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DYNAMICS OF PRICE ADJUSTMENTS: EVIDENCE FROM MICRO LEVEL DATA FOR CHILE

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Resumen

Este trabajo caracteriza la dinámica de ajustes de precios en Chile usando datos a nivel de establecimientos para los productos de la canasta del IPC. Nuestros resultados muestran que las rigideces nominales son más bajas cuando están medidas a nivel microeconómico que cuando están estimadas con datos agregados de precios. La frecuencia de ajustes de precios aparece ser relativamente estable sobre el período 1999-2005. Por otra parte, si descomponemos los ajustes de precios en cambios positivos y negativos, observamos que la frecuencia de incrementos y reducciones de precios para algunos grupos de productos está correlacionada con el nivel de la inflación agregada. Así, los datos indican que tanto el margen intensivo como el extensivo de ajuste de precios desempeñan un papel en la determinación de la dinámica de precios. Finalmente, la evidencia sugiere un grado significativo de sincronización en ajustes de precios a través de establecimientos y un moderado incremento en la dispersión de precios desde 1999.

Abstract

This paper characterizes the dynamics of price adjustments in Chile using data at the establishment level of goods in the CPI basket. Our results show that nominal rigidities are lower when measured at micro-level compared to estimates based on macro data. The frequency of price adjustments appears to be relatively stable over the sample period 1999-2005. On the other hand, if we decompose price adjustments in upward and downward changes, we observe that these frequencies of adjustments for some groups of products are correlated with the level of aggregate inflation. Thus, the data shows that the intensive and extensive margins of price adjustment play a role in determining price dynamics. Finally, we find a considerable degree of synchronization in price adjustments across establishments and a moderate increase in price dispersion since 1999

We thank comments by Klaus Schmidt-Hebbel and seminar participants at the Central Bank of Chile, CEMLA and SECHI. We are particularly thankful to Eugenio Alviz of the National Institute of Statistics (INE) for providing us the raw data. The views in this paper do not necessarily represent those of the Central Bank of Chile. All remaining errors are ours. E-mail: jmedina@bcentral.cl; drappoport@yale.edu; csotog@bcentral.cl

1 Introduction

Key to understand how monetary policy is transmitted into the economy is the price adjusting mechanism. The generalized view states that for the monetary policy to have significant real effects it must be that prices are not completely flexible, at least in the short run. Price rigidities, in turn, may affect the relationship between price dispersion and inflation, which is important to evaluate the welfare cost of inflation. If price dispersion is the result of inflation cum nominal rigidities, then high inflation rates would imply undesirable changes in relative prices distorting resource allocation (Woodford, 2003)

In this paper we characterize the price dynamics in Chile utilizing micro level data. We are interested in determining the degree of nominal rigidity in the economy, and the type of distortions in relative prices generated by aggregate inflation. We want to answer questions such as: For how long prices are fixed? Are price adjustments dependent on the state of the economy? How important are the extensive and intensive margins in the adjustment process followed by firms? How does aggregate inflation affect price dispersion in the economy? What is the degree of synchronization of price changes? We use a new data set with prices of all varieties of goods included in the Consumer Price Index (CPI) at establishment level. The data base includes monthly and weekly prices for the period 1999-2005. Under certain assumptions, the data set allow us to construct price histories of up to 72 months for about 1200 varieties of goods. We can also compute measures of prices dispersion and synchronization of price adjustments for about 450 establishments.

Micro evidence on price adjustments provides valuable information to understand the nature of the nominal rigidities in an economy. In particular, considering prices of varieties at establishment level allow us to distinguish true changes of prices from changes in prices associated to composition or aggregation effects. There are two popular approaches to characterize nominal prices rigidities. One approach states that price adjustment are a function of the time span in between adjustments (Taylor, 1980; Calvo, 1983). The other, states that such adjustments depend on the state of the economy (Caplin and Spulber, 1987).[1] Models based on the first approach assume that the fraction of firms optimizing prices each period is exogenous. This implies that the extensive margin of the price adjustments -the fraction of firms changing prices- does not depend on the state of the economy. In this case, the size of price changes (intensive margin) is the only source of variation for aggregate inflation. In contrast, models based on the second approach assume that the moment in time when prices are changed is decided by the firms. In this case, the frequency of price adjustments

[1] An alternative theory is based on the idea that infrequent price adjustments occur is due to imperfect information. See Mankiw and Reis (2002).

does depend on the state of the economy and changes in the extensive margin play a major role in explaining aggregate inflation fluctuations. Although the statistics presented in this paper do not entail a formal test of alternative theories on nominal price rigidity, they shed light on the nature of the nominal price adjustment mechanism.

Our results show that the frequency of price adjustments is larger than the implicit one in estimations with aggregate data for Chile. For example, Phillips curve estimations suggest that prices are adjusted with a frequency of more than three quarters.[2] On the contrary, the micro evidence in this work indicate that prices are adjusted on average every quarter. Also, our results show that prices are adjusted more frequently in Chile than in developed countries. However, the frequency of price changes is very heterogeneous across different types of goods. Goods included in the group Fuel are adjusted on average every two weeks, whereas service prices in the group Education and leisure are adjusted once a year, on average.

According to our results, the frequency of price adjustments seems not to be correlated with the inflation level. However, if we decompose the frequency of adjustment distinguishing between upward and downward changes, we observe that, for some of the groups of products, there is a correlation between the frequency of such adjustments and the level of inflation. This result implies that the extensive upward and downward adjustment margins have a relevant role in the aggregate inflation dynamics. Remarkable is the fact that downward price adjustments are not uncommon at the micro level. Our results also show that price dispersion across firms that sell the same variety has increased slightly since 1999. However, we do not observe a correlation between price dispersion and aggregate inflation. Moreover, we found a significant degree of synchronization amongst firms, although with an important heterogeneity across types of goods. These results tend to support the view that the state of the economy may be relevant to determine the moment at which firms adjust their prices.

That the frequency of price adjustment estimated with micro data is larger than the estimated with aggregate data is not a new result in the literature (e.g. Bils and Klenow (2004); Baudry, Le Bihan, Sevestre and Tarrieu (2004); lvarez and Hernando (2004); Aucremanne and Dhyne (2004), Dhyne et al. (2006)). Bils and Klenow (2004), for example, using micro data on consumer prices in the U.S. find that firms adjust their prices on average every two quarters, whereas the macro estimations of Gal and Gertler (1999) point to an average frequency of price adjustment of about one year. This discrepancy on the degree of nominal rigidity at a micro and macro levels has given support to the hypothesis that

[2]Cspedes, Ochoa and Soto (2005), Caputo, Liendo amd Medina (2007), and Caputo, Medina and Soto (2006) present estimations on the degree of nominal rigidity in Chile using aggregate data.

other types of rigidities are relevant to explain the persistent effects of nominal shocks in aggregate variables.[3] The debate on how to conciliate the micro evidence with aggregate results is currently on going.

The rest of the paper is organized as follows. The next section presents the methodology utilized to compute different statistics used throughout the paper. Section III describes the data base with establishment level prices. Section IV presents and discusses the main results. Section V concludes.

2 Methodology

In this section we describe the statistics utilized to characterize the behavior of prices at establishment level. In general, the statistics are similar to those utilized by Aucremanne and Dhyne (2004) and others at the ECB Inflation Persistence Network.[4]

2.1 Frequency of price adjustments

Let I be the set of varieties and J_i the number of establishments selling variety $i \in I$ in our sample. Let $p_{i,j,t}$ denote the logarithm of the price of variety i in store j at time t, with $1 \leq j \leq J_i$. We define:

$$Adj\left(p_{i,j,t}, p_{i,j,t-1}\right) = \begin{cases} 1 & \text{if } p_{i,j,t} \neq p_{i,j,t-1} \\ 0 & \text{otherwise} \end{cases}$$

$$Comp\left(p_{i,j,t}, p_{i,j,t-1}\right) = \begin{cases} 1 & \text{if } p_{i,j,t} \text{ and } p_{i,j,t-1} \text{ were quoted} \\ 0 & \text{otherwise} \end{cases}$$

We are interested in the distribution of the frequency of price adjustments across different varieties. To that end, we calculate the frequency of price adjustment of variety i, f_i, as follows:

$$f_i = \frac{\sum_{j=1}^{J_i}}{|J_i|} \frac{\sum_{t=1}^{T} Adj\left(p_{i,j,t}, p_{i,j,t-1}\right)}{\sum_{t=1}^{T} Comp\left(p_{i,j,t}, p_{i,j,t-1}\right)} \tag{1}$$

where T represents the number of months (weeks) for which data is available. Definition (1) takes into account the fact that there are several prices not available in the data base because they have not been surveyed. We assume that for a variety i in establishment j, the event of having or not its price available in the database in a particular period of time is a random phenomena, independent of the price decisions. Therefore, the frequency of

[3] Nakamura and Steinsson (2006) show that if sales are excluded from price histories then the frequency of adjustments is similar to the one obtain with aggregate data.

[4] *www.ecb.int/home/html/researcher_ipn.en.html*

price changes for those prices not being observed due to missing data is the same as the average for observed prices. It is important to notice that if prices are surveyed when it is more likely that they change then our measure would underestimate price rigidity. It is also important highlight that data does not allows us to identify qualitative changes in varieties and sales. For the same reason, our estimates of the frequency of price adjustments may be overestimated and they should be considered upper bounds.

Together with calculating the average frequency of price adjustments for the whole simple for type of goods, we also compute the average frequency of price adjustments of each variety for each instant in time. The average frequency if price changes in group G at time t is defined as follows:

$$f_{G,t} = \frac{\sum_{i \in G} \sum_{j=1}^{J_i} Adj\left(p_{i,j,t}, p_{i,j,t-1}\right)}{\sum_{i \in G} \sum_{j=1}^{J_i} Comp\left(p_{i,j,t}, p_{i,j,t-1}\right)} \tag{2}$$

where group G is a subset of the set of varieties ($G \subseteq I$).

Considering only absolute price changes may obscure important features of the price dynamics. Therefore, we compute our statistics splitting between upward and downward price adjustments. For this, we define and as follows:

$$f^{+}_{G,t} = \frac{\sum_{i \in G} \sum_{j=1}^{J_i} Adj^{+}\left(p_{i,j,t}, p_{i,j,t-1}\right)}{\sum_{i \in G} \sum_{j=1}^{J_i} Comp\left(p_{i,j,t}, p_{i,j,t-1}\right)} \quad f^{-}_{G,j} = \frac{\sum_{i \in G} \sum_{j=1}^{J_i} Adj^{-}\left(p_{i,j,t}, p_{i,j,t-1}\right)}{\sum_{i \in G} \sum_{j=1}^{J_i} Comp\left(p_{i,j,t}, p_{i,j,t-1}\right)} \tag{3}$$

where,

$$Adj^{+}\left(p_{i,j,t}, p_{i,j,t-1}\right) = \begin{cases} 1 & \text{if } p_{i,j,t} > p_{i,j,t-1} \\ 0 & \text{otherwise} \end{cases} \quad Adj^{-}\left(p_{i,j,t}, p_{i,j,t-1}\right) = \begin{cases} 1 & \text{if } p_{i,j,t} < p_{i,j,t-1} \\ 0 & \text{otherwise} \end{cases}$$

2.2 Size of price adjustments

Together with price adjustment frequency we also compute the size of those price adjustments. This allows us to decompose total inflation in a particular period into extensive margin adjustment (fraction of forms adjusting prices) and intensive margin adjustment (size of changes by those firms adjusting prices). We define the average size of price adjustments in group G at time t as follows:

$$\pi_{G,t} = \frac{\sum_{i \in G} \sum_{j=1}^{J_i} \left|p_{i,j,t} - p_{i,j,t-1}\right|}{\sum_{i \in G} \sum_{j=1}^{J_i} Adj\left(p_{i,j,t}, p_{i,j,t-1}\right)}$$

Utilizing (3) this measure can be expressed as follows:

$$\pi_{G,t} = f^{+}_{G,t}\pi^{+}_{G,t} - f^{-}_{G,t}\pi^{-}_{G,t}$$

where $\pi^{+}_{G,t}$ and $\pi^{-}_{G,t}$ are the magnitude of price increases and decreases in group G respectively. They are defined as follows:

$$\begin{aligned}
\pi^{+}_{G,t} &= \frac{\sum_{i\in G}\sum_{j=1}^{J} Adj^{+}(p_{i,j,t}, p_{i,j,t-1})(p_{i,j,t} - p_{i,j,t-1})}{\sum_{i\in G}\sum_{j=1}^{J} Adj^{+}(p_{i,j,t}, p_{i,j,t-1})} \\
\pi^{-}_{G,t} &= \frac{\sum_{i\in G}\sum_{j=1}^{J} Adj^{-}(p_{i,j,t}, p_{i,j,t-1})(p_{i,j,t-1} - p_{i,j,t})}{\sum_{i\in G}\sum_{j=1}^{J} Adj^{+}(p_{i,j,t}, p_{i,j,t-1})}
\end{aligned}$$

Expression (4) shows that the total change in prices depend on the size of upward and downward adjustments, and on the fraction of firms adjusting in either of these two directions. Increases in the size of price adjustments may be the result of either an increase in the size of upward changes or a reduction of the size of price decreases (intensive margin). By the same token, this can be the result of increases in the fraction of firms adjusting upward prices or a reduction of the fraction of firms lowering prices (extensive margin).

2.3 Price dispersion

As mentioned above, it is possible that large price dispersion across establishment would be the result of the combination of high inflation and large nominal price rigidities. To analyze this issue we compute a measure of price dispersion across establishment for each group of goods. For group G our measure of price dispersion is given by:

$$disp_{G,t} = \sqrt{\frac{1}{|N_G|}\sum_{i\in G}\sum_{j=1}^{J_i}\frac{(p_{i,j,t} - \overline{p}_{i,t})^2}{J_i}}$$

where $\overline{p}_{i,t} = \frac{1}{J_i}\sum_{j=1}^{J_i} p_{i,j,t}$ corresponds to the average price of variety i in establishments where it is sold and N_G is the number of varieties composing group G. If this group is composed of only one variety, this measure would correspond to the standard deviation of prices across establishments.

2.4 Synchronization

Another important characteristic of the price adjustment dynamics at a micro level is the degree of price adjustment synchronization amongst different firms selling a particular variety. The degree of price adjustment synchronization may indicate the way firms adjust prices in response to aggregate shocks.

To measure this price adjustment pattern, we compute the statistic proposed by Aucremanne and Dhyne (2004). Given a monthly (weekly) average frequency of price adjustment for variety i, f_i, we compute the standard deviation of the price change frequency for this variety as follows:

$$sd_i = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(f_{i,t} - f_i)^2}$$

When there is no price adjustment synchronization across establishments -as in the case of the Calvo model-, in each moment in time a fraction f_i of the prices would be adjusted, no matter the particular moment in time t. Therefore, the standard deviation of the price adjustment frequency would be zero ($sd_i = 0$).

On the contrary, when there is perfect synchronization -i.e. when all prices are simultaneously adjusted- the fraction of prices being adjusted in each moment in time will be either zero or one. Then, we would observe that all prices change a fraction f_i of time, and during the remaining $(1 - f_i)$ fraction of the time they remain fixed. Given this, if we suppose perfect synchronization then we would have that:

$$\overline{sd}_i = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(f_{i,t} - f_i)^2} = \sqrt{f_i(1 - f_i)}$$

Given that $0 < f_i < 1$, the statistic is the upper bound of the values the standard deviation of the monthly price adjustments may take. The measure proponed by Aucremanne and Dhyne (2004) is defined as the ratio between the standard deviation observed for the monthly frequency of price adjustments and :

$$s_i = \frac{sd_i}{\overline{sd}_i} \tag{4}$$

This ratio take values in the interval [0,1], being 0 complete independence and 1 perfect synchronization.

3 Data

The data set comprises establishment-level data on prices for different varieties of goods included in the CPI basket. The data covers from January 1999 until July 2005, and it is of monthly and weekly frequency. Our measure of price corresponds to final expenditure on a particular variety (last transaction or final consumer sell price). The information is taken from the National Statistics Institute (INE). Comparable information for previous years is

not available, because the basket considered in the index was updated in December 1998. The basket was chosen based on the 5th Households Budget Survey of 1996-97, which was conducted to more that 8.000 households in the main Santiago area (INE, 2005) .

The CPI basket contains more that 1.000 varieties of about 500 different products or services, arranged in 9 different groups of products. Each group has several sub-groups, each one composed by different types of articles. These types of articles are, in turn, composed by several products (Table 1).[5] For example, group *Housing* includes the subgroups: *Lease and other fixed expenditures*, *Basic Services*, *Communications*, and *Reparations*. The subgroup *Lease and other fixed expenditures* considers the following articles: *Lease*, *Mortgages* and *Other fixed expenditures*. Products included in *Other fixed expenditures* comprise: *Taxes on property*, *Fees on garbage recollection* and *Housing insurances*. Varieties of each product correspond to different brands, fantasy names and materials that characterize each product. We identify *Fuel* as a distinct group becuase these products are surveyed weekly. This is also the case of all *Food* items. All other prices at establishment-level are collected monthly. It is important to mention that prices are quoted in several points in the main Santiago area. However, due to seasonality and because of other reasons, not all prices are collected in all periods.

The establishments include: supermarkets, shops, gasoline stations and others (see Table 2). The sample was elaborated based on the Selling Locations survey of 1997, conducted to about 1300 households from the main Santiago area.[6] Prices on some special services were informed directly by the providers. In the case of housing, a special monthly survey was used.

4 Results

4.1 Frequency of price adjustments

The mean and the median of the price adjustment frequencies for each group of goods -computed with equation (1)- are summarized in tables 3 and 4; figures 1 and 2 presents kernel approximations to the whole distributions of these frequencies. According to the data, the mean of the price adjustment frequency for all the varieties of goods in the database is about 0.4, and its median is 0.3. These figures imply that, at a firm level, prices are adjusted on average every three months. If we compare these results to those of others economies,

[5]The CPI basket has 8 groups, but since some goods in the groups *Housing* and *Transport* are quoted weekly, we consider them as a ninth group called *Fuel*.

[6]Establishments were chosen according to the share of expenditure they received, rather than the frequency of selling.

we observe that in Chile prices are adjusted more often than in European countries and in the U.S., but in a similar pace as in Brazil and Mexico (table 5). Given that Brazil, Mexico and Chile share a history shaped by episodes of high and persistent inflation, the previous result could suggest that the macroeconomic record has an important role to play in the dynamics of price adjustments.

When we look at different groups of goods we find that Fuel and Energy is the one with the highest frequency of price adjustments, with a median of about 1.8 for the whole sample period. This figure implies that prices are modified, on average, every two weeks. On the contrary, the median of the frequency of price adjustment of the group Education and Leisure is about 0.08, which implies that prices are adjusted on average once a year. It is important to mention that these figures could be considered an upper bound (lower bound) for the frequency (duration) of prices as, amongst other things, the database does not exclude sales.

Tables 3 and 4 also present the mean and the median of the price adjustment frequency distributions for three sub-samples (1999-2000, 2001-2003 and 2002-2005). According to the median for all groups of goods, prices have slightly increased their degree of nominal stickiness in recent years; the median of the frequency of price adjustment fell from 0.34 during the period 1999-2000 to 0.29 during the period 2004-2005. By groups of products, this is also true for groups Housing, Housing Equipment, Transport, and Others. In contrast, prices in the group Fuel seem to have become more flexible over time as the median of frequency of adjustment raised from 1.23 during the years 1999-2000 up to 3.11 during the period 2004-2005. This last fact can be tie to the increase of the volatility of the international price of petroleum in the recent years.

The fact that the frequency of price adjustment has decrease over time, whereas the GDP growth has rise, seems to contradict the state dependent approach to characterize price adjustments. If we think that higher output growth is linked to demand expansions that require price adjustments, then we would expect the frequency of adjustment to be positively correlated with the cyclical position of the economy. We would also expect that more frequent price changes would coincide with higher inflation levels. However, we do not observe a positive association between the median frequency of price adjustments and aggregate inflation. Moreover, for some groups we observe that the highest frequency of adjustments occurs during the period in which inflation reached its highest level.

Figures 1 and 2 show kernel approximations to the distributions of the frequencies of price adjustments. In general, we observe that these distributions are asymmetric (except for Housing equipment, Health y Clothing) with more mass on the left of the distribution. However, the existence of extreme observations of very frequent price changes makes the

average price duration to be shorter when measured using the mean of the distribution than when measured with the median. Also, the distributions of price adjustment frequencies show that there is a high heterogeneity in the degree of nominal price rigidity amongst the different products in the CPI basket. In fact, for various groups the distributions are bi-modal, with a non negligible mass of good with a high degree of flexibility.

Our micro level estimations indicate that prices are more flexible than what was estimated using aggregate data. In the case of Chile, macro estimations of the Phillips curve show that prices remain unchanged for more than three quarters (Cspedes, Ochoa y Soto (2005), Caputo, Liendo y Medina (2007) y Medina y Soto (2007)), whereas the micro evidence points to an average duration of prices of about one quarter. This discrepancy in the estimation of the frequency of price adjustments, which also occurs in the case of studies for the U,S and other economies, could be explained by the fact that adjustments at the micro level are, in general, infrequent and sizable, and there can be biases when aggregating small units.[7] On the other hand, it is important to remark that the identification of the degree of nominal rigidities at a macro level, in most of the studies, is based on the persistence of inflation and output (the output gap) in response to various shocks (nominal shocks) without directly considering the existence of nominal rigidities. The interaction of nominal and real rigidities reduces the incentives of firms for producing large price adjustment, even when they are able to do it. Under this circumstances, we would observe, at a macro level, slower price adjustments in responses to nominal shocks than what would occur if only nominal rigidities where present.[8] Therefore, if we do not consider correctly the real rigidities in the economy, we would tend to overestimate the degree of nominal rigidity when estimated at a macro level. Finally, the fact that there are price changes linked to sales may lead to an underestimation of the degree of nominal rigidity at a micro level. In a recent paper, Nakamura and Steinsson (2007) suggest that the discrepancy between micro and macro estimation of the frequency of price adjustments almost disappears when sales are excluded from the data base. Unlike regular price changes, sales are transitory price changes that are not linked to macroeconomic conditions. This implies that it is relevant to distinguish between regular price changes and sales when trying to determine the degree of nominal rigidity in the economy.

The fact that the frequency of price adjustments does not exhibit a clear relationship with the aggregate state of the economy -aggregate inflation and GDP growth- could indicate that time-dependent theories on price adjustments could provide a good approximation of the true price adjustment mechanism. However, this conclusion could be the result of the

[7] See Caballero and Engel (2003).

[8] See Altig et al. (2005) and Klenow and Willis (2006)

sample period we are analyzing, where inflation has been low and stable. Gagnon (2005), using data on Mexican prices, finds that the frequency of adjustments increases in periods when inflation rises, but only for ranges of inflation that are high. When inflation is low -around 5 per year-there is no connection between changes in inflation and the frequency of price adjustments. Models in which the timing of price adjustments is an endogenous decision of the firm, the dynamics of inflation in response to shocks depends on their size. Therefore, even in this types of models, if real and nominal shocks are small, then the evolution of inflation could be similar to the one obtain with a time-dependent model (ser Burstein, 2005).

Figures 3 to 5 depict the relationship between the frequency of price adjustments for each group –$f_{G,t}$ from equation (2)– and total inflation on a monthly basis for the whole sample period.[9] From the figures is clear that for all groups there is almost no correlation between the frequency of price adjustments and aggregate inflation. However, when we decompose price changes between price increases and price decreases, we observe that for most groups there is a significative correlation between the frequency of upward and downward price adjustments and inflation (e.g. *Fuel*, *Housing*, *Clothing*, *Transport* and, to a leaser extent, *Health*, *Education and Leisure*, and *Others*). In other words, the frequency of price increases rises with the level of inflation, while the frequency of prices reductions falls with inflation. These correlations suggest that the moment at which prices are changed, either upward or downward, –the extensive margin– may be determined by the state of the economy.

The previous results also suggest that when price changes are not adequately decomposed –particularly, when price reductions are not taken into consideration– we could wrongly conclude that there is no correlation between the frequency of such changes and inflation.

4.2 Size of price adjustments

Figures 3 to 5 also depict the correlation between the average size of price changes and inflation on a monthly basis for the period 1999-2005. For most of the groups, there is evidence of a positive correlation between the absolute size of price changes and the state of the economy (aggregate inflation). This result would suggest that the intensive margin in fact plays a role in determining aggregate inflation.

However, when we split the average size of price changes between the average size of price increases and average size of price decreases, we observe that the correlation with inflation is more muted, and only for some groups. For example, for the group *Clothing* there is a positive correlation between the size of upward price adjustments seems and

[9]For the groups *Food* and *Fuel* we work with average weekly frequencies.

inflation, and a negative correlation between the size of price reduction and inflation. For other groups we do not observe a clear pattern. This implies that the variability of the size of price adjustments in each group and its association with aggregate inflation can not be completely attributed to the intensive margin adjustments. Again, the extensive margin seems to play a role in this dynamics.

4.3 Price dispersion

Tables 5 and 6 show the mean and median standard deviations of prices across establishment for different groups of varieties. When we consider all varieties, price dispersion seems to have increased over the sample period. The lowest dispersion of prices is found in the fuel group with a standard deviation of 0.04. This is not surprising since goods in this group are, in general, homogeneous. In the other extreme, clothing varieties display the higher degree of price dispersion, with a standard deviation of about 0.36.

When looking at the correlation between price dispersion and inflation, we observe no clear pattern. The inflation rate fell from 1999-2000 to 2001-2003, while during the same period price dispersion increased. We would have expected the opposite. The existence of nominal rigidities implies that when inflation is high, the dispersion of relative prices across establishments should increase. The evidence in Tables 5 and 6 is confirmed in figure 6, where we plot the correlation between price dispersion and inflation on a monthly bases for all groups. In general, aggregate inflation seems not to be correlated with price dispersion for the different groups in the sample. This result would indicate that idiosyncratic shocks could be very important to explain price dispersion across establishments.

4.4 Synchronization

Finally, we report statistics on the degree of synchronization between prices adjustments across establishments selling the same variety (Table 7). The mean of the price synchronization ratio computed using equation (4) is 0.437 and its median 0.369. This synchronization ratio is greater than zero for all groups, implying that for all varieties there is some degree of synchronization in the price adjustment mechanism across establishments.[10] The degree of synchronization is well above the figure reported by Aucremanne and Dhyne for Belgium, that is close to 0.24. This would indicate that the importance of common factor –e.g. the state of the economy– in price adjustment in Chile would be larger than in the case of Belgium.

[10]The sample was restricted to varieties sold by more than one establishment, on average, during the sample period.

At the group level, transport prices appear to be the most synchronized of all the groups, with a median ratio of 0.85. On the contrary, adjustments of prices of *Food* varieties seem to be the least synchronized, with a median ratio of 0.17. It is interesting to note that for *Housing*, *Transport*, and *Education and leisure* there are varieties for which prices changes are perfectly synchronized across establishments ($s_i = 1$). In the case of *Housing* this may reflect indexation practices. For *Education and leisure* the complete price synchronization of some of its varieties just reflects the fact that educational institutions (school, universities) adjusts prices at the beginning of the first term each year.

5 Conclusions

This paper characterizes the dynamics of price adjustments in Chile using micro-level data. We compute the frequency of price adjustments for all goods included in the CPI basket, as well as measures of the size of price changes, price dispersion, and price synchronization.

Our main results indicate that the frequency of price adjustments seems to be larger than the one estimated at macro level for Chile. This could indicate that not only nominal rigidities are present in the economy, but also real rigidities are necessary to generate persistent effects of different shock as observed in the aggregate data. However, this high price flexibility at micro level could be contaminated by the fact that sales are not excluded from the sample. We leave for future research a the analysis of the role played by sales in the pricing dynamics. Comparing our statistics with international evidence suggest that price are adjusted more often in Chile than in developed countries, but in line with other emerging market economies.

Our results also indicate that the frequency of prices changes is very heterogeneous across different products. On average, prices of *Fuel* items are changed twice a month. In turn, prices of services related to *Education and Leisure* remain unchanged for about 12 months on average. The frequency of price adjustments shows no correlation with inflation in the period analyzed. However, if we decompose price adjustments in upward and downward movements, we observe that for many groups of products there is a correlation between inflation and either the frequency of upward or downward changes. This finding hints that the extensive margin of price adjustments is important to explain price dynamics. Also, price decreases are not uncommon in the data.

Our results show that price dispersion across retailing firms has slightly increased since 1999. However, there is no relationship between price dispersion and aggregate inflation. Finally, the micro-level pricing behavior displays a significant level of synchronization across establishments with an important level of heterogeneity among groups of products.

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Table 1: CPI structure: Number of varieties per group.

Groups	Name	Number Subgroups	Number Items	Number Products	Number Varieties
1	Food	11	58	162	305
2	Housing	5	12	29	38
3	Housing equipment	7	25	84	164
4	Clothing	6	26	75	152
5	Transport	2	11	26	101
6	Health	3	9	44	110
7	Education and leisure	4	12	55	345
8	Others	3	3	8	45
9	Fuel	2	2	5	9
	Total	**43**	**158**	**488**	**1269**

Source: INE.

Table 2: Establishment types.

Establishment type	Number of establishments
Supermarkets	55
Stores	81
Street markets	54
Butcheries and fisheries	38
Department stores	79
Gasoline stations	37
Warehouses	7
Drugstores	81
Clinics	25
Bookstores	83
Schools	52
Total	**457**

Source: INE.

Table 3: Mean frequency of price change for different groups of products and periods.

	1999-2005	1999-2000	2001-2003	2004-2005
All groups	0.461	0.464	0.495	0.447
Food	0.995	0.955	1.066	0.963
Fuel	1.930	1.228	2.399	3.110
Housing	0.384	0.415	0.393	0.354
H. Equip.	0.320	0.385	0.329	0.225
Clothing	0.388	0.363	0.412	0.399
Transport	0.438	0.461	0.508	0.440
Health	0.308	0.288	0.332	0.270
Educ. n leis.	0.140	0.153	0.137	0.140
Others	0.322	0.310	0.325	0.252
GDP growth[(a)]	3.67	1.86	3.16	6.26
inflation[(a)]	2.63	3.42	2.18	3.05

Source: Own elaboration based on INE.

Table 4: Median frequency of price change for different groups of products and periods.

	1999-2005	1999-2000	2001-2003	2004-2005
All groups	0.333	0.343	0.333	0.289
Food	0.777	0.773	0.906	0.719
Fuel	1.851	1.230	2.299	2.841
Housing	0.269	0.345	0.266	0.200
H. Equip.	0.313	0.374	0.320	0.228
Clothing	0.412	0.378	0.439	0.411
Transport	0.375	0.428	0.416	0.363
Health	0.308	0.285	0.327	0.263
Educ. n leis.	0.082	0.087	0.068	0.111
Others	0.161	0.187	0.146	0.125
GDP growth[(a)]	3.65	1.86	3.16	6.26
inflation[(a)]	2.63	3.42	2.18	3.05

[(a)] median corresponds to the geometric average of annual figures.

Source: Own elaboration based on INE.

Table 5: Mean standard deviations of prices across establishments.

	1999-2005	1999-2000	2001-2003	2004-2005
All groups	0.273	0.242	0.256	0.310
Food	0.207	0.192	0.204	0.246
Fuel	0.036	0.038	0.036	0.031
Housing	0.227	0.196	0.228	0.251
H. Equip.	0.287	0.252	0.291	0.344
Clothing	0.359	0.335	0.368	0.393
Transport	0.314	0.139	0.144	0.342
Health	0.216	0.244	0.210	0.246
Educ. n leis.	0.278	0.279	0.280	0.321
Others	0.236	0.223	0.229	0.264
GDP growth[(a)]	3.67	1.86	3.16	6.26
inflation[(a)]	2.63	3.42	2.18	3.05

Source: Own elaboration based on INE.

Table 6: Median standard deviations of prices across establishments.

	1999-2005	1999-2000	2001-2003	2004-2005
All groups	0.219	0.165	0.184	0.239
Food	0.157	0.133	0.153	0.164
Fuel	0.027	0.031	0.026	0.027
Housing	0.212	0.185	0.192	0.201
H. Equip.	0.209	0.154	0.205	0.245
Clothing	0.345	0.327	0.348	0.353
Transport	0.269	0.068	0.039	0.307
Health	0.115	0.113	0.107	0.113
Educ. and leis.	0.212	0.213	0.211	0.225
Others	0.180	0.169	0.171	0.186
GDP growth[(a)]	3.65	1.86	3.16	6.26
inflation[(a)]	2.63	3.42	2.18	3.05

[(a)] corresponds to the geometric average of annual figures.

Source: Own elaboration based on INE.

Table 7: Synchronization

Group	mean	median	minimum	maximum
All groups	0.437	0.369	0.090	1.000
Food	0.196	0.172	0.090	0.672
Fuel	0.504	0.513	0.391	0.541
Housing	0.423	0.319	0.226	1.000
H. Equip.	0.358	0.335	0.221	0.803
Clothing	0.440	0.456	0.221	0.786
Transport	0.776	0.853	0.278	1.000
Health	0.536	0.613	0.208	0.852
Educ. n leis.	0.557	0.560	0.238	1.000
Others	0.490	0.498	0.256	0.772

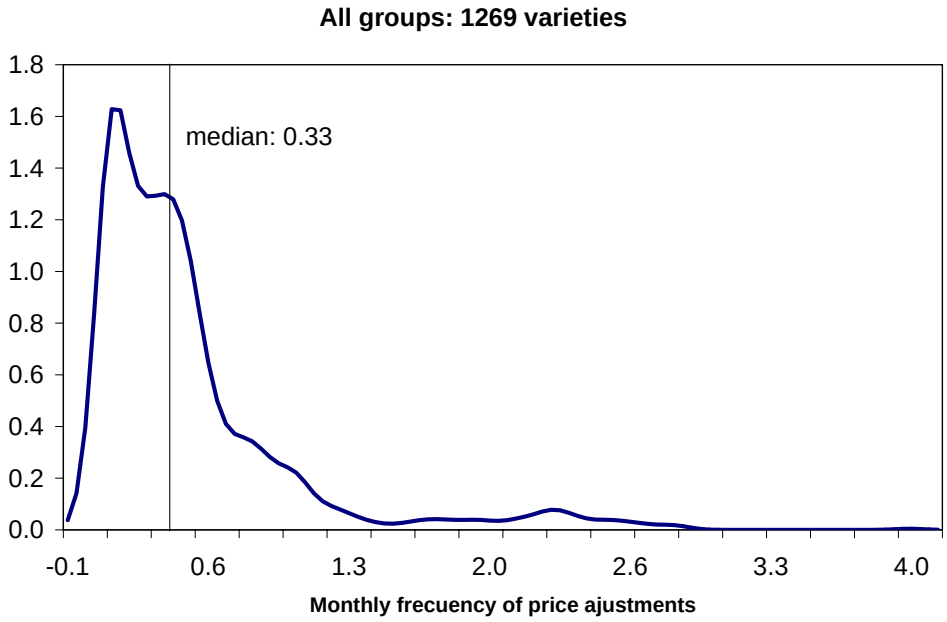
Source: Own elaboration based on INE.

Table 8: International Evidence on the frequency of price changes

		frequency (%)		duration[(a)] (months)	
Study	country	mean	median	mean	median
Auchermanne and Dhyne (2004)	Belgium	16.85	13.25	5.4	7.0
Nunes (2006)	Brazil	40.27		1.94	
Dhyne *et al* (2006)	Europe	15.1		6.1	
Baudry *et al* (2004)	France	18.9	14.9	4.8	6.2
Baharad and Eden (2004)	Israel	24	21	3.6	4.2
Bils and Klenow (2004)	US	26.1	20.9	3.3	4.3
Klenow and Kryvstov (2004)	US	29.3		2.9	
Nakamura and Steinsson (2006)	US	21.1	8.7	4.2	11.0
Gagnon (2005)	Mexico	30.4 - 36.6		2.2 - 2.8	

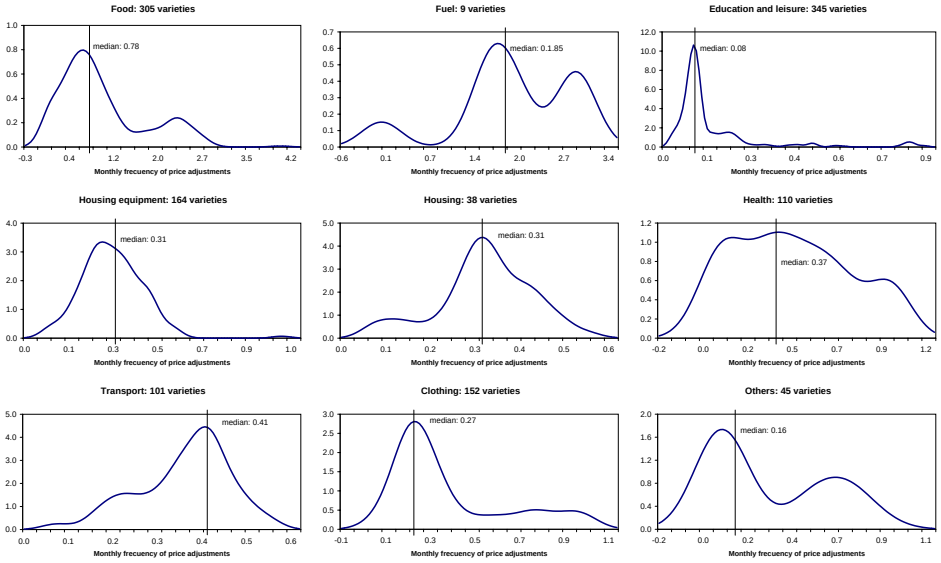
[(a)] Durations were computed as $-1/ln(1-f)$, where f denotes frequency. Following Baharad and Eden (2004), some authors (Dhyne *et al*, 2006; Baudry *et al*, 2004; Auchermanne, Dhyne, 2004; Nakamura, Steinsson, 2006) reports mean durations of price quotes inverting the frequency at the micro level and taking averages next. Our procedure underestimates mean price durations, but allows for straightforward comparisons. Gouvea (2007) works directly with the direct measure of duration.

Figure 1: Frequency distribution of price changes (All groups).



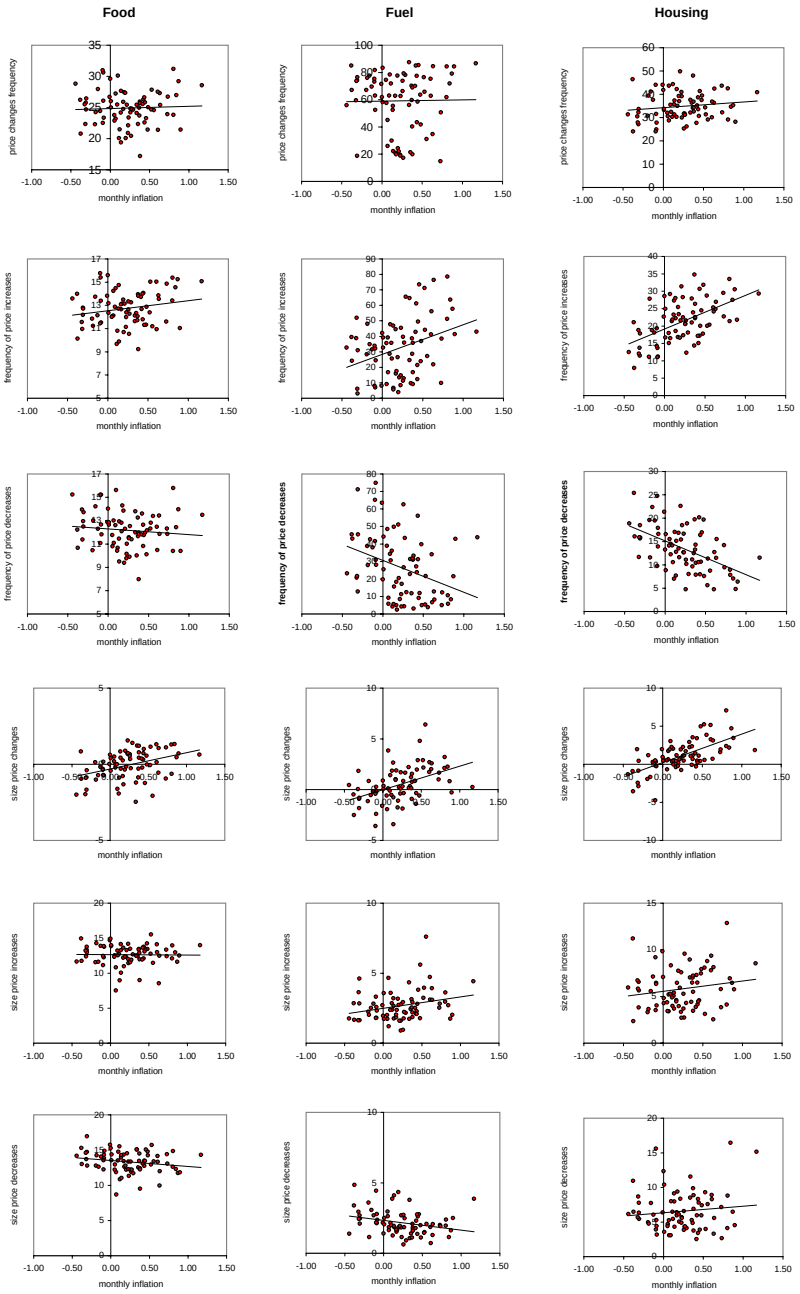
Source: Own elaboration based on INE.

Figure 2: Frequency distribution of price changes (by groups).



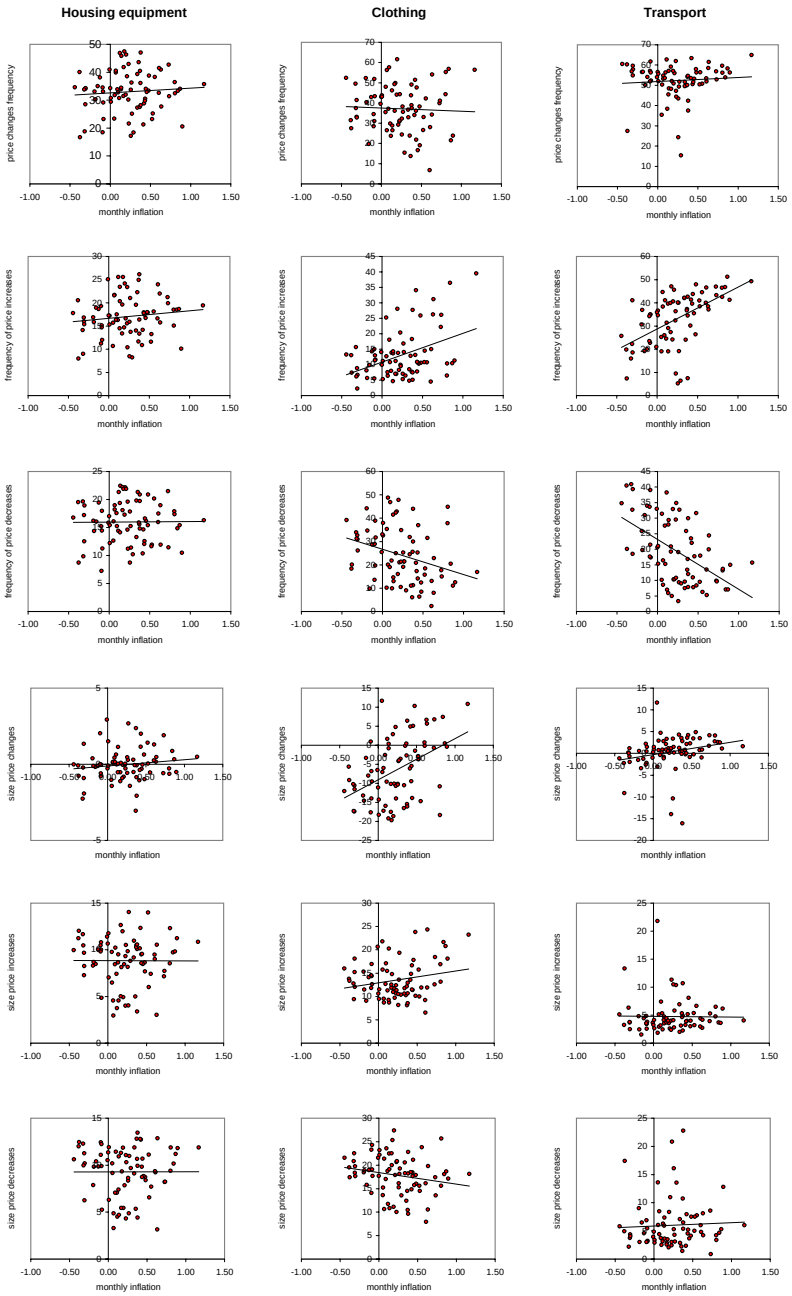
Source: Own elaboration based on INE.

Figure 3: Frequency and Magnitude of price changes and inflation rate: Food, Fuel and Housing.



Source: Own elaboration based on INE.

Figure 4: Frequency and Magnitude of price changes and inflation rate: House Equipment, Clothing and Transport.



Source: Own elaboration based on INE.

Figure 5: Frequency and Magnitude of price changes and inflation rate: Health, Education and Leisure and Others.

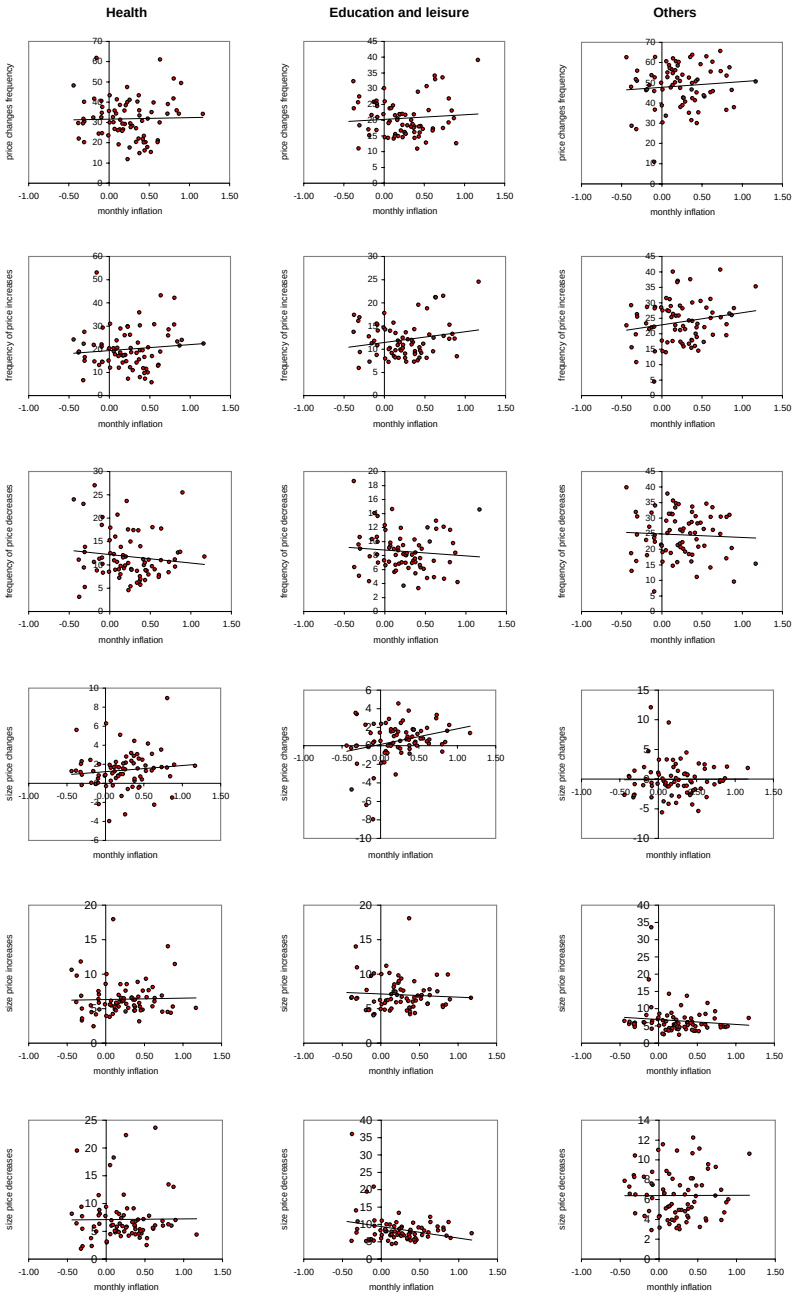


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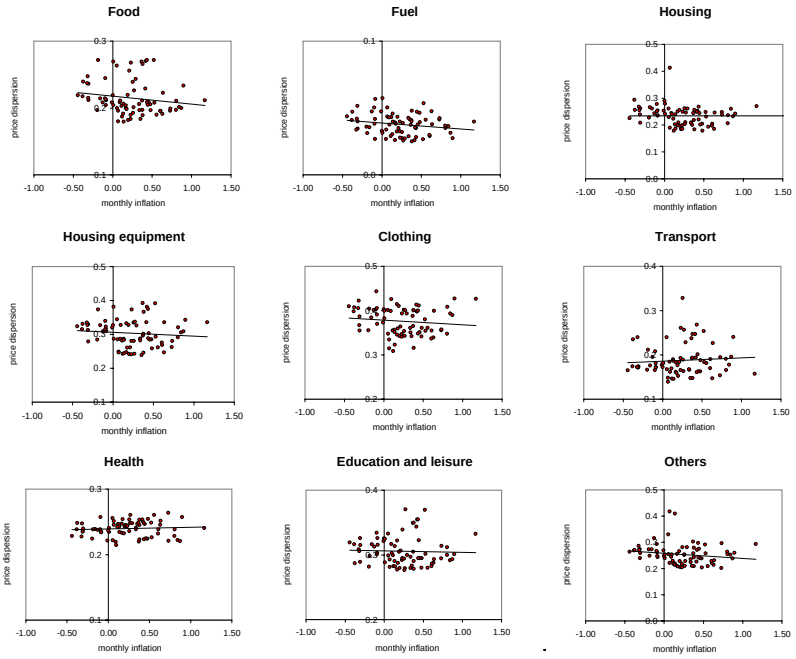
Figure 6: Price dispersion and inflation.



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