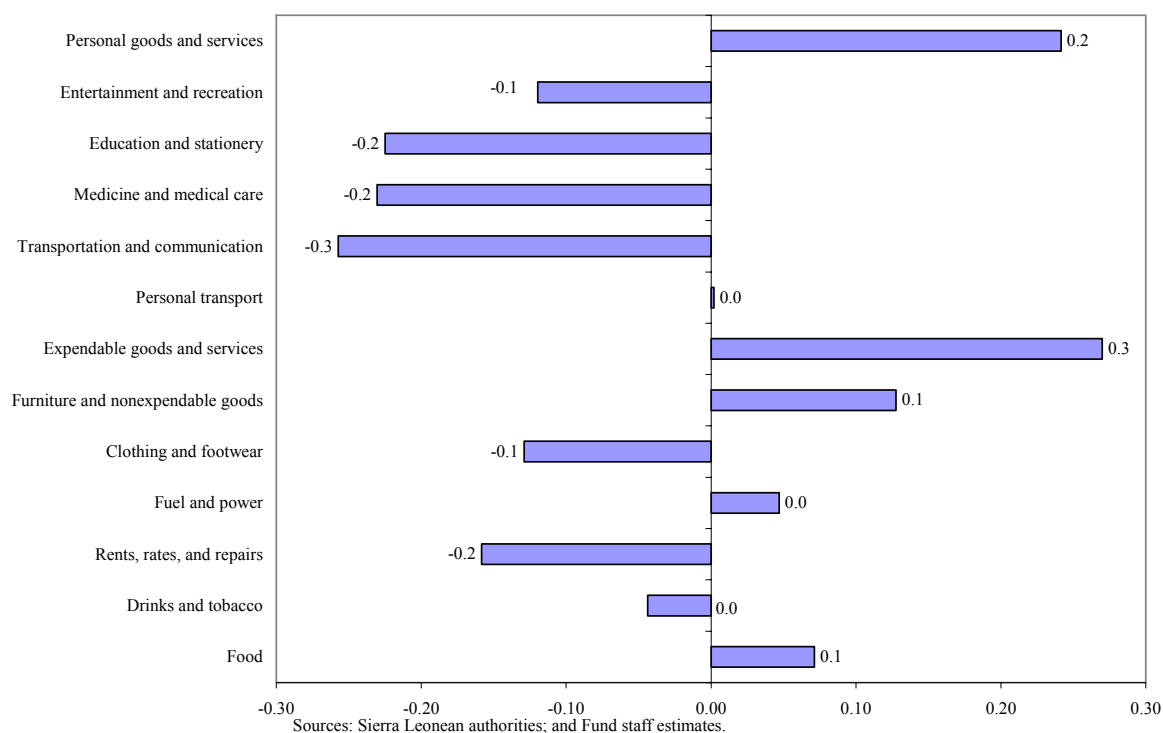
where the measure of correlation ( $\rho_i$ ) defines inflation persistence for item  $i$ .

The estimated inflation persistence is generally small and is not statistically significant (Figure 6).<sup>11</sup> For items whose prices are changed infrequently, such as transportation and

<sup>11</sup> Obtained from ordinary least squares estimation for all 251 items in Sierra Leone's consumer basket.

communication and rents, rates, and repairs, a longer price duration has not resulted in inflation persistence.<sup>12</sup> For the overall consumer price index, the estimated coefficient of inflation persistence (0.2) is similar to the reported coefficient for the United States (see Bils and Klenow, 2002), but the parameter estimate is not statistically different from zero.

Figure 6. Estimated Inflation Persistence by Product Category



#### IV. What Explains the High Frequency of Price Changes?

Menu-cost models of price adjustment suggest that inflation is higher in markets where price changes are more frequent (for example, Barro, 1972; and Taylor, 1999). This is due, in part, to the cost of changing prices. Table 1 displays cross-correlations between various indicators for all items.

<sup>12</sup> For individual items, the estimated coefficients were statistically different from zero for 14 goods in the group, comprising food, drinks, and tobacco, all of which were negative, and for 14 goods in the other groups, of which four parameter estimates were positive.



Table 1. Cross-Correlations for All Items

	Frequency	Inflation	Persistence	Variability
Frequency	1.00			
Inflation	0.32	1.00		
Persistence	0.01	0.10	1.00	
Variability	0.30	0.93	0.07	1.00

In Sierra Leone, the frequency of price changes in cross-sectional data is positively correlated with the level of inflation and inflation variability (measured by the standard deviation of monthly price change). Furthermore, average inflation is almost perfectly correlated with inflation variability. However, these results are not suggestive of the direction of causality.

The results for food and nonfood items are similar (Tables 2 and 3). However, for nonfood items the frequency of price adjustment is negatively correlated with inflation, on the one hand, and with the variability of inflation, on the other. A negative correlation for nonfood items could be explained by administrative pricing in several expenditure categories (rents, rates, and repair; medicine and medical care; transportation; and education). That is, while price changes have been infrequent, individual price adjustments could have been sizable.

Table 2. Cross-Correlations for Food Items

	Frequency	Inflation	Persistence	Variability
Frequency	1.00			
Inflation	0.38	1.00		
Persistence	0.07	0.15	1.00	
Variability	0.40	0.95	0.12	1.00

Table 3. Cross-Correlations for Nonfood Items

	Frequency	Inflation	Persistence	Variability
Frequency	1.00			
Inflation	-0.09	1.00		
Persistence	0.06	0.09	1.00	
Variability	-0.03	0.90	0.04	1.00

State-dependent pricing models assume that enterprises will adjust their prices in response to shocks.<sup>13</sup> Therefore, the frequency of price adjustments in state-dependent pricing models is

<sup>13</sup> For example, Dotsey, King, and Wolman (1999) assume that the trigger for price adjustment is a shock to the cost of labor.

endogenous. Below we estimate an equation for the frequency of price change (which is a  $1 \times k$  vector), using a constant, a variable for inflation uncertainty (standard deviation of monthly inflation), and a dummy for “nonprocessed” goods as explanatory variables.<sup>14</sup> The estimation results are reported in Table 4.<sup>15</sup>

In Table 4, the constant term may be interpreted as an unweighted average frequency of price change in the sample (the estimated average duration is about three months). The variable that measures inflation uncertainty also has a statistically significant coefficient, suggesting that higher inflation uncertainty increases the frequency of price change. Monthly inflation was statistically insignificant in the estimation. This may be because enterprises’ response to inflation uncertainty is nonlinear and therefore inflation variability is a better proxy for it. In addition, the dummy for nonprocessed items was highly significant, providing support for the argument that the retail prices of less diversified items are adjusted more frequently.

Table 4. Frequency of Price Change<sup>1/</sup>

	Estimate	S.E.	T-Value	H.C.S.E.	T-Value
Constant	0.24	0.02	10.39 **	0.02	10.13 **
StDev ( $\pi$ )/100	0.57	0.15	3.85 **	0.19	2.96 **
Dummy <sup>2/</sup>	0.50	0.04	13.38 **	0.04	12.50 **
R <sup>2</sup>		0.52			
RSS		11.96			
F(2, 242)		130.70 **			
Sigma		0.22			
Normality test	Chi <sup>2</sup> (2)	25.27 **			
Heteroscedasticity test	F(3, 238)	1.34			
Reset test	F(1,241)	0.01			

Notes: \* indicates statistical significance at 5 percent level;

\*\* indicates statistical significance at 1 percent level.

<sup>1/</sup> The dependant variable measures the average frequency of price change.

<sup>2/</sup> Dummy variable receives value “1” for nonprocessed goods and value “0” for others.

<sup>14</sup> Almost all nonprocessed goods, defined as those with relatively low value-added content, are food items.

<sup>15</sup> In the table, S.E. stands for standard error, and H.C.S.E. refers to the heteroscedasticity consistent standard errors. T-statistic values are calculated as the ratio of parameter estimate and its standard error.

## V. What Determines the Frequency of Price Changes Over Time?

In the previous section, we concluded that the frequency of price changes in cross-sectional data can be explained by inflation uncertainty and the value-added of an item. In this section, we turn to the question of how pricing behavior might change over time. As we have already explained, in time-dependent pricing models the timing of individual price changes is exogenous. An enterprise therefore sets its price every  $n^{\text{th}}$  period (Taylor, 1980) or randomly (Calvo, 1983). However, a key conclusion of the Taylor-Calvo models is that the fraction of enterprises adjusting their prices at any given period remains constant over time. As a result, inflation variability is entirely driven by the size of price changes. On the other hand, in state-dependent pricing models the fraction of enterprises changing their prices is determined by economic events. Hence, enterprises change their prices in response to market conditions.

We apply the methodology of Klenow and Kryvtsov (2005) and decompose the variance of monthly price change into two margins: an extensive margin (denoted by EM, which notes the fraction of items changing prices each month) and an intensive margin (denoted by IM, which measures the average size of price changes).<sup>16</sup> Klenow and Kryvtsov argue that these two margins are useful in interpreting the extent to which prices are set in line with time- or state-dependent pricing models. The first margin is featured in many state-dependent pricing models, while the second margin is the sole source of inflation dynamics in models of time-dependent pricing.

As before,  $\pi_t$  represents economy-wide inflation in month  $t$ , where  $\omega_{it}$  is the relative weight of item  $i$  in the consumer price index:

$$\pi_t = \sum_{i=1, \dots, k} \omega_{it} \pi_{it} \quad i = 1, \dots, k. \quad (8)$$

As derived by Klenow and Kryvtsov (2005), monthly inflation may be decomposed into the fraction of items whose prices change during month  $t$  (denote by  $fr_t$ ) and into the weighted-average price change in month  $t$  (denote by  $dp_t$ ).

$$\pi_t \equiv fr_t * dp_t, \quad (9)$$

$$\text{where } fr_t = \sum_{i=1, \dots, k} \omega_{it} I_{it} \text{ and}$$

$$dp_t = \pi_t (fr_t)^{-1}.$$

If the prices of all items change in period  $t$ , then  $fr_t = 1$  and  $\pi_t = dp_t$ . Figures 7 and 8 plot  $fr_t$  and  $dp_t$ , respectively.

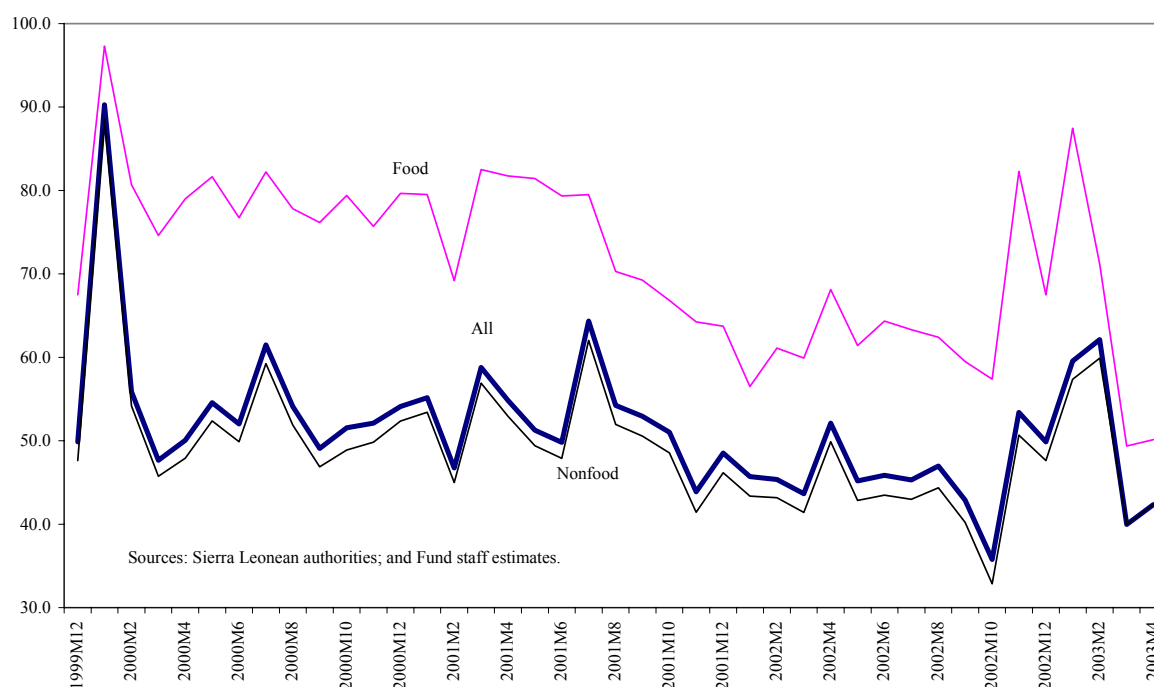
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<sup>16</sup> Klenow and Kryvtsov (2005) used micro-level consumer price data to examine pricing behavior in the United States.

The fraction of prices that are subject to change each month fluctuates between 35 percent and 90 percent (for a mean of 51 percent), which is substantial.<sup>17</sup> The average size of the monthly price change also varies considerably, between -12 and 17 percent (for a mean of 2.3 percent). The average fraction of items subject to change in the food category (fr-food) is substantially higher than in the nonfood group (fr-nonfood), whereas the average size of price change in the food group is somewhat smaller than in the nonfood category (Table 5).

The average proposition of items changing prices each month is high and consistent with our earlier conclusions using cross-sectional data. This outcome for Sierra Leone is very different from results reported for industrial countries (for example, see Bils and Klenow (2002) and Klenow and Kryvtsov (2005) for the United States; Apel, Friberg, and Hallsten (2001) for Sweden; Aucremanne and Druant (2005) for Belgium; Dias, Dias and Neves (2004) for Portugal; and Fabiani, Gattulli, and Sabbatini (2004) for Italy).

Figure 7. Fraction of Prices Changing Each Month  
(In percent)



<sup>17</sup> Klenow and Kryvtsov (2005) report that the average fraction of prices changing in the United States during 1988–2003 was about 30 percent.

Figure 8. Average Size of Monthly Price Change  
(In percent)

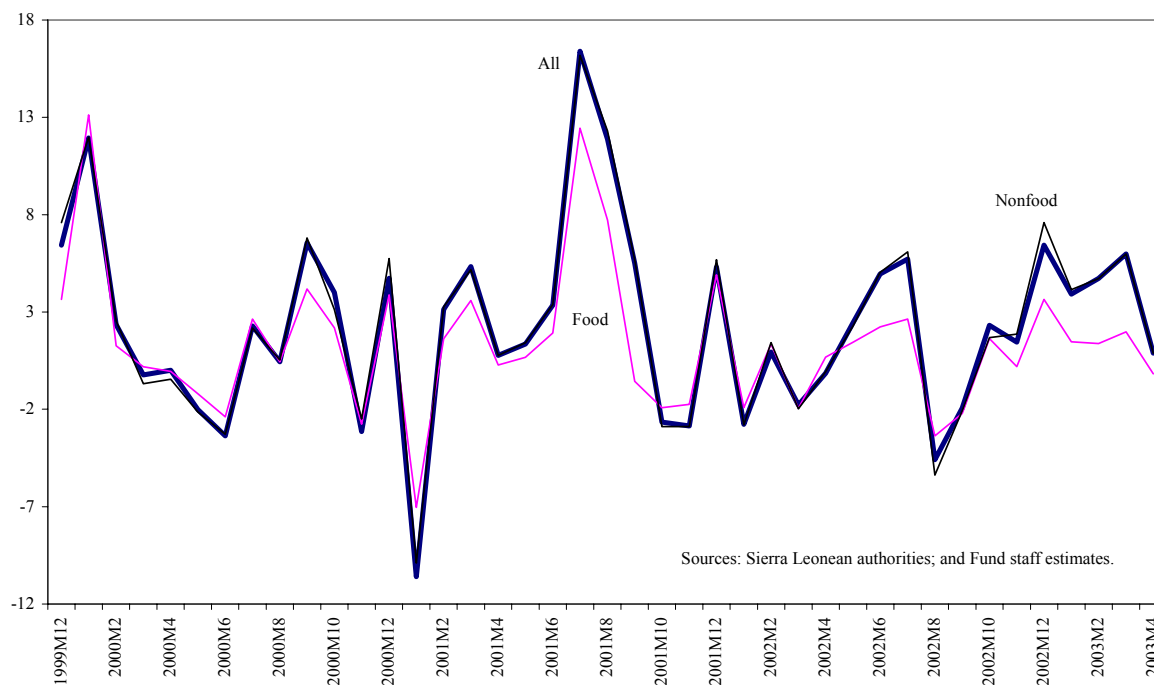


Table 5. Selected Indicators  
(In percent)

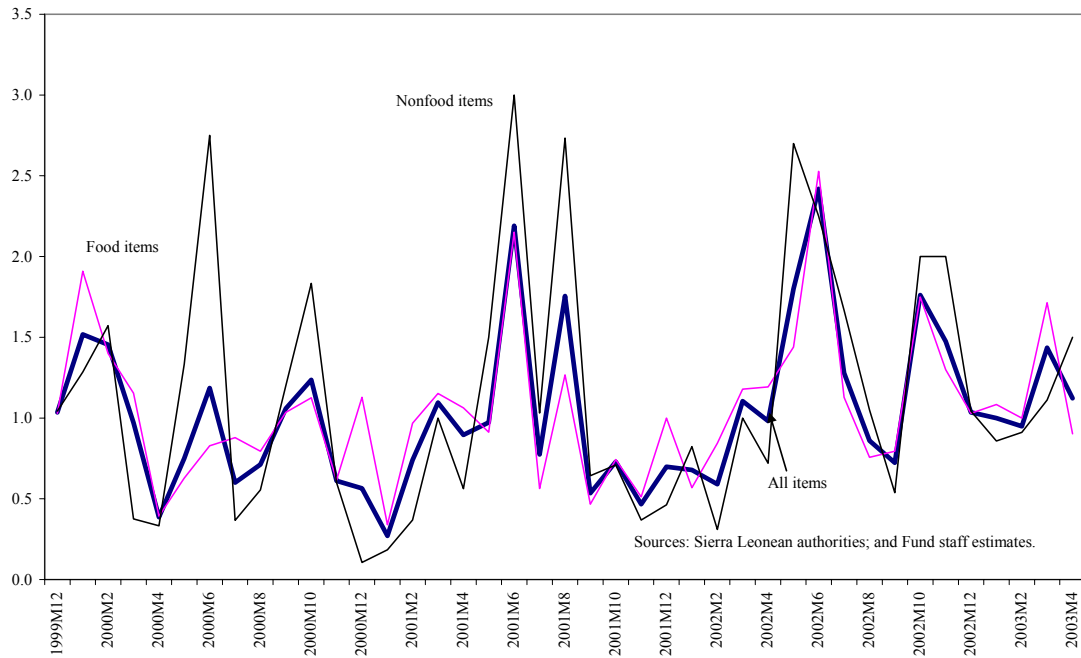
	$\pi$	fr	dp
All items	1.36	51.47	2.33
Standard deviation	2.98	8.66	4.87
Food items	1.09	71.65	1.37
Standard deviation	3.03	10.49	3.70
Nonfood items	1.36	49.36	2.42
Standard deviation	2.91	8.67	4.96

Furthermore, in an average month about 20 percent of prices rise or fall in Sierra Leone. This is consistent with our earlier results in that changes in food prices occur more frequently than changes in nonfood prices (Table 6). The ratio of rising to falling prices varies considerably over time (Figure 9).

Table 6. Prices Rising and Falling  
(In percent)

	All	Food	Nonfood
Rising	20.08	32.14	11.95
Falling	21.35	33.04	13.48

Figure 9: Ratio of Rising to Falling Prices and Inflation (December 1999–April 2003)



The variance of inflation,  $\text{var}(\pi_t)$ , may be decomposed into variances associated with the average size of monthly price change,  $\text{var}(dp_t)$ , the fraction of items changing prices,  $\text{var}(fr_t)$ , and the covariance between these two variables.<sup>18</sup> That is,

$$\begin{aligned} \text{var}(\pi_t) &= \{\text{var}(dp_t) * \underline{fr}^2\} + \{\text{var}(fr_t) * \underline{dp} + (dp_t - \underline{dp}) * (fr_t - \underline{fr}) + 2 * \text{cov}\} \\ &= \text{IM} + \text{EM}. \end{aligned} \quad (10)$$

The first term represents the intensive margin (IM), while the second term represents the extensive margin (EM). The results are reported in Table 7.

<sup>18</sup> See derivation in Klenow and Kryvtsov (2005). Variables  $\underline{dp}$  and  $\underline{fr}$  represent means of these variables in the sample.

Table 7. Variance Decomposition

	IM	EM
All items	3.06	96.94
Food items	3.91	96.09
Nonfood items	2.93	97.07

For Sierra Leone, the variance in inflation may be explained largely by the extensive margin, that is, fluctuations in the fraction of items subject to price changes. The results for food and nonfood groups are similar.

In this context, it is worth noting that the above outcome is strikingly different from that of Klenow and Kryvtsov (2005) for U.S. markets, where fluctuations in the fraction of items changing price are relatively unimportant as a source of inflation fluctuation. Aucremanne and Druant (2005) report similar findings for the Belgian economy, although the fraction of enterprises using state-dependent pricing is more pronounced in their study than in Klenow and Kryvtsov. Aucremanne and Druant also note that enterprises are likely to switch to state-dependent pricing models in special circumstances, suggesting that the magnitude of shocks also matters.<sup>19</sup>

Suppose that fluctuations in the fraction of items changing price can be explained by a linear stochastic model:

$$fr_t = a_0 + a_1 * t + \mathbf{b} * \mathbf{Z}_t + \varepsilon_t, \quad (11)$$

where  $\mathbf{Z}_t$  is a vector of variables (representing events) important for explaining changes in  $fr_t$ . For example, enterprises might adjust their prices in response to changes in production costs or because of demand shocks (for example, Fabiani, Gattulli, and Sabbatini, 2004). Apel, Friberg, and Hallsten (2001) argue that inflation and the exchange rate play important roles in pricing decisions. Past inflation could indicate future cost pressures and lead to upward adjustments in retail prices. Furthermore, an economy-wide rise in the price level would allow for higher individual prices without affecting the relative price structure (and therefore be more easily accepted by consumers). Enterprises could use other variables, such as monetary aggregates, as indicators of future cost pressures. The error term is assumed to be a white noise process.

In the estimation, the fraction of prices subject to change each month is influenced by lagged inflation and the money supply (using broad money), as shown in Table 8.<sup>20</sup> The response to

<sup>19</sup> In their study, the proportion of enterprises using a state-dependent price-setting strategy rises from 34 percent in normal circumstances to 74 percent in special circumstances.

<sup>20</sup> Lagged values of the dependent variable were not statistically significant in the estimation.  $\Delta^2 M2(t-2)$  denotes change in the growth rate of broad money ( $\Delta M2(t) = M2(t) - M2(t-1)$ ).

changes in money supply appears nonlinear and is measured by the second moment in this study. This suggests that there is a direct link from monetary policy to enterprises' pricing behavior, as changes in the money supply have a statistically significant and positive impact on the fraction of prices changing each month. Monthly inflation also seems to be important and is a key macroeconomic policy objective. The exchange rate variable (we experimented with both official and parallel exchange rates) was not statistically significant. Furthermore, there is a statistically significant negative trend in the data, suggesting that the proportion of prices changing each month tends to decline over time. This may be associated with greater economic stability observed during the sample period.

Table 8. Estimate for the Fraction of Price Changes

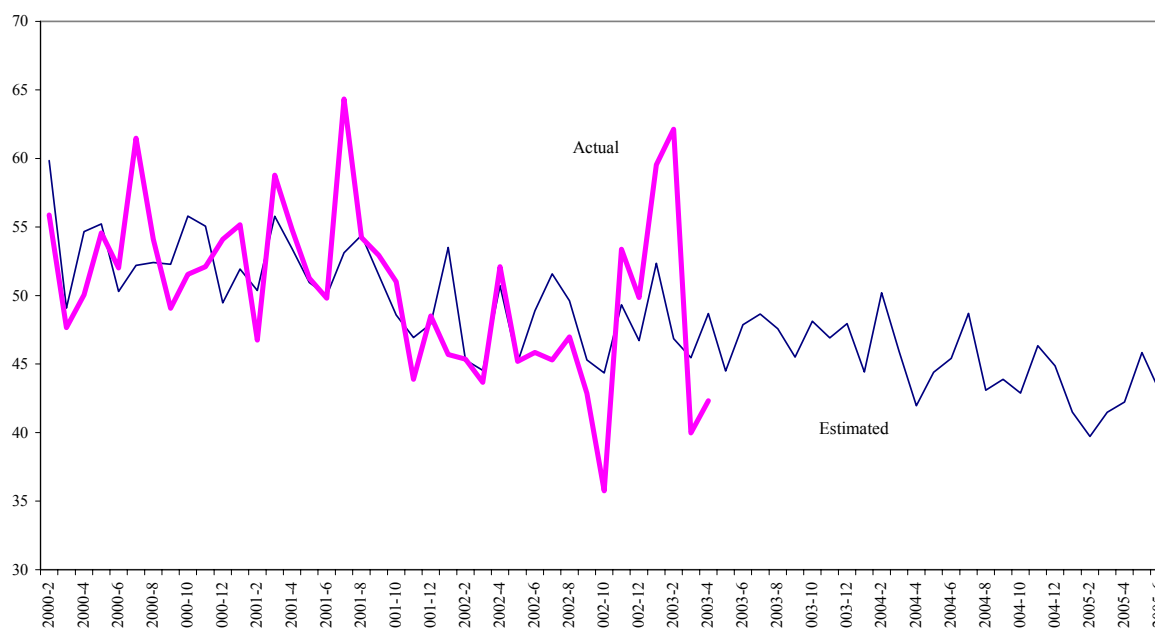
Explanatory Variables	Estimate	Std Error	T-Value
Constant	55.34	1.85	29.98 **
Time trend	-0.22	0.07	-3.00 **
$\Pi(t-1)$	1.26	0.45	2.80 **
$\Delta^2 M2(t-2)$	0.48	0.18	2.58 **
$R^2$			
RSS		955.10	
F(3, 35)		6.15 **	
Sigma		5.22	
Normality test	$\chi^2(2)$	5.46	
Heteroscedasticity test	F(6, 28)	1.11	
Reset test	F(91, 34)	2.51	

\*\* Indicates statistically significant at 1 percent level.

We extrapolate, using actual monthly inflation and broad money data for a period beyond the estimated sample (up to May 2005), how  $fr_t$  might have evolved. Figure 10 plots actual and projected values of  $fr_t$  and suggests that the fraction of prices changing each month is likely to have fallen significantly, to about 43 percent by mid-2005 from 90 percent as of January 2000 (see Figure 7).



Figure 10. Actual and Estimated Fraction of Price Changes  
(In percent; February 2000 – June 2006)



Sources: Sierra Leonean authorities; and Fund staff estimates.

## VI. Conclusions

In this paper, we have analyzed the causes of frequent price changes in Sierra Leone using micro-level price data. A number of conclusions can be drawn from this study, which, by and large, are similar to the findings of related studies on industrial countries.

First, individual prices change more frequently in Sierra Leone than in industrial countries, and the frequency of price changes varies significantly across commodity groups. Price level rigidities are therefore not widespread and have not resulted in inflation persistence, at least not at the aggregate level. This flexibility suggests that inflation could be brought down relatively rapidly, provided that macroeconomic policies are adequate. Moreover, nominal shocks are likely only to have a short-lived influence on real variables. In this context, the transmission mechanism of monetary policy would be an important area for future research, as it would improve understanding of the linkages between monetary policy and inflation in Sierra Leone. The frequency of price changes in the cross-sectional data is explained by inflation uncertainty and the value-added content of products.

Second, the fraction of items subject to price changes each month is very high and volatile. In Sierra Leone, variations in the fraction of items subject to price change are key determinants of inflation, which differs from the research findings for industrial countries, where the ratio has a low mean and is relatively stable. This suggests that pricing decisions in Sierra Leone

are driven largely by events, consistent with state-dependent pricing models, whereas in industrial countries prices are usually revisited at specified intervals, as explained by time-dependent pricing models. We also find that macroeconomic variables may be used to explain variations in the fraction of items subject to price change over time. In this context, by containing money growth and inflation, the analysis shows that monetary policy would reduce the fraction of price changes in Sierra Leone. Furthermore, a decline in the level of this fraction and its volatility would lead to lower inflation volatility and a lower frequency of price changes by enterprises.

Third, although beyond the scope of this study, one may argue that structural policies could also help reduce price volatility. For example, the volatility of food prices in Sierra Leone is high partly because of supply bottlenecks that may temporarily constrain the availability of products in the markets (food prices, for example, will always be influenced by seasonal factors). In this context, supply constraints may be eased through improvements in the road infrastructure, particularly in the rural areas, while productivity of the agricultural sector in general should be increased. Administrative barriers could also be relevant in Sierra Leone.

Finally, it is not straightforward to generalize these findings to other developing countries, in part because the research on pricing behavior, to my knowledge, has thus far been conducted exclusively using industrial country data. Before drawing broader conclusions on the basis of this study, this type of research on other developing countries appears warranted to establish, among other things, if the results obtained here are applicable to a larger group of developing countries with more complex and advanced market structures or apply mainly to post-conflict economies.

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Appendix Table 1: Description of Items

Item No.	Item Description	Unit	Item No.	Item Description	Unit	Item No.	Item Description	Unit
<b>Food</b>			<b>Drinks and tobacco</b>			<b>Expendable goods and services</b>		
1	LOCAL RICE	KG	90	SOFT DRINKS (COKE, ECT.)	PINT	174	LAUNDRY SOAP	1
2	IMPORTED RICE	KG	91	DOMESTIC BEER	PINT	175	SODA SOAP	1
3	MAIZE	KG	92	IMPORTED BEER	PINT	176	DETERGENT (SURF)	1
4	GARRI	CUP	93	PALM WINE	1 LITRE	177	WASHING BLUE	1
5	FLOUR OF WHEAT	BAG (SMALL)	94	AFAMES WINE	LITRE	178	STARCH	1
6	BREAD	KG	95	WHISKY (RED LABEL)	BOTTLE	179	TOILET SOAP	1
7	BISCUITS, NATCO	PK (0.1 KG)	96	DIAMOND/SASMAN RUM	LITRE	180	INSECTICIDE	1
8	PAN CAKE	PKT	97	OMOLE	PINT	181	MATCHES	1
9	MACARONI	PK (0.25 KG)	98	LOCAL CIGARETTES	PACKET	182	TOILET ROLL	1
10	BEEF	KG	99	IMPORTED CIGARETTES	PACKET	183	DOMESTIC WORKER	1 MONTH
11	SHEEP, GOAT MEAT	KG	100	TOBACCO LEAVES	KG	184	LAUNDRY CHARGES	1
12	PIG FEET	KG	101	KOLA NUTS	KG	<b>Personal transport</b>		
13	PORK	KG	<b>Clothing and footwear</b>			185	TYRE & TUBE FOR DATSUN, TOYOTA,	1 PAIR
14	CHICKEN (LOCAL)	KG	102	MEN'S SAFARI (READY-MADE)	1	186	BATTERY (12 VOLT)	1
15	CANNED MEAT (CORNEB BEEF)	KG	103	MEN'S TROUSER	1	187	SPARE PARTS	1
16	FRESH SNAPPER	KG	104	MEN'S KHAKI SHORT	1	188	PETROL	GALLON
17	FRESH MACKREL	KG	105	MEN'S SHIRT (POLYESTER)	1	189	DIESEL	GALLON
18	COUTA	KG	106	MEN'S SHIRT (COTTON)	1	190	ENGINE OIL	GALLON
19	DRIED SNAPPER	KG	107	MEN'S UNDERWEAR	1	191	BRAKE FLUID	1 TIN
20	DRIED BONGA (SMOKED BONGA)	KG	108	MEN'S VEST	1	192	DRIVER	1 MONTH
21	SMOKED HERRING	KG	109	MEN'S SOCKS	PAIR	<b>Transportation and communication</b>		
22	TINNED FISH (SARDAF)	0.125 KG	110	LADIES' DOCKET	1	193	PRIVATE LORRY (MINI BUS)	TRIP
23	LADY	KG	111	LADIES' HEADTIE	1	194	GOVT. BUS TO PROVINCES	TRIP
24	SHINE NOSE	KG	112	LADIES' BLOUSE	1	195	PRIVATE TAXI IN TOWN	TRIP
25	POLLOCK	KG	113	LADIES' SKIRT (COTTON)	1	196	PRIVATE BUS IN TOWN	TRIP
26	SHEEP HEAD	KG	114	LADIES' LAPPA	1	197	GOVT. BUS IN TOWN	TRIP
27	AWELU	KG	115	LADIES' UNDERWEAR (NYLON SLIP)	1	198	POSTAGE STAMP	1
28	OYSTER	KG	116	BRASSIER	1	199	TELEPHONE CALL (TO PROVINCE)	3 MINS
29	EGGS	DOZ.	117	BOYS' SHIRT, TROUSERS & SHORT	1 EACH	<b>Medicine and medical care</b>		
30	MILK (PEAK BRAND)	TIN (0.33 KG)	118	BOYS' OTHER CLOTHING	1 EACH	200	HEADACHE PILLS (PANADOL)	1 PKT
31	CONDENSED MILK	TIN (0.22 KG)	119	GIRLS' BLOUSE & SKIRT	1 EACH	201	COUGH MEDICINE (LIQUIFRUTA)	BOTTLE
32	BABY POWDERED MILK	KG	120	GIRLS' OTHER CLOTHING	1 EACH	202	MENTHOLATUM	TIN
33	CHEESE	PK (0.14 KG)	121	BABIES' CLOTHING	1 EACH	203	WORM MEDICINE (VERMOX)	PKT
34	ICE CREAM	CONE (0.07 KG)	122	CLOTHING MATERIAL (COTTON)	1 YARD	204	LAXATIVE (ANDREWS)	PKT
35	PALM OIL	PINT (0.33 L)	123	POPLIN CLOTH	1 YARD	205	TETRACYCLINE	TEN
36	GROUNDNUT OIL	PINT (0.33 L)	124	DRILL CLOTH	1 YARD	206	MALARIA PILLS (CHLOROQUINE)	TEN
37	OTHER VEGETABLE OIL	PINT (0.33 L)	125	TAILORING CHARGES FOR MEN	1 YARD	207	INJECTIONS	1
38	MARGARINE	PK (0.14 KG)	126	TAILORING CHARGES FOR LADIES	1 YARD	208	VISIT TO CLINIC	1 VISIT
39	BUTTER	PK (0.14 KG)	127	MEN'S LEATHER SHOES	1 PAIR	209	DOCTOR FEES	1 VISIT
40	BANANAS	KG	128	MEN'S RAIN BOOTS	1 PAIR	210	DRUGGIST FEES	1 VISIT
41	ORANGES	KG	129	MEN'S SLIPPERS	1 PAIR	211	DENTAL FEES	1 VISIT
42	MANGOES	KG	130	LADIES' LEATHER SHOES	1 PAIR	212	HOSPITAL SURGERY/ACCOMMDATION	1 NIGHT
43	PINE APPLE	KG	131	LADIES' PLASTIC SHOES	1 PAIR	213	OUT PATIENT FEES (GOVT. HOSPITAL)	1 VISIT
44	PAPAYA (PAW PAW)	KG	132	LADIES' SANDALS	1 PAIR	214	SPECTACLES	PAIR
45	RAW GROUNDNUTS	KG	133	BOYS' LEATHER SHOES	1 PAIR	<b>Education and stationery</b>		
46	POUNDED GROUNDNUTS	KG	134	BOYS' PLASTIC SHOES	1 PAIR	215	TUITION FEES	1 TERM
47	COCONUT	KG	135	BOYS' SANDALS	1 PAIR	216	PTA & OTHER	1 TERM
48	EQUISIE SEED	KG	136	GIRLS' LEATHER SHOES	1 PAIR	217	SCHOOL TEXT BOOK	1
49	BENNISEED	KG	137	GIRLS' PLASTIC SHOES	1 PAIR	218	EXERCISE BOOK (80 PAGES)	1
50	CASSAVA LEAVES	KG	138	GIRLS' SANDALS	1 PAIR	219	SCHOOL TRANSPORT	1
51	POTATO LEAVES	KG	139	REPAIR OF FOOTWEARS	1 PAIR	220	SCHOOL UNIFORM FOR BOYS	1
52	GREEN	KG	140	OTHER FOOT WEAR (BABIES)	1 PAIR	221	SCHOOL UNIFORM FOR GIRLS	1
53	SOUR SOUR (SOURELL)	KG	<b>Rents, rates, and repairs</b>			222	WRITING PAD	1
54	LETTUCE (SALAD)	KG	141	RENT ON PRIVATE HOUSE	1 MONTH	223	BALL PEN	1
55	JACATO	KG	142	HOUSE RENT ON SUBSIDY	1 MONTH	224	PENCIL	1
56	ONIONS	KG	143	RENTAL VALUE OF RENT-FREE HOUSE	1 MONTH	<b>Entertainment and recreation</b>		
57	CABBAGE	KG	144	RENTAL VAL. OF OWNER-OCCUPIED	1 MONTH	225	TV (21" HITACHI)	1
58	GARDEN EGGS	KG	145	CITY RATE	1 MONTH	226	RADIO (12 BANDS)	1
59	OKRA	KG	146	WATER CHARGES & OTHERS	1 MONTH	227	SPORT EQUIPMENT (3 TENNIS BALLS)	THREE
60	BROAD BEANS	KG	147	PUTTY	PKT	228	MAGAZINE	1
61	CUCUMBA	KG	148	PAINT	1 GALLON	229	NEWS PAPERS	1
62	FRESH TOMATOES	KG	<b>Fuel and power</b>			230	TRANSISTOR BATTERIES (4 FINGER TYPE)	FOUR
63	POTATOES	KG	149	ELECTRICITY	1	231	FOOTBALL TICKET	1
64	SWEET POTATOES	KG	150	GAS	1	232	CINEMA TICKET	1
65	CASSAVA	KG	151	KEROSENE	GALLON	233	VIDEO TICKET	1
66	YAM	KG	152	FIREWOOD	KG	234	CLUB OR UNION DUES	1 MONTH
67	FOFOFO	KG	153	CHARCOAL	KG	235	RELIGIOUS DUES	1 MONTH
68	SUGAR	KG	154	CANDLE	1	<b>Personal goods and services</b>		
69	SALT	KG	155	DIESEL FOR GENERATOR	1 GALLON	236	WOMEN'S HAIR DRESSING	1
70	MAGGIE	KG	<b>Furniture and non-expendable goods</b>			237	MEN'S HAIR CUT	1
71	SMALL GREEN PEPPER (CHILLI)	KG	156	BED	1	238	TOOTH BRUSH	1
72	BIG GREEN PEPPER	1 CUP	157	CHAIR	1	239	TOOTH PASTE	1
73	SMALL DRY PEPPER	1 CUP	158	DRESSING TABLE	1	240	FACE POWDER	1
74	GINGER	KG	159	GRASS MATTRESS	1	241	RAZOR BLADE	1
75	OGIRIE	KG	160	FOAM MATTRESS	1	242	GOOSE IRON	1
76	LUBI	KG	161	CURTAIN/TABLE COVER (PLASTIC)	1	243	MEN'S BRIEF CASE	1
77	TOMATO PASTE	TIN (0.125 KG)	162	BED SHEET	1	244	LADIES' HAND BAG	1
78	TYMES	KG	163	TOWEL (COTTON)	1	245	TRAVELLING SUIT CASE	1
79	COFFEE AROMATIC	KG	164	WASTE GAR. BOX/BUCKET	1	246	RING (18 CARAT GOLD)	1
80	COFFEE-NESCAFE	KG	165	FAN	1	247	WATCH (CASIO, BATTERY)	1
81	TEA (LIPTON)	BAG (0.01 KG)	166	LANTERN	1	248	UMBRELLA FOR MEN	1
82	COCOA	KG	167	DRINKING GLASS	1	249	UMBRELLA FOR LADIES	1
83	OVALTINE	KG	168	ENAMEL CUP	1	250	RAINCOAT FOR MEN	1
84	JAM (TOVA)	JAR (0.45 KG)	169	CUP & SAUCER	1	251	RAINCOAT FOR LADIES	1
85	CHOCOLATE	BAR (0.13 KG)	170	TABLE SPOON & FORK	1			
86	NATCO SWEETS	PK (0.33 KG)	171	TABLE AND KITCHEN KNIVES	1			
87	OTHER PREPARED FOOD (CASSAVA & STEW)	PLATE	172	BULB	1			
88	COOKED RICE & CURRY	PLATE	173	BROOM/BRUSH	1			
89	FOOD TAKEN IN RESTAURANT	LUNCH						

Source: Sierra Leonean authorities; and Fund staff estimates.