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HONG KONG CONSUMER PRICES ARE FLEXIBLE

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Abstract

It is generally believed that prices in Hong Kong are flexible. If this received wisdom is correct then the Currency Board system, which precludes a nominal exchange rate adjustment in response to macroeconomic shocks, may have little macroeconomic cost.

However, this belief in price flexibility is based on very little empirical evidence. In this paper, we seek to rectify this in a study the behaviour of sub-indices of the Hong Kong Consumer Price Index. We compare estimated moments in the data against the predictions of models based on flexible prices, capacity constraints, rational inattention, and menu costs. We find evidence in favour of flexible prices.

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1. Introduction

It is received wisdom that prices in Hong Kong are flexible, and therefore that the presence of a currency board system, which precludes a nominal exchange rate adjustment in response to macroeconomic shocks, results in little cost to the macroeconomy.[2] However, there has been little empirical evidence provided in support of this view. In fact, the only published academic study that addresses the degree of price flexibility in Hong Kong focused on the export sector and found that quantities change much more quickly than prices in response to shocks (Yip and Wang 2002), suggesting a lack of price flexibility.

In this paper, we address the question more directly by studying the behaviour of prices of narrowly defined consumer goods and services in the Hong Kong Consumer Price Index, and compare these with the predictions of four different models of business cycle propagation: flexible prices, capacity constraints (Hansen and Prescott 2005), menu costs (Mankiw 1985), and rational inattention (Levy *et al.,* 2004). We argue that each of these models has different implications for the size and persistence of price increases versus decreases, depending on the inflationary environment. We also examine relationships between higher order moments in the data, as a further test of menu costs.

One important contributor to our ability to identify the price setting mechanism is that the different models predict different behaviour during inflationary versus deflationary periods, and Hong Kong experienced continuous deflation (defined as a decreasing Consumer Price Index year-on-year) from November 1998 until June 2004. The combination of a large (cumulative 13.9% fall in prices) and long (68 months of continuously falling prices) deflation is unique in recent times for a high income economy.

Elsewhere, a number of papers have focused on the source of Hong Kong's deflation. For example, Genberg and Pauwels (2005) argue that the deflation was driven by declining prices of imported goods and a negative output gap; Cutler (2005) focuses on the role of a negative wealth shock; Ha and Fan (2002) find evidence of convergence between prices in Mainland China and Hong Kong that required downward price adjustment in Hong Kong; while Schellekens (2005) demonstrates that most of the deflation can be explained by cyclical factors rather than price equalization with Mainland China. Ultimately each of these explanations relies in part on Hong Kong's Currency Board System which precludes a systematic monetary policy response to domestic factors. Thus when a series of negative macroeconomic shocks resulted in an overvalued real exchange rate, adjustment to equilibrium occurred via a decline in the nominal price level rather than the nominal exchange rate.

2 See, for example, the discussion in Yip and Wang (2002).

We investigate the price adjustment mechanism in Hong Kong within a dataset that consists of 327 sub-indices from the Consumer Price Index at a monthly frequency over the January 1995- September 2007 period. We show that the data exhibits significant degrees of asymmetry between price increases and price decreases, and between pricing behaviour during inflation and deflation, and that these are consistent with the predictions of the flexible price model, but inconsistent with the other models we examine.

We are not the first to use to use variation in inflation regimes to identify the nature of price setting. For example, Gagnon (2007) studied differences between low and high inflation regimes in Mexico using store-level price data and found that price behaviour matches the predictions of menu cost models; Hoffmann and Kurz-Kim (2006) focused on a period of low inflation in Germany, and found that a mixture of time dependent and state dependent pricing can explain pricing behaviour; and Gotte, Minsch and Tyran (2005) examined how restaurants in Switzerland adjusted prices as inflation varied between 7% and 0%, finding that restaurants increased the frequency of price changes, but not the size of price changes, at higher inflation rates. In broad terms, all these studies report evidence consistent with menu costs. In contrast to these studies, we will focus on an economy that is commonly thought to have highly flexible prices (Hong Kong), and one that endured a sustained period of deflation for over five years. And we will argue that the empirical evidence for Hong Kong is consistent with flexible prices.

The next section outlines the predictions of the different models for price-setting asymmetries, and section 3 discusses the data. Section 4 assesses the degree of asymmetry in Hong Kong prices and compares these with the predictions of the models, while section 5 concludes.

2. Models of Price Setting

In this section, we outline the predictions of four different models of price changes, and how these predictions differ between price increases and price decreases, and between inflationary and deflationary regimes.

2.1 Flexible Prices

Suppose that prices in the economy are completely flexible. Any asymmetries in the behaviour of prices would reflect asymmetries in underlying shock processes. The inflationary regime provides one such asymmetry: under inflation, nominal marginal costs may be expected to drift upwards over time. As a result, price increases may be expected to be larger than price decreases. Further, because marginal cost is drifting upwards, price increases are more likely to be followed by further price increases than price decreases are to be followed by further price decreases.

Under deflation, the expected results reverse. Nominal marginal costs drift down over time, so price decreases are likely to be larger and more persistent than price increases.

2.2 Capacity Constraints

The capacity constraints model (Hansen and Prescott 2005) is a model of price setting that assumes that prices are flexible, but quantities of output are not. In particular, some sectors in the economy are likely to experience a binding capacity constraint in response to positive demand shocks. In contrast, any capacity constraint is unlikely to be binding in response to negative shocks.

The implications for price setting are as follows. In response to positive shocks, profit maximising firms raise both prices and quantities until capacity constraints bind. Thereafter they increase only prices. The upshot of this is that price increases will be relatively larger than price decreases, and especially so when the economy is growing rapidly and firms are likely to be operating at capacity. However, such price increases are likely to be mean reverting over time, as firms work to alleviate their capacity constraints.

For the case of Hong Kong, we interpret this to mean that price increases will be larger but less persistent than price decreases during the inflationary period, but for price behaviour to mimic that under flexible prices in the deflationary period, since deflation occurred during a recessionary period in Hong Kong during which few firms were likely to face binding capacity constraints.

In support of the assumption that capacity constraints are unlikely to bind during Hong Kong's deflationary period, Figure 1 and 2 plot the CPI- both for the Hong Kong economy as a whole and for the sample of goods that we will study later- and real GDP growth. We note that there were three separate recessions (defined as at least two quarters of falling seasonally adjusted real GDP growth, quarter-on-quarter) during the deflationary period, and in each case, the recession coincided with an increase in the deflation rate.

In addition to price increases being larger but less persistent than price decreases, the capacity constraints model also predicts that large price increases are more common than large price decreases, since the former are likely to result whenever capacity constraints bind.

2.3 Menu Costs

The third model of price change that we consider is the menu cost model (Mankiw 1985). The idea behind the menu cost model is that price changes are costly. As a result, firms will only adjust their prices if the difference between the actual and desired price is sufficiently large that it is worth the firm paying the menu cost to make the change. Thus there will be a range of inaction about the desired price within which prices will remain fixed. The presence of such menu costs lies at the heart of New Keynesian models of the business cycle, where the failure of prices to fully adjust to shocks implies that even a purely nominal shock may have significant real effects.[3]

In addition to papers already mentioned, empirical evidence of menu costs includes Cecchetti (1986), who finds that magazine prices change only infrequently, but more often when the inflation rate is higher, as implied by menu costs since higher inflation ensures that it is worth firms paying the price of adjusting their prices more often. Kashyup (1995) studies catalogue prices and finds that prices are updated infrequently, again consistent with menu costs. Levy *et al.* (1997) directly measures menu costs at supermarkets, and finds these to be non-trivial. They also find that a supermarket chain that is required by law to place a separate tag on every item for sale experiences menu costs almost three times as high, and changes prices much less frequently, than other supermarket chains. In contrast, survey results (Blinder (1994), Blinder *et al.* (1998) and Hall, Walsh and Yates (2000)) suggest that firms do not consider menu costs as a very important consideration when deciding whether to set prices. However, as Blanchard (1994) and Mankiw (1985) argue, a central theme of the sticky price literature is that costs of price change that may be trivial to, and have only minor implications for profits of, the individual price setter can still have large macroeconomic effects.[4]

Other studies look directly at the empirical implications for menu costs in macroeconomic data. For example, Ball, Mankiw and Romer (1988) find that menu cost models can explain differing slopes of estimated Phillips curves across countries, while Devereux and Yetman (2003) find that menu costs can explain differences in the behaviour of exchange rate pass-through across countries.

Under menu costs, the region within which firms fail to adjust their price depends on the firm's profit function. But, as illustrated by Figure 3, the profit function is asymmetric.[5] If the actual price is even a little below the optimal price, a profit maximizing firm facing menu costs may wish to raise its price, while the actual price must be much further (in absolute terms) from the optimal price for a firm facing the same menu costs to desire to reduce their price.

The source of this asymmetry has been discussed extensively elsewhere.[6] A seller whose price is too low may make a loss on every item sold, and also sell additional units of output. Both of these effects create incentives for the firm to raise prices. In contrast, a seller whose price is too high stands to sell fewer units,

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3 See, for example, Woodford (2003)

4 There is also a large volume of studies of price stickiness for Euro area economies coordinated by the European Central Bank that provides mixed evidence as well, summarised in Altissimo *et al.* (2006) and Alvarez *et al.* (2006).

5 This profit function is for the case of a monopolistically competitive firm if consumers consume a composite that is a Dixit-Stiglitz aggregator over differentiated goods. For a derivation, see Appendix 1.

6 See, for example, Devereux and Siu (2007), Ho and Yetman (2006), Burstein (2006), Ellingsen, *et al.* (2006), and King and Wolman (1999).

but this is partially offset by higher profits on each unit sold. Thus firms will be less averse to prices that are too high than prices that are too low, and therefore more reluctant to reduce prices than raise them in response to shocks.

To illustrate this asymmetry another way, Figure 4 plots the absolute deviation of the actual price from the optimal price for a firm to choose to reset its price, across a range of different levels of menu cost. It illustrates that for any given menu cost, the range of inaction when the price is too low (given by the area below the line) is less than the range of inaction when the price is too high.[7]

Peltzman (2000) finds empirical support for such asymmetries, in that output prices respond to positive cost shocks by twice as much as to negative shocks, and that the resulting price difference is persistent over time.

The above figures are for the case where there is no drift in prices over time, and therefore no deflation or inflation. But if we focus on the case of an inflationary environment, firms will be even more eager to increase their price in response to a shock since the real value of a price is declining over time anyway, as argued by Ball and Mankiw (1994, 1995). In contrast, firms will be even more reluctant to reduce prices, since prices are falling in real terms anyway. And in a deflationary environment, these arguments would reverse: firms would be less eager to increase prices, and more eager to reduce them. But at moderate levels of inflation or deflation such as those experienced by Hong Kong during our sample period, and with small menu costs so that price adjustments are relatively frequent on average, as we observe in our data, the asymmetry apparent in Figure 3 may be expected to dominate.[8]

So what would such asymmetries imply for the behaviour of individual prices? We simulate the behaviour of a price setter under both moderate inflation and moderate deflation, consistent with the historical experience of Hong Kong. We determine the margins at which a firm will choose to increase or decrease their price, along with the optimal price that the firm will set when it changes price, to maximise profits. Realistically, we assume that good-specific idiosyncratic shocks have a much larger bearing on price setting decisions than trend inflation, so that the desired price is volatile, and we observe both price increases and decreases during both inflationary and deflationary periods.[9]

[7] This asymmetry would potentially be further exacerbated by the presence of “strategic complementarity” among firms, in which the desired price of each firm depends in part on the price set by other firms. Thus if a portion of firms fail to adjust their price, other firms have an increased incentive not to adjust their price as well.

[8] In our Hong Kong data, average inflation in the CPI in the early part of the sample is 5.37% per annum, followed by an average deflation rate of 2.78%, followed by an average inflation rate at the end of the sample of 1.35%.

[9] Our simulations are based on the assumption that marginal cost follows a random walk, and the distribution of marginal cost shocks is symmetric. See Appendix 1 for details.

We plot 100 periods of our simulation at the average annual inflation rate between January 1996 and October 1998 (5.37%) and the average annual deflation rate between November 1998 and June 2004 (-2.78%) in Figures 5 and 6. Note that these simulations are directly comparable: the sequence of shocks is identical in each case. We also include the optimal flexible price for comparison. We find that realistically small menu costs result in price increases that are smaller, and more persistent, than price decreases under both inflationary and deflationary regimes. In addition, prices are systematically higher (relative to marginal cost, or optimal flexible price) during the deflation regime than during the inflation regime.

The source of this over-pricing is that under inflation, firms are more likely to hit the lower price bound and raise prices than hit the upper price bound and reduce prices, while the reverse is true under deflation. During inflation, therefore, prices are more likely to be in the lower “range of inaction” (between the optimal flexible price and a price that is low enough to trigger a price rise), and during deflation in the upper range of inaction.[10]

Ideally we would like to test directly for evidence of overpricing during deflation. However, we cannot, since we do not know the level of the optimal flexible price. Instead we will look for evidence of menu costs indirectly, by testing whether price rises are smaller but more persistent than price declines, which we would expect to result from the asymmetric loss function when a firm is subject to menu costs.

In addition, we add one additional test for menu costs by looking at the relationship between higher moments of the price data and the inflationary environment. Ball and Mankiw (1994, 1995)[11] argue that there are good reasons to expect to find such relationships if firms face menu costs. Suppose the distribution of price changes is symmetric about zero. There will be equal numbers of firms wishing to increase prices as reduce them, so that the overall price level remains stable, and independent of the variance of relative prices.

Now consider instead the case where the distribution of price changes is positively skewed. A few firms wish to raise their prices a lot, while a lot of firms wish to decrease their prices a little. With menu costs, the former firms will be more likely to change their price, and so positive skew will result in rising prices. In contrast, negative skew will result in falling prices.

Under trend inflation, we would expect to find that firms are more willing to raise prices than lower them, resulting in a positive relationship between skewness and the level of aggregate inflation. Under trend deflation, this process may be expected to go into reverse: firms are more willing to lower prices than raise them, resulting in negative skewness and declining prices. We would also expect to find that the

10 Movement in the degree of asymmetry in the price bounds due to differences in the inflationary regime is not enough to offset this.

11 See also Bryan and Cecchetti (1999), Gerlach and Kugler (2007), and Verbrugge (1999).

size of inflation or deflation is increasing in the volatility of the microeconomic price changes as well, since firms will be more willing to adjust their prices the greater is the volatility that they face.

2.4 Rational Inattention

Another model of price setting that makes similar predictions for price changes to the menu cost model is the model of rational inattention (Levy *et al*., 2004). Suppose that consumers do not adjust their consumption bundle in response to sufficiently small price changes. Firms then face increased incentives to increase prices by small magnitudes, since the increased profit per unit sold will not be offset by decreased sales. Firms also face decreased incentives to reduce prices by small magnitudes, since the loss in profit per unit sold will not be offset by increased sales. In contrast, large increases or decreases will be symmetric, since either will trigger re-optimizing by agents. Levy *et al*. (2004) find empirical support for rational inattention in scanner data from a large US supermarket chain.

In our model, in addition to the predictions of the menu cost model, rational inattention would imply that smaller price changes are more likely to be increases than decreases, and small increases are more persistent than small decreases since firms will tend to pass on marginal cost increases via a series of small price rises to avoid suffering output losses.

2.5 Summary

We summarise the predictions of our four models of price setting for the behaviour of price changes in Table 1. The presence of both inflationary and deflationary/recessionary periods in Hong Kong should allow us to discriminate between different models as explanations of price setting in Hong Kong.

In addition to the above predictions, we should be able to distinguish between flexible prices and capacity constraints by observing the distribution of price changes. In particular, capacity constraints would imply that large price increases are more common than large price decreases. Similarly, in comparing menu costs with rational inattention, the latter would imply that small price increases are more common than small price decreases.

3. Data

We test the models of price setting using a unique dataset that includes 327 components of the Hong Kong CPI at monthly frequency over the 153 months from January 1995 to September 2007, for a total of 50031 observations on the price level. These components together make up 45% of the overall CPI. Included within the sample are most of the components of the CPI that are set in the market (excluding those set by regulatory agencies), are not imputed, and are not subject to large seasonal fluctuations over time, as provided by the Hong Kong Census and Statistics Department.[12]

Note that our dataset consists of disaggregate good-level prices that are weighted averages across different locations and stores, and as such are themselves aggregates. This is in contrast with some other studies of price movements that focus on store-level prices, which allow for more systematic modelling of the price setting decisions by firms, such as many of the papers summarised in Alvarez *et al*. (2006) and Altissimo *et al.* (2006) using European data, as well as Bils and Klenow (2004), Golosov and Lucas (2007), and Klenow and Kryvstov (2005) using US data.

The coverage of the different major components of the CPI contained within our sample is given in Table 2.[13] Further, as illustrated in Figure 1, the goods included in our sample broadly track the overall performance of the CPI over the sample period, which divides broadly into three periods: moderate inflation before November 1998, followed by deflation until June 2004, followed by low inflation until the end of the sample.

As a further illustration of the data, Figure 7 demonstrates the range of behaviour that the different price series display, along with the weight of the series in the CPI. From the volatility of the price of fresh flowering cabbage, to the steady downward price of mobile phones, to the almost constant price of English language newspapers, there is a large degree of differentiation in the price behaviour of different goods and services. This is both due to heterogeneous price setting behaviour across different goods and services, and differing numbers of individual prices being aggregated into the sub-indices of prices in our dataset.

Within the dataset, there is also significant variation in the number of price increases and decreases over time. Figure 8 plots the percent of all prices that are rising, falling, or remaining constant on a year-on-year basis within the panel. One can clearly see that in all periods, a significant number of goods experience both rising and falling prices, although this number varies substantially between inflationary and deflationary periods.[14, 15]

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12 All data series made available by the Census and Statistics Department for the purposes of this study are utilized throughout.

13 For a further break-down by individual goods, see Appendix 2.

14 Note that the “no change” category is defined as good categories where the price index takes on the same numerical value to one decimal place as it did twelve months earlier. There are a total of 941 such observations in the sample. A more stringent definition of “no change” would require no change in the price index in any of the intervening months as well. Approximately one third of all such observations, spread over 21 different goods, satisfy this stricter definition of “no change,” with “English Newspaper” (105 observations), “Postal and Courier Services” (52), “Preserved Vegetables” (47), “Examination Fees” (36) and “Chinese Newspaper” (27) providing most of the observations.

In fact, this variation alone is sufficient to explain nearly all of the variation in inflation, as illustrated by Figure 9, which plots the inflation rate against the number of goods with increasing prices less the number of goods with falling prices. The correlation coefficient between these two series is 0.94.

In other studies, authors have found important seasonal influences in price-setting decisions. For example, Altissimo *et al*. (2006) find that price changes are more likely to take place during the first quarter (especially in January) or after the summer period (especially in September) in Euro area data, and are less frequent in July and August, while Nakamura and Steinsson (2007) find that the frequency of price changes is highest in the first quarter and lowest in the fourth quarter in US data.

We would expect any seasonal pattern in Hong Kong data to be apparent from the average magnitude of price changes in each month across the different sub-indices, as provided by monthly fixed effects from a regression with a dependent variable of month-over-month price changes. The results, together with 95% confidence bands, are reported in Figure 10. These indicate that there are important differences in price behaviour over the calendar year. In particular, price changes are largest in February/March and October and smallest at the end of the year. In the remainder of our analysis we will focus on year-on-year changes in individual price series, so that our results are not influenced by seasonal patterns in the data.

4. Empirical Evidence on Price Setting

We now test the different models of price setting in Hong Kong data by looking at the persistence and size of price changes between inflationary and deflationary periods, and then higher order moments, and comparing these with the predictions of the models outlined in Section 2. In comparing the data with the models, we must bear in mind that the former consists of observed price aggregates across different stores of narrowly defined goods (as opposed to prices of individual goods at a specific store), while the latter strictly applies to individual store level data. Changes in prices in the data therefore reflect decisions at the individual firm level that determine the size of price changes, the frequency of price changes, and the degree of synchronicity of price changes across firms. In principle, changes across one of these dimensions could be offset by changes across the others. For example larger, less frequent, price changes, if spread uniformly across firms through time, could result in exactly the same observed behaviour as smaller, more frequent, price changes. But this possibility is unlikely, given the variation we find in the behaviour of our microeconomic price aggregates.

[15] As Smith (2006) points out, whether there is deflation or inflation, some prices are typically rising while others are typically falling. The transition from inflation to deflation is a change in the balance between these two, rather than a change in the behaviour of all prices.

We will continue our analysis under the assumption that, for narrowly defined goods (as in our sample), firms' price setting decisions for a given good are highly correlated. That is, there is a "good-specific" marginal cost shock that is sufficiently large relative to any "store-specific" shock, and there is sufficient competition among firms selling the same good in different locations, that we should expect to find behaviour of good level prices in our dataset that is broadly similar to the store level prices.

4.1 Persistence

To examine the behaviour of persistence in Hong Kong price data, we first examine aggregate data and estimate the following equation,

$$\Delta P_t = \beta + \rho_1 \Delta P_{t-12} + \rho_2 D_t \Delta P_{t-12} + \varepsilon_t, \quad (1)$$

where $\Delta P_t = \log(P_t) - \log(P_{t-12})$, D_t is a dummy variable that takes on a value of 1 when there is deflation (defined as $\Delta P_t < 0$), and time is measured in months. The results are presented in Table 3, in the top panel for the CPI, and in the lower panel for the portion of the CPI that is in our dataset.

We can see that Hong Kong inflation is much more persistent during inflationary episodes than deflationary episodes at annual frequency, both for the complete CPI and for the portion of the CPI on which we have data. This is in keeping with Burdekin and Siklos (2004), who report that inflation is more difficult to predict during deflationary episodes than inflationary ones, and in contrast to Bordo and Filardo (2005) who found that there was little difference in the degree of persistence in aggregate inflation between inflationary and deflationary episodes before World War 1.

At first appearance, these results accord with the predictions of the menu cost model that price increases are more persistent than price decreases, since prices tend to rise during inflationary periods and fall during deflationary periods. But the predictions of the menu cost model apply not to aggregate prices, but instead to individual good prices.

So our next step is to consider the individual price series for each of the 327 components for which we have data. Our estimated equation takes the form

$$\Delta P_{it} = \beta_i + \rho_1 \Delta P_{it-12} + \rho_2 D_t \Delta P_{it-12} + \rho_3 D_{it-12} \Delta P_{it-12} + \varepsilon_{it}, \quad (2)$$

where goods are indexed by *i*, $\Delta P_{it} = \log(P_{it}) - \log(P_{it-12})$, D_{it} is a dummy variable that takes on a value of 1 when the price of good *i* is falling year-over-year, and D_t is as defined above. We also include good-level fixed effects, and incorporate robust variance-covariance estimates.[16] The results are contained in Table 4.

From these results we can see that, first, inflation persistence is simply not present in the sub-indices of the CPI on an annual basis, but is instead a result of aggregation across the different goods.[17] In fact, inflation rates at the micro level are significantly negatively correlated through time, indicating mean reversion in the price level.

Second the presence of deflation in the aggregate price level has no significant separate effect on the degree of persistence at annual frequency. This is consistent with the idea that the important difference between deflation and inflation is the number of firms whose prices are rising or falling, as opposed to the behaviour of the price aggregate, as suggested by Smith (2006).

Third, when we interact the lagged price level with the sign of price changes at the microeconomic level, we find there is greater mean-reversion in the price level when prices are rising than when they are falling. That is, if prices fell in the previous year, it is less likely that the price decrease will be reversed (via a price rise in the current period) than if prices increased in the previous period. Note, however, that this is exactly the opposite of the prediction of the menu cost and rational inattention models. It is also only partially in agreement with the capacity constraints model, since it implies that price increases should be less persistent than price decreases during inflation. In contrast, the results are consistent with the qualitative predictions of the flexible price model.

As a further test of our model, we consider all possible interactions between the dummy variables, by estimating the following equation,

$$\begin{aligned}\Delta P_{it} = \beta_i + \rho_1 D_t D_{it-12}\Delta P_{it-12} + \rho_2 D_t (1-D_{it-12})\Delta P_{it-12} + \rho_3 (1-D_t) D_{it-12}\Delta P_{it-12} \\ + \rho_4 (1-D_t)(1-D_{it-12})\Delta P_{it-12} + \varepsilon_{it},\end{aligned} \tag{3}$$

and obtain the following results: (See Table 5)

Now we see that there are significant differences between all the estimated parameters,[18] and that the estimates again accord only with the flexible price model. Price increases are more persistent than price decreases under inflation, while the converse is true under deflation.

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16 We incorporate Newey-West variance-covariance estimates with a maximum of 4 lags that are robust to both heteroskedasticity and autocorrelation.

17 Clark (2006) and Bils and Klenow (2004) also report that aggregate inflation displays greater persistence than disaggregate inflation.

18 For a full set of hypothesis tests on equality of the coefficients, see Table A1 in Appendix 3.

4.2 Size

Our next set of results focus on the size of price changes. We compare the size of changes in the sub-indices of the CPI between price rises and price falls, and also between inflationary and deflationary periods. We first estimate

$$\left|\Delta P_{it}\right| = \beta_i + \gamma_0\left|\Delta P_t\right| + \gamma_1 D_t + \gamma_2 D_{it} + \varepsilon_{it}, \tag{4}$$

where $|\;|$ indicates absolute value, and the variables are as defined above, again using robust variance-covariance estimates. The results are given in Table 6.

We find that price changes are smaller during deflation than during inflation, but that price decreases are larger than price increases. Given that these two results are at apparent odds with each other (since price changes during deflation are mostly price decreases), we interact both dummy variables, estimating

$$\begin{aligned}\left|\Delta P_{it}\right| = \beta_i + \gamma_0\left|\Delta P_t\right| + \gamma_1 D_t D_{it} + \gamma_2 D_t(1-D_{it}) + \gamma_3(1-D_t)D_{it}\\ +\gamma_4(1-D_t)(1-D_{it}) + \varepsilon_{it},\end{aligned} \tag{5}$$

and present the results in Table 7.

In this case, the results accord with the qualitative predictions of both the flexible price model and the capacity constraints model. Price increases are larger than price decreases during inflation, with the converse being true during deflation.[19] In contrast, they are inconsistent with the predictions of the menu cost and rational inattention models.

As an additional test, we also consider the frequency of different sizes of price changes. Recall that the capacity constraints model implies that large price increases are relatively more common than large price decreases, since binding capacity constraints will trigger increased price rises. Meanwhile the rational inattention model implies that small price increases are relatively more common than small price decreases, since firms face incentives to increase prices by small amounts so as not to trigger re-optimisation by inattentive consumers. We present the relevant percentiles of the distribution of price changes in Table 8.

From Table 8, it is clear that the distribution of small price increases is very similar to the distribution of small price decreases, in contrast to the predictions of the rational inattention model, and at the other end

[19] See Appendix 3, Table A2 for a full set of hypothesis tests on equality of the estimated parameters.

of the distribution, the largest price changes are more likely to be price decreases rather than price increases, in contrast to the predictions of capacity constraints.[20]

4.3 Higher Order Moments

We next consider the relationship between higher order moments and the inflationary environment, as suggested by Ball and Mankiw (1994, 1995). We follow Gerlach and Kugler (2007), Verbrugge (1999), and Bryan and Cecchetti (1999) in constructing a measure of inflation within our sample at each point in time as

$$\pi_t = \frac{\sum_i w_i \Delta P_{it}}{\sum_i w_i}, \tag{6}$$

where w_i is the weight attached to each component in the CPI, and $\Delta P_{it} = \log(P_{it}) - \log(P_{it-12})$. Higher order moments are then defined as

$$m_{rt} = \sum_i w_i (\Delta P_{it} - \pi_t)^r / \sum_i w_i, \tag{7}$$

with skewness computed as

$$SKEW_t = \frac{m_{3t}}{[m_{2t}]^{3/2}}. \tag{8}$$

As in Gerlach and Kugler (2007), we randomly assign 50% of all price observations to calculating the mean, and the remaining 50% of the observations to calculating the higher order moments. By so doing, we avoid creating any artificial correlation between the mean and the higher order moments, which may potentially lead to bias in our estimation results.[21] We also repeat our estimation procedure 100 times (since the estimates themselves now contain sampling error), and report the average estimates.

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[20] We also examined the interaction between the size of price changes and the persistence of those changes. We found that small (defined as less than 2%) price increases are less persistent than small price decreases, again in contrast to the predictions of rational inattention, but that large price increases (defined as greater than 10%) are more likely to be reversed than large price decreases, which is consistent with the predictions of the capacity constraints model.

[21] The source of this bias is that an extreme positive (negative) observation for an individual price increases (decreases) the mean, variance, and skewness by construction, independent of any underlying economic rationale for them to be related; see the discussion in Bryan and Cecchetti (1999). For an alternative solution to this problem, Verbrugge (1999) used the median and trimmed mean (in place of the mean) as a measure of central tendency, and the non-parametric triples U-statistic in place of skewness.

Our estimated equation takes the following form:

$$\begin{aligned}\pi_t &= \beta_1 D_t + \beta_2(1-D_t) + \delta_1 D_t STD_t + \delta_2(1-D_t)STD_t \\ &+ \phi_1 D_t SKEW_t + \phi_2(1-D_t)SKEW_t + \varepsilon_t,\end{aligned} \quad (9)$$

where D_t is as defined above, STD_t is the square root of the second moment, and $SKEW_t$ is as defined in (12) above. We use Newey-West standard errors to allow for serial correlation and heteroskedasticity. The results, both across the full sample and with split samples, are given in Table 9.

In the "full sample" column, all coefficients are consistent with the predictions of the menu cost model. However, once we split the sample to avoid artificial correlation in the moments (right column), we find only one significant coefficient that is consistent with menu costs: more volatile microeconomic prices during inflation lead to more inflation. Aside from that, we find little evidence of systematic relationships between the moments of the data.

Gerlach and Kugler (2007) test the relationship between the moments of inflation on Hong Kong data using the twelve main sub-components of the CPI, and find that a higher standard deviation is (weakly) related to higher inflation or deflation, and that skewness is positively correlated with the level of inflation both under deflation and inflation, broadly in agreement with the theoretical predictions of menu costs suggested by Ball and Mankiw. But ideally, if we are seeking to model the behaviour of individual firms setting prices subject to menu costs, applying this test at a more microeconomic level should yield more accurate results. Further, greater disaggregation results in a significantly larger panel, and therefore an increased chance of identifying empirical relationships. The fact that our results provide little support for menu cost models in contrast to Gerlach and Kugler (2007) is a puzzle that we leave to future work.[22]

4.4 Discussion

Our concerns with the nature of price setting stem in part from its implications for the cost of deflation for the Hong Kong economy. As we have shown, if price setting is subject to menu costs and the profit function is asymmetric, then deflation may be inherently more costly than inflation. This is because prices will be systematically "too high" (relative to the optimal flexible price level) under deflation, and so output (and consumption) will be systematically "too low." Indeed, in our simulations of the menu cost model discussed earlier, the average price is 3.6% greater than the optimal flexible price during deflation, while the difference is insignificantly different from zero during inflation, indicating that the macroeconomic cost

[22] Bryan and Cecchetti (1999) also argue that menu costs would imply a stronger link at shorter horizons than longer ones, since all firms will have adjusted their prices at sufficiently long horizons, implying effectively price flexibility. We checked all horizons from 1 to 24 months, and found little variation in the estimates across horizons.

of deflation may be large. Note that this is an equilibrium level effect, and not due to a surprise deflationary: in our simulations, deflation is perfectly anticipated.[23]

However, across the tests that we have applied to Hong Kong data, we find little support for the implications of menu costs. Indeed, we also find little support for rational inattention or the capacity constraints model. We also conducted a large number of hypothesis tests based on interacting the size and persistence of price changes with the inflationary environment (reported in Appendix 3), and find that there are significant differences between nearly all of the estimated parameters. So it is not the lack of asymmetry that causes us to reject the models that we have examined, but rather inconsistency between the identified asymmetries and those implied by the models. In contrast, we find that our results are consistent with flexible prices.

In testing the implications of the different models of price setting, we have utilised simple, robust statistical methods, taking advantage of the relatively large size of the dataset (50031 observations) to obtain clear results. An alternative approach that we leave to future work would utilise regime-switching models (for example, Hamilton (1990)). We also examined threshold autoregressive models (for example, Fang and Wei (2006)) as a more direct test of the menu cost model, but found little empirical support for this, consistent with the results reported here.

5. Conclusions

We have outlined the predictions of four models of price change for the behaviour of microeconomic price changes. We have highlighted that menu costs imply that firms are more reluctant to reduce prices than raise them. As a consequence, deflation would be characterised by prices that are systematically “too high” relative to optimal flexible prices, resulting in lower levels of real consumption and output.

We have tested for the implications of these models using a rich set of microeconomic prices that covers both inflationary and deflationary periods for Hong Kong. Given the high degree of diversity in the behaviour of individual series (see Figure 7), we have used simple, robust statistical methods, focusing on the size of price changes, the degree of mean reversion in prices, and higher order moments in our panel.

We can identify many aspects of asymmetric pricing behaviour in our data, and also in our models. But with the exception of flexible prices, there is little agreement between the predictions of the models and the data. For example, menu costs imply that price decreases are more likely to be reversed by future price rises than vice versa, and that the skewness of price changes is positively correlated with the inflation rate. We can reject the first of these hypotheses, and find no empirical support for the second.

[23] In comparison, Ellingsen *et al*. (2006) focus on the economic cost of unanticipated deflationary shocks under menu costs and an asymmetric profit function, and argue that the output loss resulting from a small deflationary

We therefore conclude that the menu cost model does not provide a good description of price setting behaviour in Hong Kong. Likewise, capacity constraints imply that large price increases are more common than large declines, and that the large increases are more likely to be reversed, since they reflect binding capacity constraints that may be relaxed with time as firms increase capacity. These predictions receive mixed support in the data. And rational inattention implies that small price rises are relatively frequent, and persistent, when compared with small price declines, neither of which receives any empirical support.

In contrast, our predictions are broadly consistent with the predictions of a flexible price model, which predicts that price increases are larger and more persistent than price decreases during inflationary periods, while the reverse is true during deflationary periods.

Our study is not without limitations. For example, one key assumption we have made is that the distribution of marginal cost shocks is symmetric. While this seems a reasonable assumption, our results may be sensitive to the degree of asymmetry in marginal cost shocks.

shock is twice as large as the output gain from a small inflationary shock for realistic parameters.

References

Altissimo, Filippo, Michael Ehrmann and Frank Smets (2006), "Inflation Persistence and Price-Setting Behaviour in the Euro Area: A Summary of the IPN Evidence," European Central Bank Occasional Paper 46.

Alvarez, Luis J., Emmanuel Dhyne, Marco M. Hoeberichts, Claudia Kwapil, Herve Le Bihan, Patrick Lunnemann, Fernando Martins, Roberto Sabbatini, Harald Stahl, Philip Vermuelen and Jouko Vilmunen (2006), "Sticky Prices in the Euro Area: A Summary of New Micro Evidence," *Journal of the European Economic Association*, 4(2-3): 575-84.

Ball, Laurence, Gregory N. Mankiw and Ricardo Reis (2005), "Monetary Policy for Inattentive Economies," *Journal of Monetary Economics*, 52(4): 703-25.

Ball, Lawrence and Gregory N. Mankiw and David Romer (1988), "The New Keynesian Economics and the Output-Inflation Trade-Off," *Brookings Papers on Economic Activity*, 1: 1-65.

Ball, Lawrence and Gregory N. Mankiw (1994), "Asymmetric Price Adjustment and Economic Fluctuations," *Economic Journal*, 104(423): 247-61.

Ball, Lawrence and Gregory N. Mankiw (1995), "Relative-Price Changes as Aggregate Supply Shocks," *Quarterly Journal of Economics*, 110(1): 161-93.

Bils, Mark and Peter J. Klenow (2004), "Some Evidence on the Importance of Sticky Prices," *Journal of Political Economy*, 112(5): 945-85.

Blanchard, Olivier J. (1994), "Comment: On Sticky Prices: Academic Theories Meet the Real World," in N. Gregory Mankiw, ed., *Monetary Policy*, National Bureau of Economic Research Studies in Business Cycles, Volume 29, Chicago: University of Chicago Press: 150-4.

Blinder, Alan S. (1994), "On Sticky Prices: Academic Theories Meet the Real World," in N. G. Mankiw, ed., *Monetary Policy*, Chicago: University of Chicago Press.

Blinder, Alan S., Elie R. D. Canetti, David E. Lebow and Jeremy B. Rudd (1998), "Asking About Prices: A New Approach to Understanding Price Stickiness," New York: Russell Sage.

Bordo, Michael and Andrew Filardo (2005), "Deflation and Monetary Policy in Historical Perspective," *Economic Policy*, 20(44): 799-844.

Bryan, Michael F. and Stephen G. Cecchetti (1999), “Inflation and the Distribution of Price Changes,” *Review of Economics and Statistics*, 81(2): 188-96.

Burdekin, Richard C. K. and Pierre L. Siklos (2004), “Fears of Deflation and the Role of Monetary Policy: Some Lessons and an Overview,” in Burdekin, Richard C.K. and Pierre L. Siklos, eds., *Deflation: Current and Historical Perspectives*, Cambridge, UK: Cambridge University Press: 1-27.

Burstein, Ariel T. (2006), “Inflation and Output Dynamics with State-Dependent Pricing Decisions,” *Journal of Monetary Economics*, 53(7): 1235-57.

Cecchetti, Stephen G. (1986), “The Frequency of Price Adjustment: A Study of the Newsstand Prices of Magazines,” *Journal of Econometrics*, 31(3): 255-74.

Clark, Todd E. (2006), “Disaggregate Evidence on the Persistence of Consumer Price Inflation,” *Journal of Applied Econometrics*, 21(5): 563-87.

Cutler, Joanne (2005), “The Relationship Between Consumption, Income and Wealth in Hong Kong,” *Pacific Economic Review*, 10(2): 217-41.

Devereux, Michael B. and Henry Siu (2007), “State Dependent Pricing and Business Cycle Asymmetries,” *International Economic Review*, 48(1): 281-310.

Devereux, Michael B. and James Yetman (2003), “Price Setting and Exchange Rate Pass-Through: Theory and Evidence,” in Price Adjustment and Monetary Policy: Proceedings of a Conference Held by the Bank of Canada, November 2002, Bank of Canada: 347-71.

Ellingsen, Tore, Richard Friberg and John Hassler (2006), “Menu Costs and Asymmetric Adjustment,” CEPR Discussion Paper 5749.

Fan, Simon C. and Xiangdong Wei (2006), “The Law of One Price: Evidence from the Transitional Economy of China,” *Review of Economics and Statistics*, 88(4): 682-97.

Gagnon, Etienne (2007), “Price Setting During Low and High Inflation: Evidence from Mexico,” Board of Governors of the Federal Reserve System International Finance Discussion Papers 896.

Genberg, Hans and Laurent L. Pauwels (2005), “Wage-Price Dynamics and Deflation in Hong Kong,” *Pacific Economic Review*, 10(2): 191-216.

Gerlach, Stefan and Peter Kugler (2007), "Deflation and Relative Prices: Evidence from Japan and Hong Kong," Manuscript.

Golosov, Mikhail and Robert E. Lucas, Jr. (2007), "Menu Costs and Phillips Curves," *Journal of Political Economy*, 115(2): 171-99.

Gotte, Lorenz, Rudolf Minsch and Jean-Robert Tyran (2005), "Micro Evidence on the Adjustment of Sticky-Price Goods: It's How Often, Not How Much," CEPR Working Paper 5364.

Ha, Jiming and Kelvin Fan (2002), "Convergence Between Hong Kong and the Mainland," Hong Kong Monetary Authority Research Memorandum, http://www.info.gov.hk/hkma/eng/research/RM8-2002.pdf

Hall, Simon, Mark Walsh and Anthony Yates (2000), "Are UK Companies' Prices Sticky?" *Oxford Economic Papers*, 52(3): 425-46.

Hamilton, James D. (1990), "Analysis of Time Series Subject to Changes in Regime," *Journal of Econometrics*, 45(1-2): 39-70.

Hansen, Gary D. and Edward C. Prescott (2005), "Capacity Constraints, Asymmetries, and the Business Cycle," *Review of Economic Dynamics*, 8(4): 850-65.

Ho, Alex Wai-Yip and James Yetman (2006), "Shock Size, Asymmetries, and State Dependent Pricing," *Economics Letters*, 90(3): 440-5.

Hoffmann, J. and J. Kurz-Kim (2006), "Consumer Price Adjustment under the Microscope: Germany in a Period of Low Inflation," European Central Bank Working Paper 652.

Kashyup, Anil K. (1995), "Sticky Prices: New Evidence from Retail Catalogs," *Quarterly Journal of Economics*, 110(1): 245-74.

King, Robert G. and Alexander L. Wolman (1999), "What Should Monetary Policy Do if Prices are Sticky?" in John B. Taylor, ed., *Monetary Policy Rules,* University of Chicago Press for National Bureau of Economic Research: Cambridge, MA, with comments and discussion: 349-404.

Klenow, Peter J. and Oleksiy Kryvtsov (2005), "State-Dependent or Time-Dependent Pricing: Does it Matter for Recent U.S. Inflation?" NBER Working Paper No.11043, Cambridge MA: National Bureau of Economic Research.

Levy, Daniel, Mark Bergen, Shantanu Dutta and Robert Venable (1997), “The Magnitude of Menu Costs: Direct Evidence from Large U.S. Supermarket Chains,” *Quarterly Journal of Economics*, 112(3): 791-825.

Levy, Daniel, Haipeng Chen, Sourav Ray and Mark Bergen (2004), “Asymmetric Price Adjustment “in the small:” An Implication of Rational Inattention,” Manuscript.

Mankiw, Gregory N. (1985), “Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly,” *Quarterly Journal of Economics*, 100(2): 529-37.

Nakamura, Emi and Jon Steinsson (2007), “Five Facts About Prices: A Reevaluation of Menu Cost Models,” Manuscript.

Peltzman, Sam (2000), “Prices Rise Faster Than They Fall,” *Journal of Political Economy*, 108(3): 466-502.

Rotemberg, Julio J. (2005), “Customer Anger at Price Increases, Changes in the Frequency of Price Adjustment and Monetary Policy,” *Journal of Monetary Economics*, 52(4): 829-52.

Schellekens, Philip (2005), “Deflation in Hong Kong SAR,” *Pacific Economic Review*, 10(2): 243-60.

Smith, Gregor W. (2006), “The Spectre of Deflation: a Review of Empirical Evidence,” *Canadian Journal of Economics*, 39(4): 1041-72.

Verbrugge, Randal J. (1999), “Cross-Sectional Inflation Asymmetries and Core Inflation: a Comment on Bryan and Cecchetti,” *Review of Economics and Statistics*, 81(2): 199-202.

Woodford, Michael (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton: Princeton University Press.

Yip, Paul S. L. and R. F. Wang (2002), “Is Price in Hong Kong That Flexible? Evidence from the Export Sector,” *Asian Economic Journal,* 16(2): 193-208.

Table 1. Predictions of Price Setting Models for Price Increases vs. Price Decreases

Price adjustment model	Inflation	Deflation
Flexible	Larger, more persistent	Smaller, less persistent
Capacity constraints	Larger, less persistent	Smaller, less persistent
Menu costs	Smaller, more persistent	Smaller, more persistent
Rational inattention	Smaller, more persistent	Smaller, more persistent

Table 2. Coverage (2004/2005-Based Weights)

Catergory	Sample	CPI	Coverage(%)
Food	22.8	25.8	88.4
Alcoholic drinks and tobacco	0.7	0.8	91.1
Clothing and Footware	1.2	4.3	27.7
Durable Goods	3.7	4.6	79.6
Miscellaneous Goods	3.6	5.0	72.7
Miscellaneous Services	13.1	16.1	81.1
Housing	0.0	30.6	0.0
Electricity, gas and water	0.0	3.4	0.0
Transport	0.0	9.5	0.0
	45.0	100.0	

Table 3A. Persistence: Aggregate CPI*

$$\Delta P_t = \beta + \rho_1 \Delta P_{t-12} + \rho_2 D_t \Delta P_{t-12} + \varepsilon_t$$

ρ_1	ρ_2	R^2
0.55		0.41
(0.00)		
0.89	**-0.70**	0.52
(0.00)	**(0.00)**	

Table 3B. Persistence: Aggregate Sample*

$$\Delta P_t = \beta + \rho_1 \Delta P_{t-12} + \rho_2 D_t \Delta P_{t-12} + \varepsilon_t$$

ρ_1	ρ_2	R^2
0.50		0.36
(0.00)		
0.64	**-0.37**	0.39
(0.00)	**(0.01)**	

* P-values in parentheses; variables that are significant at the 5% level are in bold.

Table 4. Persistence: Micro Sample*

$$\Delta P_{it} = \beta_i + \rho_1 \Delta P_{it-12} + \rho_2 D_t \Delta P_{it-12} + \rho_3 D_{it-12} \Delta P_{it-12} + \varepsilon_{it}$$

ρ_1	ρ_2	ρ_3	AR(1)	R^2
-0.16			**305**	0.12
(0.00)			**(0.00)**	
-0.16	0.01		**300**	0.12
(0.00)	(0.77)		**(0.00)**	
-0.23	-0.03	**0.16**	**306**	0.12
(0.00)	(0.42)	**(0.00)**	**(0.00)**	

* Incorporates Newey-West standard errors. P-values in parentheses; variables that are significant at the 5% level are in bold. Column labelled "AR(1)" contains the F(1,326) distributed Wooldridge test statistic for serial correlation in panel data.

Table 5. Persistence: Micro Sample*

$$\Delta P_{it} = \beta_i + \rho_1 D_t D_{it-12} \Delta P_{it-12} + \rho_2 D_t (1 - D_{it-12}) \Delta P_{it-12} + \rho_3 (1 - D_t) D_{it-12} \Delta P_{it-12}$$
$$+ \rho_4 (1 - D_t)(1 - D_{it-12}) \Delta P_{it-12} + \varepsilon_{it}$$

ρ_1	ρ_2	ρ_3	ρ_4	AR(1)	R^2
0.08	**-0.75**	**-0.44**	-0.06	**304**	0.20
(0.00)	**(0.00)**	**(0.00)**	(0.11)	**(0.00)**	

* Incorporates Newey-West standard errors. P-values in parentheses; variables that are significant at the 5% level are in bold. Column labelled "AR(1)" contains the F(1,326) distributed Wooldridge test statistic for serial correlation in panel data.

Table 6. Size of Price Changes: Sample*

$$\left|\Delta P_{it}\right| = \beta_i + \gamma_0 \left|\Delta P_t\right| + \gamma_1 D_t + \gamma_2 D_{it} + \varepsilon_{it}$$

γ_0	γ_1	γ_2	*AR(1)*	R^2
0.39	**-0.26**		**240**	0.59
(0.00)	**(0.00)**		**(0.00)**	
0.39	**-0.33**	**0.20**	**239**	0.59
(0.00)	**(0.00)**	**(0.02)**	**(0.00)**	

* Incorporates Newey-West standard errors. P-values in parentheses; variables that are significant at the 5% level are in bold. Column labelled "AR(1)" contains the F(1,326) distributed Wooldridge test statistic for serial correlation in panel data.

Table 7. Size of Price Changes: Sample*

$$\left|\Delta P_{it}\right| = \beta_i + \gamma_0 \left|\Delta P_t\right| + \gamma_1 D_t D_{it} + \gamma_2 D_t (1 - D_{it}) + \gamma_3 (1 - D_t) D_{it}$$
$$+ \gamma_4 (1 - D_t)(1 - D_{it}) + \varepsilon_{it}$$

γ_1	γ_2	γ_3	γ_4	*AR(1)*	R^2
4.09	**3.02**	**2.63**	**4.21**	**237**	0.59
(0.00)	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	

* Incorporates Newey-West standard errors. P-values in parentheses; variables that are significant at the 5% level are in bold. Column labelled "AR(1)" contains the F(1,326) distributed Wooldridge test statistic for serial correlation in panel data.

Table 8. Percentiles of Size of Price Changes (in Percent): Sample

Percentile	All Prices	Increases	Decreases
1%	0.00	0.00	0.00
5%	0.20	0.21	0.20
10%	0.45	0.50	0.48
25%	1.30	1.39	1.30
50%	3.16	3.27	3.15
75%	6.45	6.50	6.50
90%	11.20	10.89	11.70
95%	15.63	14.89	16.62
99%	30.70	28.30	33.20

Table 9. Higher Order Moments*

$$\pi_t = \beta_1 D_t + \beta_2(1-D_t) + \delta_1 D_t STD_t + \delta_2(1-D_t)STD_t$$
$$+\phi_1 D_t SKEW_t + \phi_2(1-D_t)SKEW_t + \varepsilon_t$$

	Full sample	Split sample
δ_1	**-0.42**	0.29
	(0.00)	(0.05)
δ_2	**0.59**	**0.38**
	(0.00)	**(0.00)**
ϕ_1	0.02	0.02
	(0.41)	(0.55)
ϕ_2	**0.04**	-0.01
	(0.00)	(0.52)
DW	0.81	1.38
R^2	0.80	0.50

* Incorporates Newey-West standard errors with two lags. P-values in parentheses; variables that are significant at the 5% level are in bold. Split sample results are averages across 100 sets of estimates based on randomly assigning 50% of observations to the calculation of the mean (π_t), and the remainder to the calculation of the higher order moments (STD_t and $SKEW_t$). Row labelled "*DW*" contains Durbin-Watson test statistic.

Figure 1. Inflation in Hong Kong

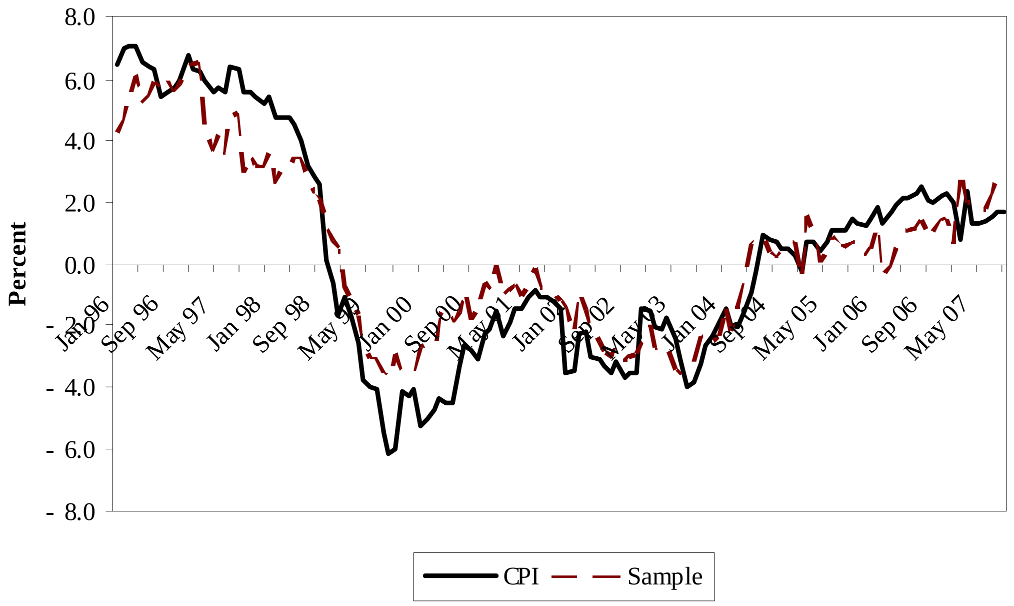


Figure 2. Hong Kong Real GDP Growth

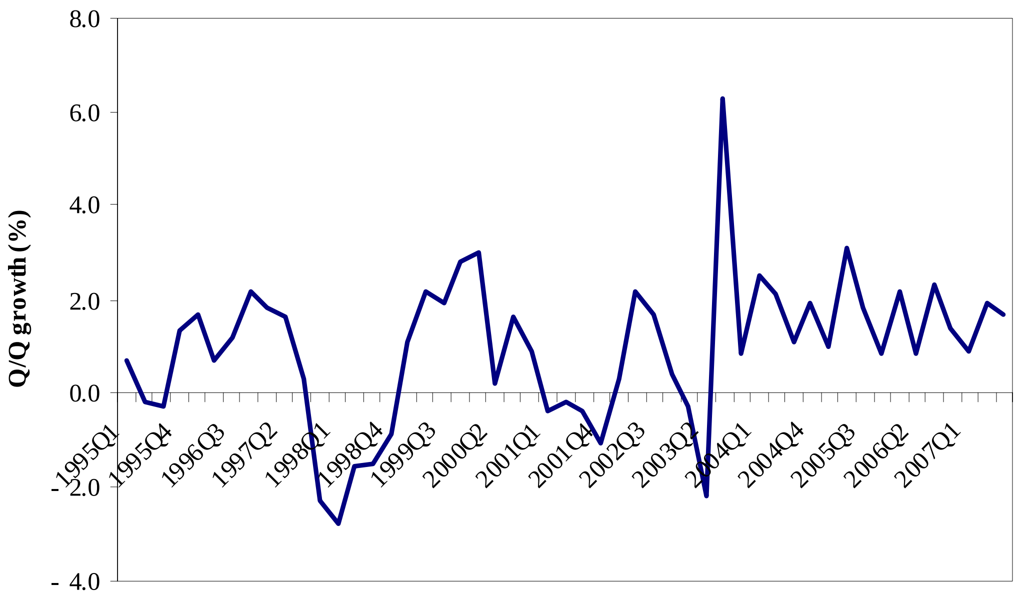


Figure 3. Firm Profits

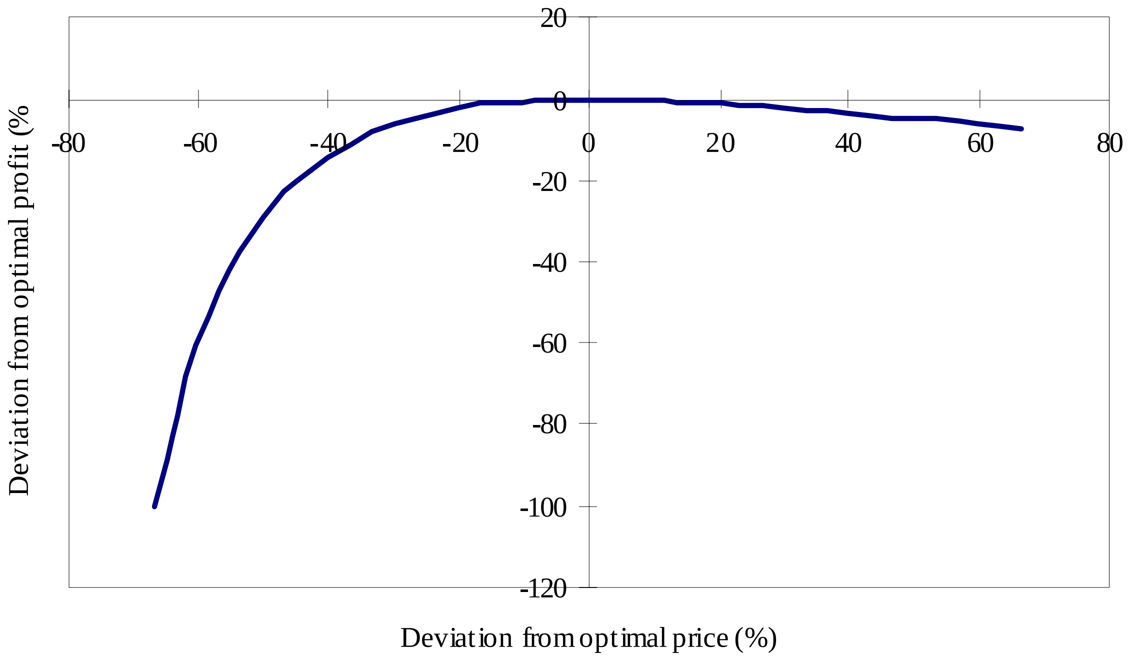


Figure 4. Range of Inaction, Deviation from Flexible Price

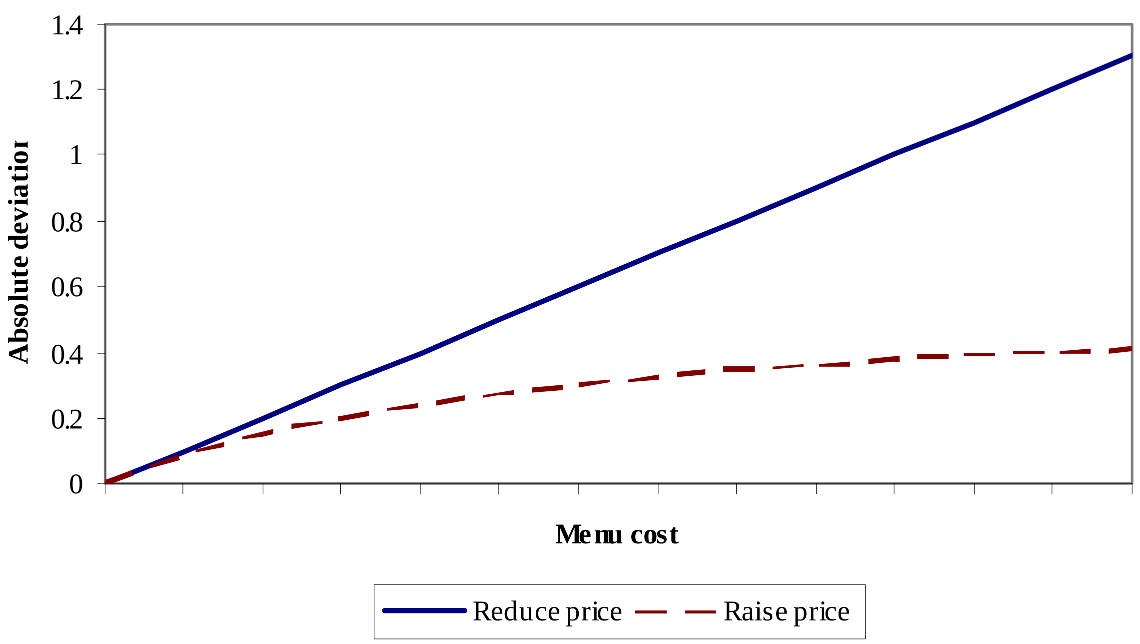


Figure 5. Simulated Price Behaviour Under Moderate Inflation

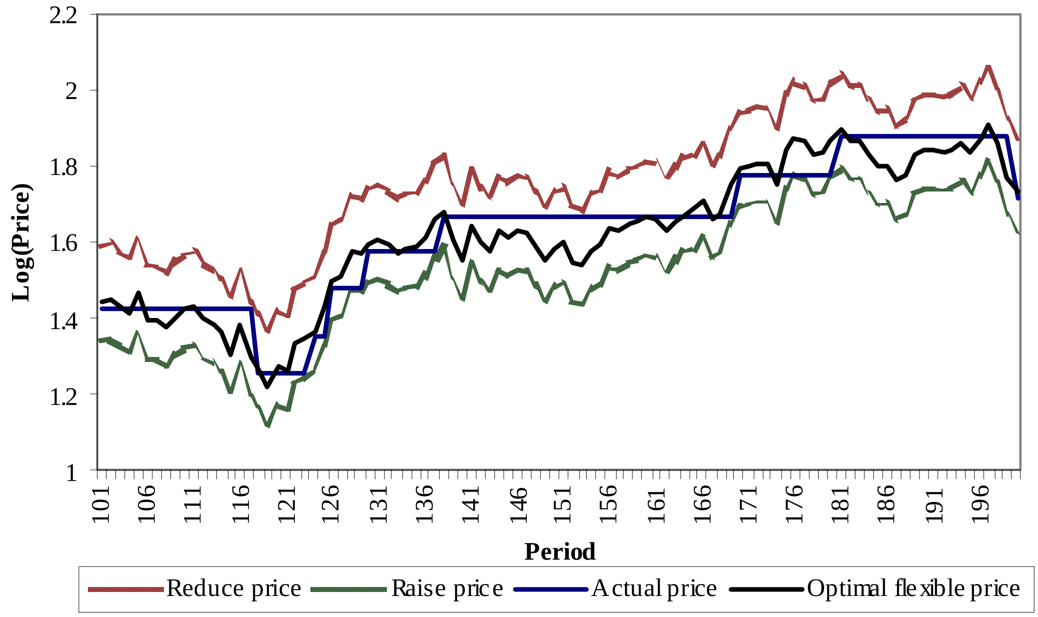


Figure 6. Simulated Price Behaviour under Moderate Deflation

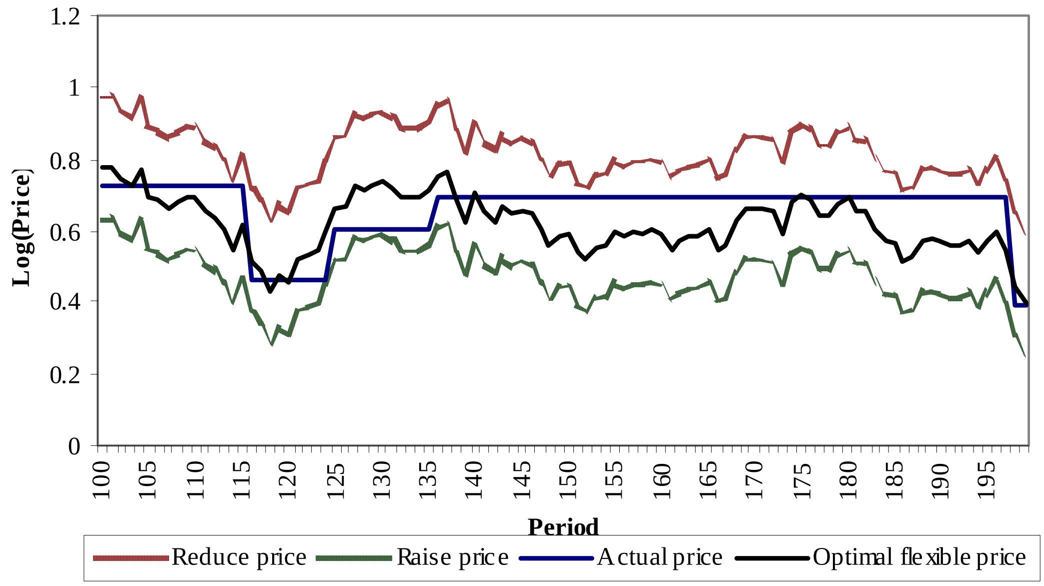


Figure 7. Individual Price Series

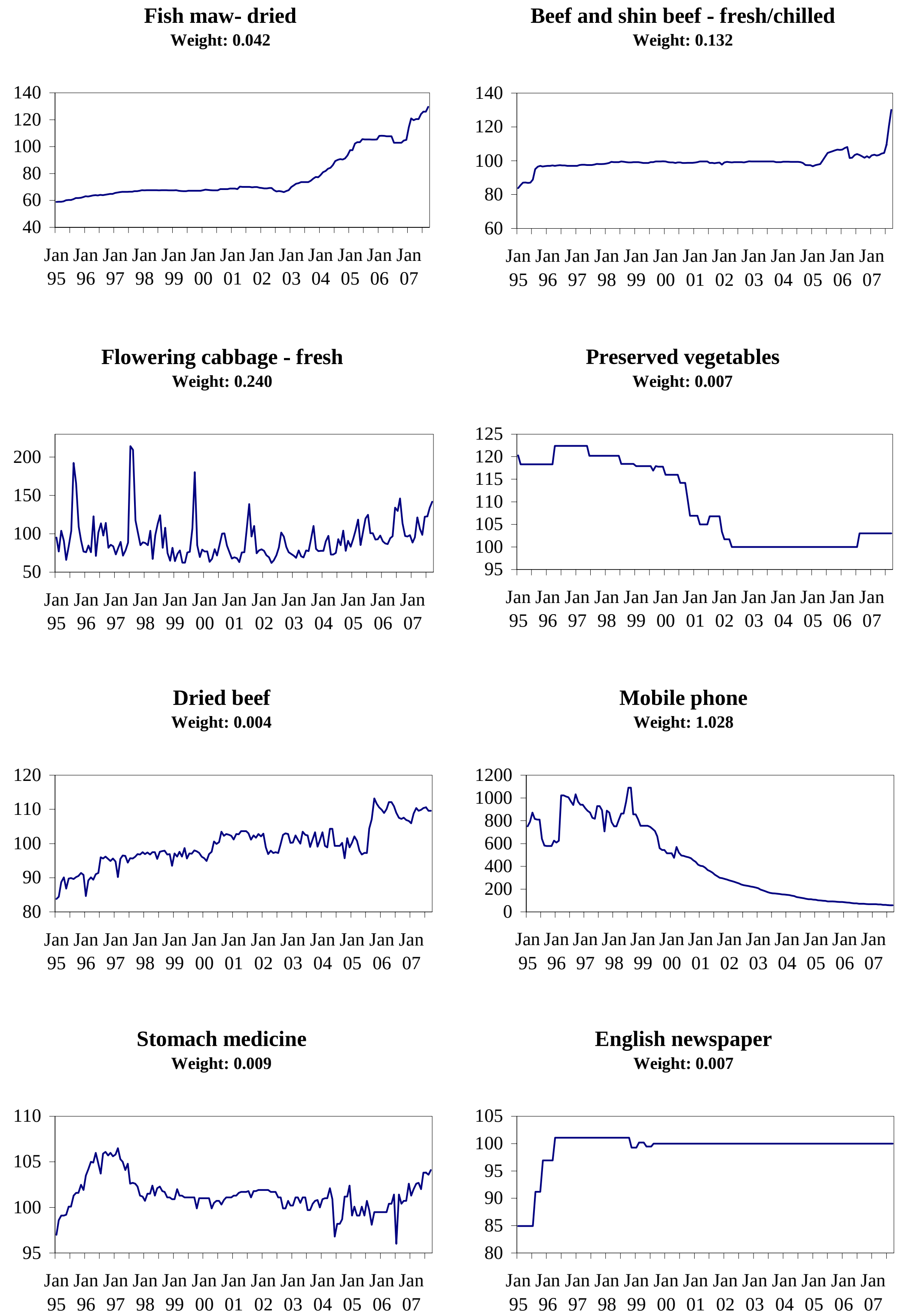


Figure 8. Composition of Price Changes, Year on Year

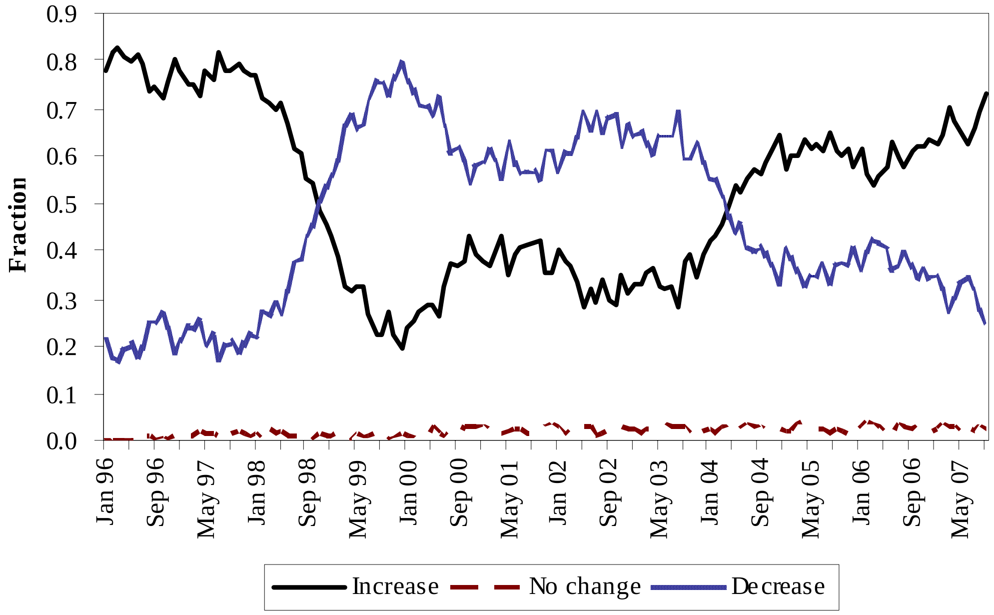


Figure 9. Qualitative Price Change vs. Inflation Rate

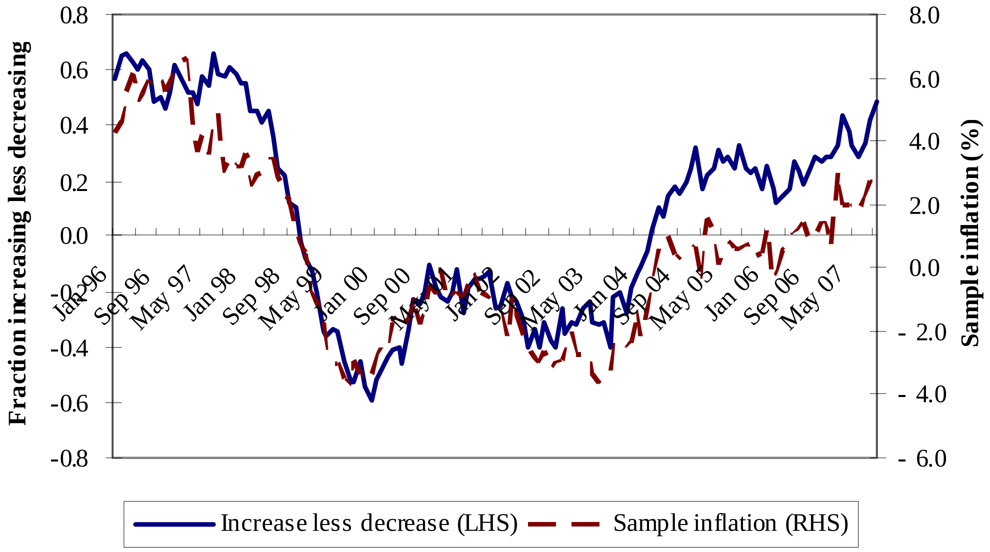
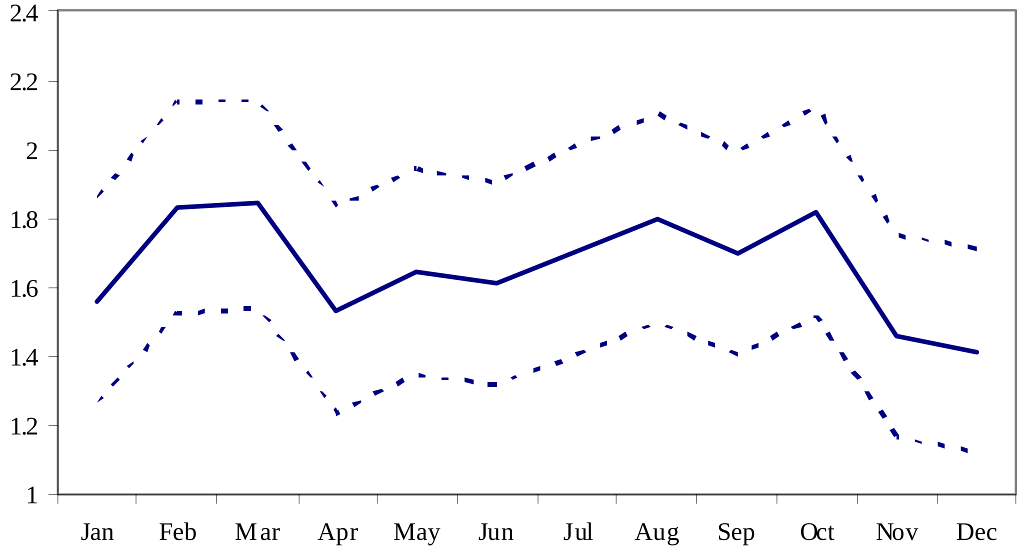


Figure 10. Monthly Fixed Effects, Estimates and 95% Confidence Intervals



Appendix 1. Profit Function and Simulations

Suppose that consumers consume a consumption bundle that is a Dixit-Stiglitz aggregator over different types of goods (indexed by *i*) given by

$$q_t = \left[\int_i \left(q_t^i \right)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}. \quad (10)$$

Consumer optimisation implies demand for each good of

$$q_t^i = \left(\frac{p_t^i}{p_t} \right)^{-\sigma} q_t. \quad (11)$$

Assuming a firm's real profits are given by

$$\Pi_t^i = \left(\frac{p_t^i - mc_t^i}{p_t} \right) q_t^i, \quad (12)$$

where mc_t^i is the marginal cost of good *i*, profit maximization will imply a price given by

$$p_t^i = \frac{\sigma}{\sigma - 1} mc_t^i. \quad (13)$$

Figure 3 illustrates the profit function for $\sigma = 1.5$.

To generate the simulation results reported in Figures 5 and 6, we further assume that marginal cost follows a random walk with drift. The drift component is equal to the average inflation (deflation) rate, while the permanent marginal cost shock has a standard deviation of 5% of the marginal cost of the good. Menu costs (that is, the cost of each price change) is assumed to be 0.1% of total revenue, and the discount rate applied to future profits is given by $\beta = 0.996$. Results are robust to a range of alternative parameter values.

Appendix 2. Sample Items (2004/2005-Based Weights)

Items	Weight(%)	Items	Weight(%)	Items	Weight(%)
Rice - main staple	0.27	Sweetened dates - dried and preserved	0.01	Radio	0.00
Bread	0.43	Figs - dried and preserved	0.00	Desktop computer set	0.21
European cake	0.13	Canned fruit	0.01	Computer software	0.01
Chinese cake	0.01	Hen egg	0.08	Telephone set (incl. cordless)	0.03
Chinese pudding and dessert	0.06	Salted duck egg	0.01	Mobile phone	1.03
Biscuit	0.15	Granulated white sugar	0.01	Electronic dictionary	0.03
Grouper - live	0.08	Honey	0.01	Frying pan and wok	0.02
Seabream - live	0.01	Candy	0.09	Pot	0.02
Rabbitfish - live	0.01	Chocolate	0.10	Vacuum cooking pot	0.01
Golden thread - fresh/chilled	0.18	Chewing gum	0.01	Knife and chopper	0.00
Big-eye - fresh/chilled	0.03	Soup and broth	0.08	Men's watch - electronic/ quartz/ solar	0.02
Mackerel - fresh/chilled	0.01	Bean curd	0.03	Men's watch - mechanical	0.06
Grouper - fresh/chilled	0.05	Bean curd products	0.01	Women's watch - electronic/ quartz/ solar	0.04
Sole - fresh/chilled	0.02	Bean vermicelli	0.00	Women's watch - mechanical	0.08
Horse-head - fresh/chilled	0.02	Mushroom - dried	0.04	Wall clock	0.00
Pomfret - fresh/chilled	0.09	Fungus - dried	0.01	Table clock	0.00
Hair-tail - fresh/chilled	0.01	Fried shrimp paste	0.01	Automatic camera	0.01
Seabream - fresh/chilled	0.02	Potato chips	0.05	Single-lens reflex camera	0.01
Rabbitfish - fresh/chilled	0.01	Dried pork	0.01	Video camera/ camcorder	0.06
Thread fin - fresh/chilled	0.01	Dried beef	0.00	Spectacles	0.17
Grass carp - live	0.15	Cooked nuts	0.03	Sunglasses	0.02
Mud carp - live	0.00	Dried and preserved fruit	0.02	Contact lens (excl. disposable contact lens)	0.02
Big head - live	0.06	Jelly	0.01	Keyboard instrument	0.06
Snake head - live	0.01	Cantonese restaurant/ fan-tim	5.19	Perambulator	0.00
Edible tilapia - live	0.01	Shanghainese restaurant	0.21	Vitamin	0.05
Freshwater grouper - live	0.08	Zhaozhou restaurant	0.07	Stomach medicine	0.01
Grey mullet - fresh/chilled	0.02	Hakka restaurant / Tung Kong fan-tim	0.01	Analgesics and antipyretics	0.01
Prawn and shrimp, fresh/chilled	0.06	Other Chinese restaurants	0.02	Cold remedies	0.03
Prawn and shrimp, live	0.07	Caf? (mainly serving Chinese style food)	3.42	Cough drug	0.01
Crab - live/fresh/chilled	0.08	Noodle, rice-stick and congee stall	0.36	Ointment	0.03
Squid - live/fresh/chilled	0.02	Noodle, rice-stick and congee shop	0.32	Cod liver oil	0.01
Salted and dried fish - dried	0.02	Vegetarian food shop	0.03	Antiseptics and disinfectants	0.01
Abalone - dried	0.02	Western restaurant	1.95	Herbal medicine	0.16
Scallop - dried	0.05	Japanese restaurant	0.55	Proprietary medicine	0.09
Oyster - dried	0.01	Korean restaurant	0.06	Proprietary medicine for external use	0.01
Shrimp - dried	0.01	Thai restaurant	0.12	Health and weight control supplement	0.07
Shark's fin - dried	0.01	Vietnamese restaurant	0.05	Adhesive tape/ plaster	0.01
Fish maw - dried	0.04	Malaysian / Singaporean restaurant	0.02	English newspaper	0.01
Fish - frozen	0.06	Indonesian restaurant	0.01	Chinese newspaper	0.50
Abalone - frozen	0.02	Café/tea/coffee stall (mainly non-Chinese style food)	0.87	English book (excl. textbook)	0.05
Fish - canned	0.02	Fast food shop	2.83	Chinese book (excl. textbook)	0.09
Abalone - canned	0.01	Canteen/ cafeteria	0.25	Ball pen	0.01
Fish ball and slice	0.05	Bar and lounge	0.10	Notebook	0.01
Best cut and lean meat - fresh/chilled	0.60	Dessert shop	0.03	Exercise book	0.01
Pork belly - fresh/chilled	0.01	Chinese wine	0.02	Greeting card/ postcard	0.00
Pork chop - fresh/chilled	0.05	Brandy	0.02	Computer consumables	0.01
Spare rib - fresh/chilled	0.19	Red wine	0.08	Face make-up	0.07
Liver - fresh	0.01	Cigarettes	0.62	Lipstick	0.03
Fore shank - fresh	0.01	Denim suit and jeans - men's	0.11	Perfumery	0.03
Bone - fresh	0.17	Vest and singlet - men's	0.01	Skin care products	0.38
Beef and shin beef - fresh/chilled	0.13	Briefs and boxer shorts - men's	0.01	Bath soap and toilet soap	0.07
Fillet and steak - fresh/chilled	0.02	Denim suit and jeans - women's	0.13	Shampoo and hair conditioner	0.12
Brisket - fresh/chilled	0.01	Slip and corselette - women's	0.07	Hair treatment products	0.03
Chicken - live/fresh/chilled	0.37	Brassiere - women's	0.01	Tooth paste	0.03
Duck - live/fresh/chilled	0.01	Briefs - women's	0.01	Tooth brush	0.01
Pigeon - live/fresh/chilled	0.00	Denim suit and jeans - children's	0.01	Oral sterilizing solution	0.01
Pork chop - frozen	0.03	Pants - children's	0.00	Toilet paper	0.10
Spare rib - frozen	0.00	Women's socks and stockings	0.02	Facial tissue	0.06
Ham - frozen	0.03	Women's panty hose	0.00	Face and bath towel	0.03
Fillet - frozen	0.02	Children's stockings	0.01	Sanitary napkin	0.03
Steak - frozen	0.02	Belt	0.02	Diaper for adults	0.01
Whole chicken - frozen	0.00	Necktie	0.01	Diaper for babies	0.06
Chicken wing - frozen	0.13	Knitting wool	0.01	Floor polish	0.01
Chicken leg - frozen	0.03	Dress shoes - men's	0.10	Broom and mop	0.01
Chicken breast/ fillet - frozen	0.01	Sports shoes - men's	0.16	Gold/ platinum jewellery	0.21
Sausages - frozen	0.04	Slippers - men's	0.00	Silver and costume jewellery	0.04
Barbecue pack - frozen	0.01	Dress shoes - women's	0.27	Doll and soft toy	0.04
Roasted pork	0.12	Sports shoes - women's	0.12	Building block (incl. lego)	0.01
Barbecue pork	0.08	Slippers - women's	0.01	Model	0.04
Roasted spare rib	0.00	Dress shoes - children's	0.03	Tricycle, play car and bicycle	0.00
Lo-mei	0.01	Sports shoes - children's	0.06	Electronic game and accessories	0.04
Chicken/ soy sauce chicken	0.05	Bed (incl. baby bed)	0.05	Miniature car (incl. remote control car)	0.01
Roasted duck/ goose	0.05	Wardrobe	0.04	Films and disposable camera	0.00
White cabbage - fresh	0.07	Wall cabinet	0.04	Blank video tape	0.00
Flowering cabbage - fresh	0.24	Cupboard	0.01	Compact disc record	0.05
Chinese kale - fresh	0.02	Storage shelf/ cupboard	0.02	Aquarium fish	0.01
Chinese lettuce - fresh	0.06	Sofa	0.07	Feedstuff for pets	0.09
Cabbage lettuce - fresh	0.04	Chair, stool, folding chair and rocking chair	0.01	Plant	0.01
Leaf mustard - fresh	0.00	Dining table (set)	0.01	Purchases of textbooks - Kindergarten	0.05
Chinese spinach - fresh	0.01	Writing and computer desk	0.01	Purchases of textbooks - Primary	0.19
Tientsin cabbage - fresh	0.01	Air-conditioner - electric	0.13	Purchases of textbooks - Secondary	0.27
Round cabbage - fresh	0.02	Refrigerator - electric	0.08	Religious items	0.05
European celery - fresh	0.01	Washing machine - electric	0.12	Light bulb	0.02
Chinese chive - fresh	0.00	Cooker hood - electric	0.03	Dry cell	0.03
Broccoli - fresh	0.04	Ventilator - electric	0.00	Plug, socket and adapter	0.01
Cauliflower - fresh	0.01	Electric water heater - electric	0.02	Washing basin/ bucket	0.00
Wax gourd - fresh	0.02	Electric rice cooker - electric	0.04	Crystal	0.02
Hairy gourd - fresh	0.03	Microwave oven - electric	0.03	Photo frame	0.01
Bitter gourd - fresh	0.02	Blender/ mixer - electric	0.00	Vase	0.00
Angled loofah - fresh	0.01	Electric kettle and vacuum flask - electric	0.02	Fresh flower	0.09
Green cucumber - fresh	0.02	Air purifier - electric	0.00	Feeding bottle and accessories	0.01
Egg plant - fresh	0.01	Vacuum cleaner - electric	0.04	Clothes hanger and clip	0.02
Chinese radish - fresh	0.01	Electric iron - electric	0.01	School fees - major	2.92
Green turnip - fresh	0.01	Hairdryer - electric	0.00	School fees - continuing education	0.91
Carrot - fresh	0.03	Electric shaver - electric	0.01	School fees - others (e.g. music, dancing, drawing, etc.)	0.41
String beans - fresh	0.02	Electric fan - electric	0.03	Examination fees	0.02
Tomato - fresh	0.04	Dehumidifier - electric	0.04	Boarding and lodging fees	0.02
Lotus root - fresh	0.01	Heater/ radiator - electric	0.01	Medical services	2.57
Potato - fresh	0.02	Ceiling lamp - electric	0.02	Cinema entertainment	0.17
Ginger - fresh	0.01	Desk lamp - electric	0.00	Package tours	1.65
Bean sprout - fresh	0.01	Gas stove	0.04	Expenses on parties	0.17
Sweet pepper - fresh	0.01	Television set	0.54	Charges for sports and games	0.13
Onion - fresh	0.01	Video tape recorder	0.04	Admission charges to entertainment places	0.26
Mushroom - fresh	0.03	Video disc player	0.16	Laundry services	0.04
Preserved vegetables - preserved	0.01	Hi-Fi set	0.04	Hair-dressing	0.39
Beans and peas - canned	0.01	Amplifier/ tuner	0.03	Repairs to personal and household goods	0.08
Banana - fresh	0.05	Compact disc record player	0.00	Telephone and other communications services	3.27
Pomelo - fresh	0.01	Loudspeaker	0.00	Postal and courier services	0.01
Kiwifruit - fresh	0.01	Mini disc player	0.02	Photographic and photo-printing services	0.04

Appendix 3. Tests of Parameter Equality

Tests of equality of the coefficients in equation (3) are contained in Table A1.

Table A1. Persistence- Micro Sample*

Null Hypothesis	*t*-Statistic
P1. Price increases are more likely to be reversed than price decreases.	**3.04** **(0.00)**
P2. Price changes are more likely to be reversed when there is deflation than when there is inflation.	0.80 (0.42)
P3. Price increases during deflation are more likely to be reversed than price increases during inflation.	**15.61** **(0.00)**
P4. Price decreases during inflation are more likely to be reversed than price decreases during deflation.	**14.89** **(0.00)**
P5. Price increases during inflation are more likely to be reversed than price decreases during deflation.	**2.91** **(0.00)**
P6. Price increases during deflation are more likely to be reversed than price decreases during inflation.	**5.82** **(0.00)**
P7. Price decreases during inflation are more likely to be reversed than price increases during inflation.	**6.53** **(0.00)**
P8. Price increases during deflation are more likely to be reversed than price decreases during deflation.	**18.56** **(0.00)**

* This table contains t-statistics (p-values) of a test with the null hypothesis of equality of the persistence in inflation. Incorporates Newey-West standard errors. P-values in parentheses; variables that are significant at the 5% level are in bold.

Tests of equality of the coefficients in equation (5) are contained in Table A2.

Table A2. Size of price changes- sample*

Null Hypothesis	*t*-Statistic
S1. |Price rises| > |Price falls|	**-2.09**
	(0.04)
S2. |Price changes during inflation| >	**4.26**
|Price changes during deflation|	**(0.00)**
S3. |Price increases during inflation| >	**16.94**
|Price increases during deflation|	**(0.00)**
S4. |Price decreases during deflation| >	**8.37**
|Price decreases during inflation|	**(0.00)**
S5. |Price increases during inflation| >	1.20
|Price decreases during deflation|	(0.23)
S6. |Price increases during deflation| >	**-2.88**
|Price decreases during inflation|	**(0.00)**
S7. |Price increases during inflation| >	**8.96**
|Price decreases during inflation|	**(0.00)**
S8. |Price decreases during deflation| >	**15.34**
|Price increases during deflation|	**(0.00)**

* This table contains t-statistics (p-values) of a test with the null hypothesis of equality of the absolute value of the size of price changes. A positive test statistic indicates agreement with the statement in the first column; a negative coefficient disagreement. Incorporates Newey-West standard errors. P-values in parentheses; variables that are significant at the 5% level are in bold.