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Menu Costs, Relative Prices, and Inflation: Evidence for Canada

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Abstract

The menu-cost models of price adjustment developed by Ball and Mankiw (1994; 1995) predict that short-run movements in inflation should be positively related to the skewness and the variance of the distribution of disaggregated relative-price shocks in each period. We test these predictions on Canadian data using the distribution of changes in disaggregated producer prices to measure the skewness and standard deviation of relative-price shocks. We find the Canadian data, both in the context of partial correlations and standard price Phillips curve equations, are highly supportive of the predictions that arise from the menu-cost models. Indeed, we find that the positive relationship between inflation and the skewness of the distribution of relative-price shocks is one of the most robust features of the Canadian Phillips curve and significantly improves our ability to explain inflation dynamics.

Résumé

Selon les modèles de coût d'ajustement des prix élaborés par Ball et Mankiw (1994 et 1995), il existe une relation positive entre, d'une part, les fluctuations à court terme de l'inflation et, d'autre part, l'asymétrie et la variance de la distribution des variations de prix relatifs durant chaque période. Pour vérifier la validité de cette hypothèse dans le cas du Canada, les auteurs mesurent l'asymétrie et l'écart-type des variations de prix relatifs à l'aide de la distribution des variations de diverses composantes de l'indice des prix à la production. Les résultats qu'ils obtiennent à l'aide des données canadiennes confortent les prévisions de ces modèles, que l'analyse soit menée sous l'angle des corrélations partielles ou dans le cadre de courbes de Phillips traditionnelles. La relation positive dégagée entre l'inflation et l'asymétrie de la distribution des variations de prix relatifs est même l'une des caractéristiques les plus robustes de la courbe de Phillips au Canada, et sa prise en compte améliore considérablement la capacité d'un modèle d'expliquer la dynamique de l'inflation.

Contents

1. Introduction

Traditional models of aggregate price adjustment have stressed expectations of future inflation, the degree of economic slack in goods and labour markets, and changes in key relative prices as the main determinants of inflation in the short run. More recently, Ball and Mankiw (1995) have suggested that skewness of the distribution of relative-price shocks may also be an important short-run determinant of inflation. This prediction is based on the menu-cost model of price adjustment. If firms face costs in adjusting prices or menu costs, a firm will change its actual price only if the desired adjustment is large enough to warrant paying the menu cost. As a result, firms may respond to large shocks but not to small ones, which implies that large shocks will have a disproportionate effect on the price level and thus on inflation in the short run. More specifically, if the size of the relative-price shocks is unevenly distributed across increases and decreases—that is, the distribution of relative-price shocks is skewed—relative-price shocks will affect the aggregate price level.

One interpretation of the menu-cost model is that it provides an explanation of why changes in relative prices can affect inflation. In a classical model, a relative-price shock should lead some firms to increase their nominal prices and others to decrease them, leaving the aggregate price level unchanged. The classical argument is that, when the prices of some goods rise as a result of a relative-price shock, this leaves consumers with less income to buy other goods, so their prices decline. In the presence of menu costs, however, only firms whose desired price adjustment is greater than some critical size will in fact change their prices. Consider, for example, the impact of a large increase in the relative price of oil. Firms that use oil as an important input in production will want to increase their prices considerably and, with perfectly flexible prices, these increases would be balanced by small price declines in the prices of other goods. But in the presence of menu costs, only firms faced with a large increase in their price will in fact adjust their price, while firms desiring small increases or decreases will leave their prices unchanged. The net result will be a rise in the aggregate price level.

Other sticky-price models have similar predictions for the effects of relative-price shocks. For example, models that assume that prices of goods are flexible while wages are rigid (Phelps 1978), or that the prices for some goods are flexible while the prices of other goods are sticky (Gordon 1975), predict that a large change in the relative price of a key input such as oil can affect the aggregate price level. As Ball and Mankiw (1995) emphasize, however, these variations on the sticky-price theme have different predictions as to what should be most closely related to inflation dynamics. The menu-cost model suggests that it is not the fact that some goods (such as oil and food) have more flexible prices than other goods or wages that makes them important determinants of inflation. Rather, the explanatory power of the relative prices of oil and food stems from the fact that these goods often have large price shocks and are therefore important determinants of the skewness of the overall distribution of relative-price shocks. Therefore, a testable prediction of the menu-cost model is that the skewness of the distribution of all relative-price changes should outperform the relative prices of certain commodities in explaining inflation.

A second implication of the menu-cost models as developed in Ball and Mankiw (1994) is that, in the presence of trend inflation, the variance of relative-price shocks will also be positively related to inflation in the short-run. If firms face menu costs, they will adjust prices in response to trend inflation at discrete intervals; thus actual prices between adjustments will be falling relative to desired prices. In this setting, prices will tend to be more flexible upwards than downwards if there is trend inflation, since in this case positive shocks are more likely to trigger price adjustments than are negative shocks of the same size. The reason is that, in the face of negative shocks, the firm is less likely to pay the menu costs and change its actual price because some of the price adjustment will come about as a result of inflation. This asymmetry in price adjustment will result in an "inflationary bias" in the sense that inflation in the short run will be higher than implied by long-run money growth. The degree to which it is higher will be increasing in the variance of relative-price shocks, since more variability in the relative-price distribution will tend to magnify the effects of asymmetric price adjustment on the aggregate price level.

The idea that the variance of relative-price changes influences inflation is the reverse of the more familiar idea that inflation creates variability in relative prices (Friedman 1977; Fischer 1981). The menu-cost model does not deny that there may be some causation from inflation to relative-price variability, but it suggests that there may also be causation in the other direction.

Ball and Mankiw's (1995) empirical results on U.S. data find strong support for the prediction that inflation is positively related to the skewness of the distribution of relative-price changes. This is true both for simple correlations between inflation and skewness that control for the inertia in inflation, and in the context of estimated Phillips curves. In addition, they find that, when they add their measure of skewness to an otherwise conventional Phillips curve that includes the relative prices of oil and food, the coefficients on these relative prices are close to zero and statistically insignificant. While the coefficient on the skewness variable continues to be positive and statistically significant, they also find some evidence of an independent effect of the variance of relative prices on inflation in their Phillips curves. These empirical results are based on annual data, inflation is defined in terms of the producer price index, and the distribution of relative-price changes is computed for each year based on four-digit producer price index components. Other empirical work appears to support the conclusions in Ball and Mankiw (1995). Loungani and Swagel (1995), for instance, use a panel VAR methodology and annual data from 13 OECD countries to examine the effect of skewness in the relative-price distribution on consumer price inflation. These authors find that an innovation to the skewness measure leads to an increase in inflation of about 0.5 per cent. This quantitative estimate appears to be robust to numerous changes in identifying assumptions as well as to changes in the conditioning set of variables.

The purpose of this paper is to examine the empirical support for the predictions of the menu-cost model using Canadian data. In particular, following Ball and Mankiw (1995), we construct the distribution of relative-price changes based on the disaggregated components of the producer price index, and examine the relationship between inflation and the skewness and variance of this distribution. As in Ball and Mankiw (1995), we begin by examining these relationships using simple models for inflation that control only for inflation inertia. We then move on to Phillips curves that control for expected inflation, the degree of economic slack, and changes in key relative prices. We also extend the original Ball and Mankiw (1995) analysis to examine the extent to which the skewness and the variance of the producer price index distribution is related to movements in broader price indexes, such as the GDP deflator, and to price indexes that attempt to measure “core” inflation such as the consumer price index excluding food and energy. In addition, we consider both annual and quarterly data.

The paper is organized as follows. Section 2 provides an informal review of the economic theory that underlies the postulated relationship between inflation, and the skewness and variance of the distribution of relative-price changes. Section 3 describes the data used to construct the distribution of relative-price shocks and the different measures of skewness that we initially considered. Sections 4 and 5 present the empirical evidence on explanatory power of the skewness and variance of the distribution of relative-price shocks. The former section reports evidence from partial correlations based on annual data, whereas the latter presents evidence from standard price Phillips curves estimated on quarterly data. Section 6 offers concluding remarks.

2. The theory and its testable predictions

This section provides a brief and informal review of Ball and Mankiw’s (1994; 1995) contributions to the theory of price adjustment in the presence of menu costs. The review follows the original articles closely while emphasizing the intuition and the testable predictions of these models for the interaction between relative prices and inflation. Menu-cost models are fundamentally about price-level adjustments, so their predictions for inflation are confined to the short run. To distinguish between the short run and beyond, “trend inflation” is associated with on-going or expected inflation and is taken to be exogenous in this partial-equilibrium setting. Following the original Ball and Mankiw papers, the discussion begins by examining the implications of the distribution of relative-price shocks for aggregate price adjustment in the absence of trend inflation, and then considers the implications of allowing for trend inflation.

2.1 Asymmetric shocks with no trend inflation

Ball and Mankiw (1995) consider an economy with monopolistically competitive firms that experience shocks to their desired prices. These shocks can be interpreted as either demand shocks or cost shocks. It is assumed that there is no trend inflation so the mean of the distribution of shocks is zero. With perfectly flexible prices, the average of all price changes is zero and the aggregate price level is constant. Price adjustment, however, is assumed to be costly. Specifically, a firm must incur a fixed cost—the menu cost—to change its price. In this environment, a firm faced with a shock to its desired relative price will change its price if the costs of deviating from its desired price exceeds the menu costs, and a firm will leave its price unchanged if the menu costs exceed the costs of having a price that deviates from its desired price. At any given price, therefore, a firm will have a range of inaction within which it will not adjust its price to a shock. In Ball and Mankiw's (1995) model, the firm's range of inaction is symmetric. When this is combined with asymmetry in the distribution of shocks, the average of all prices—the aggregate price level—will depend on the higher moments of the distribution of shocks. The intuition behind these predictions is summarized in Figures 1 to 3.

Panel A of Figure 1 depicts a mean-zero symmetric distribution of shocks to desired prices. The symmetric range of inaction is between the lower (L) and upper (U) cutoff prices. If the desired price exceeds U, the firm will raise its price, and if the desired price is less than L, it will lower its price. With a symmetric distribution of shocks, these upper and lower tails are equal, so just as many firms are raising prices as are lowering prices, and thus the aggregate price level remains unchanged. In Panel B, the mean-zero distribution of shocks is skewed to the right, so the upper tail is now larger than the lower tail. In this case, more firms are raising prices than lowering them, so the aggregate price level rises. Panel C shows the opposite case. Here the distribution of shocks is skewed to the left, so the lower tail is bigger than the upper tail, and the aggregate price level falls. *The testable prediction is that inflation is related to the difference in the size of the two tails—when the right tail is larger (smaller) than the left tail, inflation will rise (fall).*

As Ball and Mankiw (1995) show, this difference in the size of the left and right tails depends on both the skewness and the standard deviation of the distribution. This is illustrated in Figure 2. As shown in Panel A, raising the variance of a symmetric distribution increases the size of both tails by the same amount, so price increases and reductions continue to net to zero. However, as shown in Panel B for the case of positive skewness, this is not the case if the distribution of shocks is skewed. Increasing the variance of the distribution continues to increase the size of both tails, but the absolute increase in the right tail is larger. Thus, the number of firms raising prices increases relative to the number lowering prices and the result is a larger rise in the aggregate price level. *The empirical prediction is therefore that the effects of skewness will be larger the higher is the variance, but variance itself has no independent effect on inflation.*

These predictions link the moments of the distribution of desired prices to aggregate price-level adjustment. Ball and Mankiw (1995) give these predictions empirical content by showing that they also go through using the distribution of actual price changes in place of the unobserved distribution of desired price changes.

2.2 Symmetric shocks with trend inflation

The implications of menu costs for price adjustment in the presence of trend inflation and with symmetric shocks to desired prices is explored in Ball and Mankiw (1994). The basic setup is again an economy with a continuum of monopolistically competitive firms that face (menu) costs to change prices. Thus, again, firms will adjust prices only if the deviation between the initial price and the desired price surpasses some threshold. Ball and Mankiw (1994) then show that, under certain conditions, trend inflation introduces an asymmetry in price adjustment. More specifically, as illustrated in Figure 3, the impact of trend inflation in this setting is to shift the range of inaction to the left (from U-L to U^{π}- L^{π}) so firms are more likely to raise prices than to lower them.

The intuitive argument is based on the idea that inflation facilitates declines in relative prices while hindering increases. In the presence of menu costs, a firm will find it optimal to adjust its price at discrete intervals, and between adjustments its relative price will be falling as result of inflation. With trend inflation, a firm hit with a negative shock to its desired relative price can either pay the menu costs and change its price immediately, or not pay the menu costs and wait for inflation to reduce its relative price to the desired level. The higher is inflation, the faster the firm's real price will be eroded by inflation, and the less likely the firm will be to pay the menu cost. Thus, as shown in Figure 3, the effect of trend inflation is to reduce the size of the zone in which firms pay the menu costs and lower their prices. In contrast, when faced with a positive shock to its desired relative price, waiting will simply widen the gap between the actual relative price and its desired level since inflation will continue to erode the actual relative price. The firm is therefore more likely to pay the menu costs in this case and raise its actual price immediately. Thus, trend inflation has the effect of increasing the size of the right tail in Figure 3.

With asymmetric price adjustment, increasing the variance of the shocks to desired relative prices now raises the aggregate price level even if the distribution of the shocks is itself symmetric. As depicted in Figure 4, raising the variance of the shocks results in a larger absolute increase in the size of the right tail as compared to the left tail, so the aggregate price level increases. *The empirical prediction, therefore, is that with trend inflation there is an independent effect of variance so, even if the distribution of price shocks is symmetric, variance and inflation should be positively related.*

In general, of course, there may be both trend inflation and asymmetry in the distribution of relative-price shocks. In this case, we may expect to see both the relative size of the tails of the distribution of relative-price shocks and the variance of this distribution contributing to the short-run evolution of inflation.

3. Measures of asymmetry

Our measure of skewness is based on annual and quarterly percentage changes in Canadian industrial producer price indices (IPPI) over the 1962 to 1994 sample period. The number of industries in our cross section is 77 over the 1962 to 1971 period, 96 over 1972 to 1981, and 119 over 1982 to 1994.[1] Examples of industry-level IPPIs include those for “poultry products,” “frozen fruit,” “wooden kitchen cabinets,” and “soft drinks.” The IPPI components that are used represent the most disaggregated levels we are able to obtain; in most cases, we are able to obtain data at the four-digit level but in some cases at only the two-digit level. Each industry price change is weighted by the relative importance of that industry in 1986. For each period, we use these industry-level price indexes to create a distribution of price changes from the previous period.

Fundamentally, the theory implies that inflation depends on the size of the tails of the distribution in relative-price changes. We therefore calculate a measure that captures both the direct effects of skewness and the magnifying effect of the variance. In this regard, we follow Ball and Mankiw (1995) and construct our measure as

$$ASYMX = \sum_{i=1}^{N} r_i D_i^- + \sum_{i=1}^{P} r_i D_i^+ \tag{1}$$

where r_i is the *ith* industry relative-price change (that is, the industry price change weighted by the relative importance of that industry minus the mean of the weighted-industry inflation rates). The variables D_i^- and D_t^+ are binary variables; the former takes the value one when the *ith* industry’s relative-price change falls in the lower X per cent of the distribution and zero otherwise, whereas the latter variable is one when the *ith* industry’s relative-price change falls in the upper X per cent of the distribution and zero otherwise. In other words, $ASYMX$ accumulates the relative-price increases in the upper tail of the distribution and subtracts them from the absolute value of the accumulated relative-price declines in the lower tail. Since the distribution is defined in terms of relative-price changes, the mean of the distribution is zero in every period. So, for example, if the distribution is skewed to the right, the accumulated relative-price increases in the upper X per cent of the distribution will be larger than the absolute value of the accumulated relative-price declines in the lower X per cent of the distribution, and $ASYMX$ will take on a positive value. More generally, $ASYMX$ will be zero if the distribution is symmetric, positive if the accumulated

1. More detailed information on the IPPIs may be found in the Statistics Canada publication, “Industry price indexes, 1986 = 100,” Catalogue 62-558.

relative-price changes are larger in the right tail, and negative if they are larger in the left tail. In addition, for any given skewness, the absolute value of $ASYMX$ increases when a larger variance magnifies the tails. This measure of asymmetry, therefore, combines the effects of skewness and its interaction with the variance into a single empirical measure.

An alternative approach is to measure skewness and variance separately and then to measure their interaction as their product. We denote the skewness of the distribution of price changes as SK and the standard deviation of the distribution as SD. The interaction between skewness and variance is measured by $SK \cdot SD$. This interaction measure, like $ASYMX$, is zero when the distribution is symmetric regardless of the variance but, for a given level of skewness, its absolute size is positively related to the variance of the distribution. Preliminary data analysis with $ASYMX$ and $SK \cdot SD$ suggested that there is somewhat of a trade-off to be faced when choosing between the two. The product $SK \cdot SD$ has the advantage that its calculation does not require the researcher to choose the cutoff level X for price changes. The disadvantage of this measure is that the skewness is quite sensitive to outliers. In particular, we found that very large price changes in one or two components of the IPPI could have a considerable impact on SK, even if the weights on these components were very small. Thus, at times $SK \cdot SD$ becomes dominated by one or two outliers and does not provide a good general measure of the overall shape of the distribution. In contrast, $ASYMX$, because it is based on the areas under the two tails, is relatively robust to outliers and has the advantage that it corresponds more directly to the theory outlined in Section 2. The drawback of this measure is that it requires the researcher to make an arbitrary choice for X. Fortunately, this difficulty can be largely overcome by trying a range of values for X. In preliminary work, we used both $ASYMX$ (for a range of X) and $SK \cdot SD$ but found the results for $ASYMX$ to be more reliable. Accordingly, most of the empirical results in the next two sections focus on $ASYMX$.

To give an initial sense of the asymmetries and the effect of the cutoff point X on the calculation of $ASYMX$, Figure 5 plots the measure of asymmetry when X is set equal to 10 and 25 per cent. The upper panel of Figure 5 plots these two annual measures of asymmetry while the lower panel plots the quarterly measures. There are several items to note. First, the measures of asymmetry are generally positive which accords well with the upward trend in prices experienced in Canada over the sample period. Second, the measures appear to capture large movements in relative prices. For instance, the two positive spikes in 1973–74 and 1979–80 correspond to the OPEC oil-price shocks, and the run-up at the end of the sample squares with the rise in commodity prices. The negative value in 1991 corresponds to the drop in commodity prices associated with a slowdown in world demand and an increase in supply arising from the opening of the former Soviet Union for trade. Third, the two measures are highly correlated suggesting that the choice of the cutoff point is not crucial to our interpretation. Indeed, the contemporaneous correlation coefficients are over 0.99 for both annual and quarterly measures. Not surprisingly, preliminary analysis indicated that the empirical results we present in the upcoming sections are quite robust to the use of either $ASYM10$ or $ASYM25$ and thus, for the sake of brevity, we present only the empirical results based on using $ASYM25$.

Finally, for completeness, we also provide a plot of the standard deviation measures in Figure 6. As shown, both the annual and the quarterly measures rise sharply in 1973–74 and 1979–80 following the OPEC oil-price shocks in 1973 and 1979.

4. Partial correlations with inflation

In this section, we use annual data over the 1963 to 1994 sample period to investigate the ability of our asymmetry variable to account for movements in different measures of inflation. In particular, we focus on year-over-year percentage changes in the IPPI, GDP implicit-price deflator (PGDP), the consumer price index (CPI), and the consumer price index excluding food and energy (CPIXFE). Examining a range of inflation measures should allow us to determine the robustness of our results to different price definitions.

Table 1 reports the relationship between $ASYM25$ and different measures of inflation while controlling for the effects of one-period lagged inflation. For each price index, the first columns are benchmark equations that relate current inflation to a constant and its one-period lag, whereas the second columns introduce $ASYM25$ to the simple benchmark equation. The partial correlations tend to confirm the theory's prediction about the inflationary effects of skewness in relative-price changes. The $ASYM25$ variable is always significant, absorbs the unexplained structure in the residuals, contributes substantially to the goodness-of-fit, and reduces the coefficient on the autoregressive (AR) inflation term. For instance, the benchmark IPPI inflation equation has an $\bar{R}^2$ of 0.59, empirical residuals that appear to be serially correlated at the 2 per cent level, and an AR(1) coefficient of about 0.77. When $ASYM25$ is added to the equation, the $\bar{R}^2$ increases to over 95 per cent, the residuals appear to be well behaved, and the AR(1) coefficient decreases from 0.77 to 0.16. The results for the other measures of inflation lead to similar qualitative conclusions, but these impacts become more muted as we move from measures of inflation based on input prices to those based on final demand prices. This is consistent with the fact that, as we move to more final goods, material inputs tend to make up a smaller share of the cost of production of the goods, and hence the impact of changes in the relative prices of material inputs should be smaller. Note also that the statistical significance of $ASYM25$ in the CPIXFE inflation equation suggests that our asymmetry measure is capturing more than just food and energy price innovations.

Another useful exercise is to compare $ASYM25$ with other moments of the distribution of relative-price changes. In particular, we examine whether the standard deviation (SD), skewness (SK), and their interaction ($SK \cdot SD$) provide a better empirical proxy for the distribution of unobserved shocks. Recall that our asymmetry measure captures both the direct effect of skewness and the magnifying effects of the variance. Thus, the information contained in the other moments of the distribution should appear to be redundant unless there is an independent effect of the variance as predicted by the effects of trend inflation on price adjustment. Table 2 presents the results for these comparisons using IPPI and PGDP inflation (note that the shaded parameter estimates indicate insignificance at the 10 per cent level). It is evident from the table that all moments measures are insignificant at conventional levels. The only exception is the skewness variable in the PGDP inflation equation; in this case, the parameter estimate is incorrectly signed and its economic effect is small relative to $ASYM25$ suggesting that it is simply dampening the estimated effects of skewness rather than changing them qualitatively. Overall, the results from Table 2 suggest that $ASYM25$ encompasses the information contained in the second and third moments of the distribution of relative-price changes, and there is little evidence of an independent effect of the variance of the relative-price distribution on inflation.

Given the construction of our asymmetry variable and the presence of large innovations in commodity and oil prices during the sample period, it is possible that $ASYM25$ may be simply proxying commodity and oil-price shocks. Therefore, as a final experiment, we consider the correlation between inflation and our asymmetry measure while controlling for changes in the: (i) relative price of oil (POIL); (ii) relative price of non-energy commodities (PCOM); and (iii) real exchange rate (PFX). To construct the latter measure, we follow Duguay (1994) and use a two-year moving average of the rate of change in the Canada-U.S. real exchange rate (so an increase in PFX is a depreciation). For each experiment, an inflation equation that includes its own one-period lag and $ASYM25$ is augmented with a contemporaneous and one-period lag of the previously mentioned relative-price variables. The results from these experiments are reported in Tables 3 and 4.[2] To summarize these results, our asymmetry variable is always statistically significant regardless of the measure of inflation that we use. This suggests that $ASYM25$ contains information not embodied in the other relative prices, and provides further evidence in favour of the skewness-inflation prediction of the menu-cost model. We provide more evidence in the next section.

5. Evidence from a Phillips curve

The purpose of this section is to examine the statistical ability of our asymmetry measure to account for movements in quarterly inflation rates in a model that controls for other factors that have often been postulated to explain short-run inflation behaviour. We use a standard price Phillips curve which relates inflation to a measure of the business cycle (the so-called output gap) and some

2. Henceforth, all reported regression results are due to a general-to-specific modelling procedure with all lags of the variables initially set equal to the seasonal frequency. When contemporaneous and all lagged variables are found to be insignificant, we simply present the one with the lowest *p*-value.

proxy of expected inflation as our starting point. For the first two tables presented in this section, we use a measure of the business cycle based on the Hodrick and Prescott (1996) filter, and use lags of inflation to proxy for expected inflation.[3]

We begin by examining a price Phillips curve using quarter-over-quarter PGDP inflation over the 1963Q1 to 1992Q4 sample period. Note that we truncate the sample early to avoid the end-of-sample problems associated with the Hodrick-Prescott filter. The first column of Table 5 reports a simple specification that yields standard results: lagged inflation and the output gap are positive and statistically significant. Column 2 presents estimation results when $ASYM25$ is added to the simple specification in column 1. We find the parameter estimate associated with contemporaneous $ASYM25$ to be positive and statistically significant which offers further support for the theory developed in a previous section. Recall from our previous discussion that a prediction of the menu-cost model is that the standard deviation of the relative-price distribution should also be related to inflation dynamics in the presence of trend inflation. To explore this issue, we include the standard deviation of the relative-price changes to determine whether it has any independent effects on inflation. In contrast to the partial-correlation results, the estimated Phillips curves presented in column 3 support the prediction that the variance of the relative-price distribution should have an independent role for explaining the behaviour of inflation. That is, the coefficient on SD is positive and statistically significant at less than the 1 per cent level. We then include a dummy variable to account for the period in which the Anti-Inflation Board (AIB) was fully operational (1976Q1 to 1978Q2). The results reported in column 4 imply that the inclusion of the AIB dummy variable does little to change the significance of our asymmetry variable.

In Ball and Mankiw's (1995) empirical analysis, the dependent variable is producer-price inflation, and this is regressed on the skewness of the distribution of changes to industry-level relative producer prices, along with other determinants of inflation. In a recent paper, Bryan and Cecchetti (1996) argue that Ball and Mankiw's empirical evidence linking skewness of the

3. The output gap is measured as the deviation between actual output and the Hodrick-Prescott filter of output using the standard setting of 1600 for the smoothness parameter.

distribution of relative-price changes to inflation is a statistical artifact, resulting from the fact that the mean and the skewness of the distribution of producer prices will be positively correlated by construction. In our Phillips curve, the dependent variable is inflation as measured by the GDP deflator so, unless the skewness of the distribution of producer prices is positively correlated with the rate of increase of the GDP deflator by construction, the problem raised by Bryan and Cecchetti will not arise in our analysis. Moreover, since our dependent variable is not producer-price inflation, a simple way to control for Bryan and Cecchetti's problem is to include the rate of IPPI inflation as an explanatory variable in the estimated Phillips curve. The results of this experiment are reported in the fifth column of Table 5. If the explanatory power of the skewness of the distribution of IPPI relative-price changes is coming only from the correlation between the mean and skewness of the distribution of IPPI price changes, then the presence of IPPI inflation in the Phillips curve regression should render the skewness variable statistically insignificant. As shown, in fact it is the rate of IPPI inflation that is insignificant, while the coefficient on $ASYM25$ remains positive and statistically significant at the 5 per cent level. This suggests that the statistical significance of $ASYM25$ is not a statistical artifact of the correlation noted by Bryan and Cecchetti.

The last three columns of Table 5 include different relative-price measures into the specification reported in column 2. To summarize these results, we simply note that the overall effect of these variables is small, and that their presence in the reduced-form inflation equation has a very small impact on both the parameter estimate of $ASYM25$ and its statistical significance. Indeed, the $ASYM25$ parameter estimates are always within one standard error of each other.

As reported in Table 6, identical experiments for CPI inflation lead us to similar conclusions.[4] In addition to estimating Phillips curve specifications for CPI inflation, we perform full-sample dynamic simulations of three equations: (i) the standard equation (Table 6, column 1); (ii) the standard equation with the asymmetry variable (Table 6, column 2); and (iii) the standard equation augmented with a contemporaneous change in PCOM and a one-period lag of the change

4. Some may argue that inflation is a non-stationary process, and as such our inferences are invalid. However, estimation with the first differences of GDP and CPI inflation and of the asymmetry measure did not change our conclusions regarding the latter's statistical significance.

in POIL. These simulations are presented in Figure 7. The upper panel compares the dynamic simulations from equations (i) and (ii) with actual inflation while the lower panel compares actual inflation with the dynamic forecasts from equations (ii) and (iii). It is evident from these plots that the standard equation augmented with $ASYM25$ tracks actual inflation better than the other two equations. This feature is especially pronounced when there are large swings in inflation. In terms of forecasting errors, the $ASYM25$ model generates a root-mean-squared error (RMSE) of about 0.40 whereas models (i) and (iii) produce RMSE of about 0.71 and 0.58, respectively. Moreover, the forecasting errors from the $ASYM25$ model show significantly less serial correlation than the other two specifications. When we estimate an AR(1) model using the forecasting errors from the three equations, we find that the AR root corresponding to the errors from models (i) and (iii) are about 0.80 and 0.71 respectively whereas that from the $ASYM25$ model is about 0.39. In sum, we find that including $ASYM25$ into an otherwise standard reduced-form inflation equation significantly improves its explanatory ability.

The evidence from the reduced-form inflation equations, thus far, is consistent with the theory described in Section 2. These regressions, however, assume that inflation does not induce skewness in the distribution of disaggregated IPPIs. To determine whether this assumption is empirically valid, we perform Granger-causality tests on a system which includes CPI inflation, the output gap, and $ASYM25$.[5] The results from these regressions suggest that skewness Granger-causes CPI inflation at less than the 1 per cent level but that inflation does not Granger-cause our skewness measure at even the 10 per cent level. Recall that an implication of the menu-cost model as developed in Ball and Mankiw (1994) is that there may be some causation from relative-price variability to inflation, in addition to the more familiar idea that inflation creates variability in relative prices. To examine this hypothesis, we replace $ASYM25$ with SD in the previously mentioned system and again perform Granger-causality tests. The test results support the hypothesis of bidirectional feedback between inflation and relative-price variability.

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5. The lag lengths for the Granger-causality tests are determined on the basis of a general-to-specific testing-down procedure. The results for the following Granger-causality tests are available from the authors upon request.

For the next series of experiments, we use a different measure of inflation expectations to explore the robustness of our results to our measure of expected inflation. More specifically, we augment the previously presented Phillips curve equations with a one-step-ahead forecast for inflation that is generated by a 3-state Markov-switching model for inflation that allows for shifts in the inflation process (see Ricketts 1995). Since this expectations measure corresponds to the one-quarter-ahead CPI inflation rate, we use one-period changes in the CPI as our dependent variable. One difficulty is that this measure of expected inflation may be endogenous in our Phillips curve regressions, since the next period's expected inflation depends on inflation in the current period. We therefore apply a modified version of the Wu (1973) and Hausman (1978) test to determine whether simultaneity poses a problem for our estimation results.

Tables 7 and 8 present these estimation results. For each variation, we present results with and without a unit restriction on inflation expectations. The $ASYM25$ parameter estimate from the unconstrained regressions are again stable and statistically significant. In contrast, the effect of the $ASYM25$ variable is sometimes small and insignificant when the unity restriction is imposed. We note, however, that there appear to be two potential problems with these specifications. First, except for the benchmark equation, the unity restriction is strongly rejected by the data. The source of these rejections appears to be the presence of our asymmetry variable. If we compare the unconstrained specifications in columns 1 and 2, we see a decrease of about 0.10 for both expected and lagged-inflation parameter estimates. Interestingly, if we remove the $ASYM25$ variable and re-estimate the specifications, the unit restriction on inflation expectations is not rejected by the data. This result is consistent with our previous observation that including $ASYM25$ typically leads to a sharp decline in inflation persistence. Second, the Wu-Hausman tests reject the null of no simultaneity at less than the 1 per cent level for all the cases we consider. Econometrically, this result suggests that the parameter estimates are biased so our inferences based on standard hypothesis testing is questionable. Accordingly, we do not place a great deal of weight on these results.

Finally, we use another measure of the business cycle to examine the sensitivity of our results to a different measure of this variable. Recall that we have been using a business-cycle measure constructed from the Hodrick-Prescott filter. We now consider an estimate of the output gap based on the Extended Multivariate (EMV) filter developed at the Bank of Canada (see Butler 1996 for details). The EMV filter, unlike the Hodrick-Prescott filter, incorporates other sources of economic information to gauge potential output. As well, the EMV filter is conditioned on a non-linear specification of the output-inflation trade-off. More specifically, a positive output deviation from trend is deemed to have a greater inflationary effect than a same-sized negative output gap has for lowering inflation. We perform the same experiments as in Tables 5 and 6, except that we add a positive output-gap term ($GAPPOS$) to the Phillips curve specification to control for the non-linear effect of the output gap embedded in the construction of the EMV filter. The estimation results are reported in Tables 9 and 10. Again the empirical results show that the parameter estimates on the asymmetry variable are always significant and robust to different specifications of the Phillips curve. Indeed, the effect of $ASYM25$ on inflation is more robust than the effect of the output gap; that is, when $ASYM25$ is added, the coefficients on the output gap or $GAPPOS$ become insignificant at conventional levels. In short, we again find strong evidence in favour of the menu-cost approach to explaining inflation behaviour.

6. Concluding remarks

To summarize, using Canadian data, we find considerable empirical support for the predictions of Ball and Mankiw's (1994; 1995) menu-cost model of price adjustment. In particular, we find that the asymmetry in the distribution of disaggregated relative producer-price changes has considerable explanatory power for inflation, both in the context of partial correlations and in price Phillips curves that control for other important influences on inflation. This is true whether we measure inflation using the GDP deflator, the CPI, or the CPI excluding food and energy; it is true for different measures of the degree of economic slack; and it holds when key relative prices are included separately in the Phillips curve. Indeed, by the standards of the Phillips curve literature, the importance of the asymmetry in the distribution of relative-price shocks is one of the most robust features of aggregate price adjustment in Canada. This appears to reflect the fact that the skewness of this distribution contributes importantly to explaining inflation dynamics, particularly in key periods when inflation has changed rapidly.

In addition, our Phillips curve evidence suggests that the variance of the distribution of relative-price changes also affects inflation. Since there is trend inflation in much of the sample, this finding is consistent with the prediction of menu-cost models that the variance of cost shocks will affect inflation in the presence of trend inflation. This Phillips curve evidence together with the results from Granger-causality tests suggests the presence of bidirectional causality between inflation and relative-price variability.

At a minimum, these results suggest that the menu-cost model provides a promising avenue for future research on inflation. From the perspective of monetary policy, the ability to explain inflation better is an important step towards more effective inflation control. The next step is to examine whether the menu-cost model is helpful for short-run forecasting of inflation. If the skewness of the distribution of relative-price changes is sufficiently persistent or if its movements are dominated by components that are available on a more timely basis (such as commodity prices), it may be possible to use partial information on the distribution of relative-price changes to improve short-run inflation forecasts. Another potential avenue for future work is to explore the implications of menu-cost models for the measurement of trend or “core” inflation. Since the shape of the distribution of relative-price shocks should have only a transitory effect on inflation, one approach to measuring core inflation would be to use our estimation results to strip out the transitory effects on inflation of asymmetry in the distribution of relative-price changes. We plan to turn to these and other extensions in the future.

Data Appendix

This appendix describes the data definitions, their source, reference numbers (provided in parentheses), and in some cases their construction. The two of the price measures that we use are taken from the CANSIM data: producer price index (D693420); and gross domestic product implicit-price deflator, computed by dividing nominal gross domestic product (D20000) by gross domestic production measured in 1986 dollars (D20463). The two consumer price indices that we use are constructed at the Bank of Canada. Statistics Canada currently publishes seasonally adjusted CPI data only back to 1978. The longer series we use is obtained by seasonally adjusting the total CPI (or the CPI excluding food and energy as the case may be), and splicing it together with the official Statistics Canada series starting in 1978.

The so-called output-gap measure is constructed by passing the log of real Canadian gross domestic product (D20463) through a Hodrick-Prescott filter with the tightness parameter set equal to 1,600 to approximate trend output. *PCOM* is computed at the Bank of Canada and is defined as an index of U.S. dollar commodity prices (based on Canadian production weights) deflated by the U.S. GDP deflator. *POIL* is also constructed at the Bank of Canada and is defined as the ratio between the U.S. dollar price of West Texas crude oil and the U.S. GDP price deflator.

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Table 1:
Partial Correlation Regression Results[a]
Dependent Variable: Y/Y Inflation
1963 to 1994

	IPPI		PGDP		CPI		CPIXFE	
Constant	0.012 (0.005)	-0.001 (0.002)	0.009 (0.005)	0.008 (0.005)	0.007 (0.005)	0.006 (0.005)	0.008 (0.005)	0.005 (0.006)
π_{t-1}	0.766 (0.126)	0.163 (0.055)	0.821 (0.100)	0.528 (0.103)	0.864 (0.109)	0.668 (0.096)	0.839 (0.118)	0.735 (0.105)
$ASYM25$		0.357 (0.023)		0.142 (0.030)		0.103 (0.027)		0.066 (0.025)
$\bar{R}^2$	0.586	0.952	0.648	0.792	0.714	0.801	0.661	0.717
LM(1)	0.024	0.263	0.069	0.281	0.074	0.371	0.085	0.369
ARCH(1)	0.021	0.502	0.156	0.189	0.815	0.575	0.789	0.318

a. Standard errors are in parentheses. Henceforth, LM(k) corresponds to a Lagrangean Multiplier test for serial correlation of order 1 to k whereas ARCH(k) corresponds to an autoregressive conditional heteroskedasticity test of order 1 to k. For regressions where there is evidence of non-spherical residuals, the standard errors are calculated using Newey and West's (1987) HAC covariance estimator with the truncation parameter set equal to the seasonal frequency.

Table 2:
Partial Correlation Regression Results[a]
Includes Other Moments of IPPI Distribution
Dependent Variable: Y/Y Inflation
1963 to 1994

Variable	IPPI			PGDP		
Constant	0.001 (0.003)	-0.004 (0.003)	0.001 (0.002)	0.010 (0.005)	0.003 (0.006)	0.007 (0.005)
π_{t-1}	0.147 (0.053)	0.147 (0.057)	0.164 (0.055)	0.517 (0.100)	0.501 (0.105)	0.534 (0.105)
$ASYM25$	0.381 (0.025)	0.332 (0.033)	0.374 (0.030)	0.168 (0.033)	0.099 (0.047)	0.157 (0.040)
SK	-0.001 (0.001)			-0.002 (0.001)		
SD		0.063 (0.059)			0.101 (0.085)	
$SK \cdot SD$			-0.006 (0.006)			-0.005 (0.009)
$\bar{R}^2$	0.958	0.953	0.952	0.808	0.795	0.787
LM(1)	0.178	0.325	0.194	0.618	0.285	0.364
ARCH(1)	0.445	0.598	0.329	0.546	0.127	0.298

a. Henceforth, shaded parameter estimates indicate insignificance at the 10 per cent level.

Table 3:
Partial Correlation Regression Results[a]
Includes Relative-Price Variables
Dependent Variable: Y/Y Inflation
1963 to 1994

	IPPI			PGDP		
Variable	PCOM	POIL	RPFX	PCOM	POIL	RPFX
Constant	0.002 (0.002)	0.001 (0.003)	0.001 (0.002)	0.007 (0.005)	0.013 (0.006)	0.010 (0.004)
π_{t-1}	0.175 (0.075)	0.161 (0.061)	0.161 (0.054)	0.679 (0.136)	0.491 (0.108)	0.468 (0.097)
$ASYM25$	0.338 (0.030)	0.344 (0.025)	0.356 (0.023)	0.089 (0.040)	0.107 (0.031)	0.154 (0.027)
ΔRP	-0.007 (0.029)	0.013 (0.010)	-0.479 (0.217)	0.034 (0.040)	0.037 (0.014)	-1.053 (0.272)
ΔRP_{t-1}	0.058 (0.021)	0.001 (0.010)	0.387 (0.220)	0.069 (0.031)	0.009 (0.015)	0.310 (0.304)
$\bar{R}^2$	0.961	0.952	0.957	0.821	0.824	0.864
LM(1)	0.172	0.342	0.300	0.678	0.659	0.421
ARCH(1)	0.856	0.704	0.833	0.675	0.412	0.305

a. Henceforth, *RP* corresponds to the relative-price measures displayed in the second row of the table.

Table 4:
Partial Correlation Regression Results
Includes Relative-Price Variables
Dependent Variable: Y/Y Inflation
1963 to 1994

	CPI			CPIXFE		
Variable	PCOM	POIL	RPFX	PCOM	POIL	RPFX
Constant	0.007 (0.005)	0.012 (0.005)	0.007 (0.005)	0.007 (0.005)	0.011 (0.006)	0.005 (0.005)
π_{t-1}	0.674 (0.129)	0.627 (0.089)	0.637 (0.096)	0.734 (0.131)	0.706 (0.099)	0.748 (0.103)
$ASYM25$	0.092 (0.036)	0.061 (0.028)	0.112 (0.027)	0.058 (0.029)	0.047 (0.031)	0.066 (0.024)
ΔRP	-0.055 (0.034)	0.029 (0.013)	-0.262 (0.312)	-0.075 (0.031)	0.016 (0.013)	-0.723 (0.306)
ΔRP_{t-1}	0.070 (0.033)	0.031 (0.013)	-0.287 (0.322)	0.075 (0.033)	0.031 (0.013)	0.165 (0.320)
$\bar{R}^2$	0.832	0.843	0.815	0.784	0.756	0.761
LM(1)	0.231	0.877	0.873	0.641	0.805	0.707
ARCH(1)	0.942	0.919	0.908	0.980	0.989	0.568

Table 5:
Phillips Curve Regression Results
Dependent Variable: PGDP Q/Q Inflation
1963Q1 to 1992Q4

Variable	1	2	3	4	5	PCOM	POIL	RPFX
Constant	0.003 (0.001)	0.004 (0.001)	0.003 (0.001)	0.004 (0.001)	0.005 (0.001)	0.004 (0.001)	0.005 (0.001)	0.005 (0.001)
π_{t-1}	0.434 (0.084)	0.199 (0.092)	0.168 (0.114)	0.196 (0.092)	0.152 (0.120)	0.199 (0.112)	0.176 (0.092)	0.138 (0.089)
π_{t-2}	0.344 (0.084)	0.187 (0.084)	0.162 (0.095)	0.189 (0.084)	0.160 (0.097)	0.251 (0.091)	0.184 (0.083)	0.170 (0.080)
GAP_{t-1}	0.089 (0.032)	0.081 (0.029)	0.076 (0.024)	0.080 (0.029)	0.069 (0.022)	0.081 (0.021)	0.079 (0.029)	0.069 (0.029)
$ASYM25$		0.034 (0.007)	0.028 (0.008)	0.035 (0.007)	0.029 (0.011)	0.030 (0.007)	0.034 (0.007)	0.039 (0.007)
SD			0.022 (0.009)					
AIB				-0.001 (0.002)				
π_t^{IPPI}					0.100 (0.082)			
ΔRP						0.025 (0.016)	0.008 (0.004)	-0.678 (0.160)
ΔRP_{t-1}								0.664 (0.156)
$\bar{R}^2$	0.597	0.660	0.668	0.658	0.667	0.667	0.666	0.702
LM(4)	0.681	0.639	0.784	0.533	0.652	0.138	0.569	0.562
ARCH(4)	0.843	0.304	0.069	0.160	0.065	0.058	0.577	0.346

Table 6:
Phillips Curve Regression Results
Dependent Variable: CPI Q/Q Inflation
1963Q1 to 1992Q4

Variable	1	2	3	4	5	PCOM	POIL	RPFX
Constant	0.002 (0.001)	0.003 (0.001)	0.002 (0.001)	0.003 (0.001)	0.003 (0.001)	0.003 (0.001)	0.003 (0.001)	0.003 (0.001)
π_{t-1}	0.601 (0.076)	0.381 (0.074)	0.362 (0.072)	0.380 (0.076)	0.340 (0.078)	0.369 (0.072)	0.393 (0.087)	0.380 (0.073)
π_{t-2}	0.246 (0.085)	0.170 (0.073)	0.140 (0.078)	0.169 (0.073)	0.200 (0.073)	0.157 (0.079)	0.183 (0.078)	0.170 (0.073)
GAP_{t-1}	0.060 (0.026)	0.045 (0.015)	0.041 (0.016)	0.046 (0.015)	0.041 (0.015)	0.045 (0.015)	0.043 (0.022)	0.044 (0.015)
$ASYM25$		0.027 (0.004)	0.023 (0.004)	0.027 (0.004)	0.019 (0.005)	0.028 (0.005)	0.024 (0.005)	0.027 (0.004)
SD			0.015 (0.007)					
AIB				-0.001 (0.001)				
π_t^{IPPI}					0.084 (0.043)			
ΔRP						-0.009 (0.010)		
ΔRP_{t-1}							0.008 (0.003)	-0.016 (0.026)
$\bar{R}^2$	0.713	0.773	0.776	0.736	0.775	0.772	0.782	0.771
LM(4)	0.036	0.023	0.072	0.020	0.002	0.022	0.101	0.027
ARCH(4)	0.039	0.955	0.971	0.959	0.951	0.941	0.882	0.958

Table 7:
Phillips Curve Regression Results with an Alternative Measure of Expected Inflation
Dependent Variable: CPI Q/Q Inflation
1963Q1 to 1992Q4

Variable	1		2		3	
$E(\pi_{t+1})$	0.631 (0.101)	0.604 (0.090)	0.526 (0.092)	0.612 (0.089)	0.528 (0.095)	0.616 (0.091)
π_{t-1}	0.383 (0.093)	0.396 (0.090)	0.304 (0.092)	0.388 (0.089)	0.300 (0.094)	0.384 (0.091)
GAP_{t-1}	0.052 (0.025)	0.058 (0.023)	0.038 (0.020)	0.042 (0.020)	0.038 (0.020)	0.043 (0.020)
$ASYM25$			0.020 (0.005)	0.005 (0.002)	0.020 (0.005)	0.005 (0.002)
AIB					0.001 (0.001)	0.001 (0.001)
$\bar{R}^2$	0.717	0.718	0.750	0.728	0.748	0.726
Unit Sum Restriction	NA	0.545	NA	< 0.001	NA	< 0.001
Wu-Hausman Test	0.002	0.004	0.003	0.003	0.003	0.002
LM(4)	0.012	0.020	< 0.001	< 0.001	< 0.001	< 0.001
ARCH(4)	0.063	0.096	0.763	0.075	0.764	0.080

Table 8:
Phillips Curve Regression Results with an Alternative Measure of Expected Inflation
Dependent Variable: CPI Q/Q Inflation
1963Q1 to 1992Q4

Variable	PCOM		POIL		RPFX	
$E(\pi_{t+1})$	0.530 (0.098)	0.651 (0.090)	0.522 (0.096)	0.596 (0.093)	0.525 (0.092)	0.615 (0.089)
π_{t-1}	0.305 (0.091)	0.349 (0.090)	0.328 (0.096)	0.404 (0.093)	0.305 (0.092)	0.385 (0.089)
GAP_{t-1}	0.038 (0.020)	0.035 (0.020)	0.035 (0.019)	0.040 (0.019)	0.037 (0.020)	0.040 (0.020)
$ASYM25$	0.020 (0.005)	0.004 (0.002)	0.017 (0.005)	0.003 (0.002)	0.020 (0.005)	0.005 (0.002)
ΔRP						
ΔRP_{t-1}	0.003 (0.012)	0.024 (0.011)	0.007 (0.005)	0.010 (0.005)	-0.010 (0.036)	-0.010 (0.036)
$\bar{R}^2$	0.748	0.709	0.756	0.739	0.748	0.726
Unit-Sum Restriction	NA	0.002	NA	< 0.001	NA	< 0.001
Wu-Hausman Test	0.004	< 0.001	0.002	< 0.001	0.003	0.003
LM(4)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
ARCH(4)	0.744	0.054	0.989	0.706	0.768	0.070

Table 9:
Phillips Curve Regression Results with an Alternative Measure of the Output Gap
Dependent Variable: PGDP Q/Q Inflation
1963Q1 to 1992Q4

Variable	1	2	3	PCOM	POIL	RPFX
Constant	0.004 (0.001)	0.005 (0.001)	0.005 (0.001)	0.004 (0.001)	0.005 (0.001)	0.005 (0.001)
π_{t-1}	0.370 (0.084)	0.152 (0.091)	0.152 (0.091)	0.156 (0.091)	0.134 (0.091)	0.114 (0.088)
π_{t-2}	0.196 (0.092)	0.164 (0.082)	0.164 (0.083)	0.207 (0.090)	0.161 (0.082)	0.162 (0.080)
GAP_{t-1}	0.051 (0.033)	0.033 (0.031)	0.034 (0.032)	0.035 (0.031)	0.032 (0.031)	0.026 (0.029)
$GAPPOS_{t-}$	0.150 (0.086)	0.163 (0.080)	0.161 (0.085)	0.146 (0.081)	0.158 (0.033)	0.141 (0.077)
$ASYM25$		0.033 (0.007)	0.033 (0.007)	0.030 (0.007)	0.033 (0.007)	0.036 (0.007)
AIB			-0.001 (0.002)			
ΔRP				0.016 (0.013)	0.007 (0.004)	-0.598 (0.162)
ΔRP_{t-1}						0.597 (0.156)
$\bar{R}^2$	0.621	0.677	0.674	0.678	0.681	0.710
LM(4)	0.843	0.544	0.536	0.244	0.609	0.561
ARCH(4)	0.666	0.275	0.261	0.124	0.496	0.213

Table 10:
Phillips Curve Regression Results with an Alternative Measure of the Output Gap
Dependent Variable: CPI Q/Q Inflation
1963Q1 to 1992Q4

Variable	1	2	3	PCOM	POIL	RPFX
Constant	0.002 (0.001)	0.003 (0.001)	0.003 (0.001)	0.003 (0.001)	0.003 (0.001)	0.003 (0.001)
π_{t-1}	0.572 (0.078)	0.388 (0.074)	0.388 (0.078)	0.376 (0.072)	0.400 (0.088)	0.387 (0.074)
π_{t-2}	0.249 (0.083)	0.172 (0.076)	0.171 (0.075)	0.158 (0.081)	0.185 (0.079)	0.171 (0.076)
GAP_{t-1}	0.044 (0.023)	0.032 (0.014)	0.032 (0.014)	0.030 (0.014)	0.032 (0.021)	0.032 (0.014)
$GAPPOS_t$	0.054 (0.039)	-0.012 (0.040)	-0.011 (0.042)	0.001 (0.037)	-0.016 (0.052)	-0.016 (0.042)
$ASYM25$		0.026 (0.005)	0.026 (0.005)	0.027 (0.005)	0.023 (0.005)	0.026 (0.005)
AIB			0.001 (0.001)			
ΔRP				-0.011 (0.011)		
ΔRP_{t-1}					0.008 (0.003)	-0.017 (0.029)
$\bar{R}^2$	0.721	0.768	0.766	0.768	0.777	0.767
LM(4)	0.005	0.051	0.046	0.053	0.197	0.060
ARCH(4)	0.051	0.937	0.938	0.924	0.885	0.940

Figure 1
The Distribution of Shocks and Price Adjustments

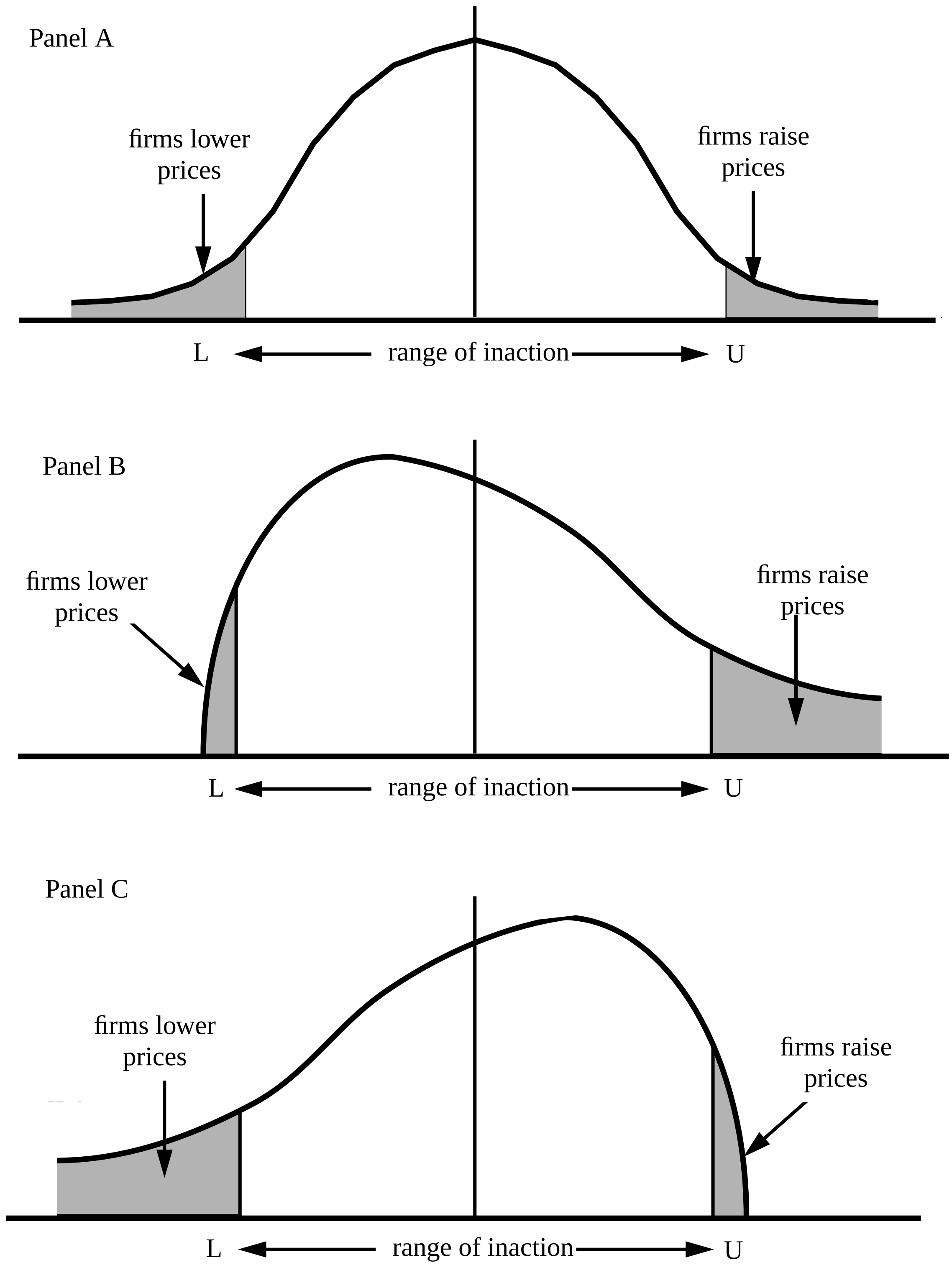
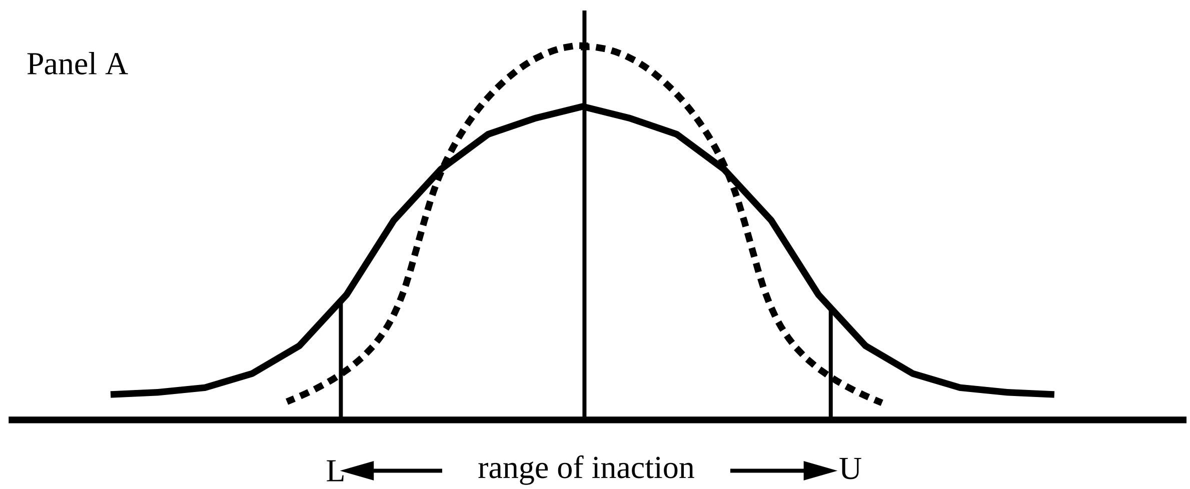


Figure 2
The Interaction Between Variance and Skewness



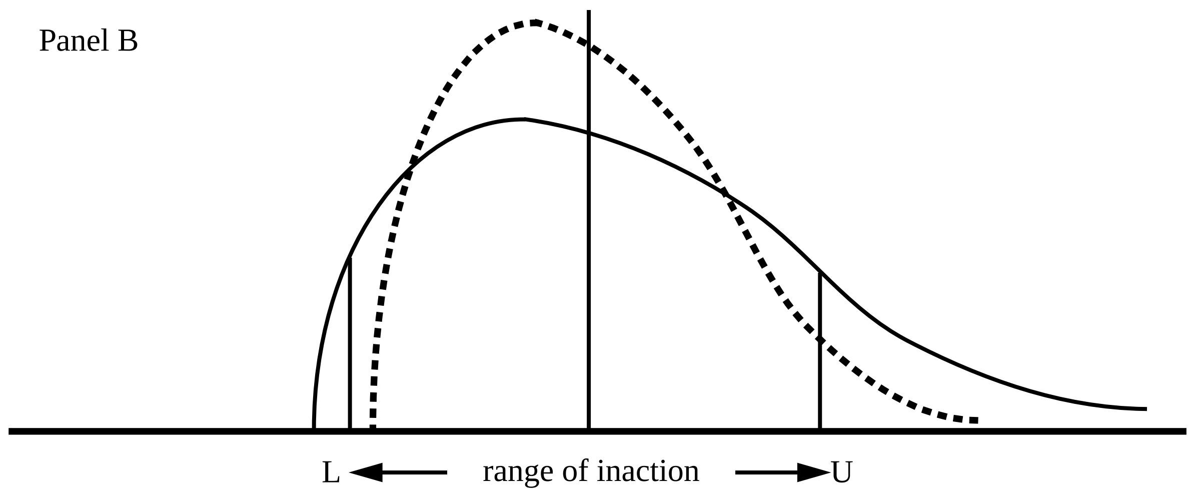


Figure 3
Trend Inflation and Price Adjustment

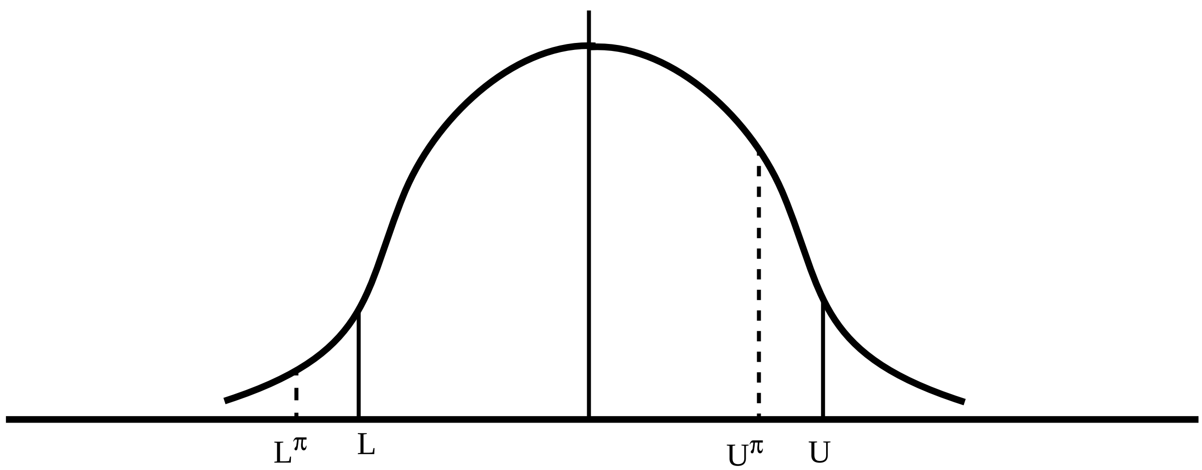


Figure 4
Variance with Trend Inflation

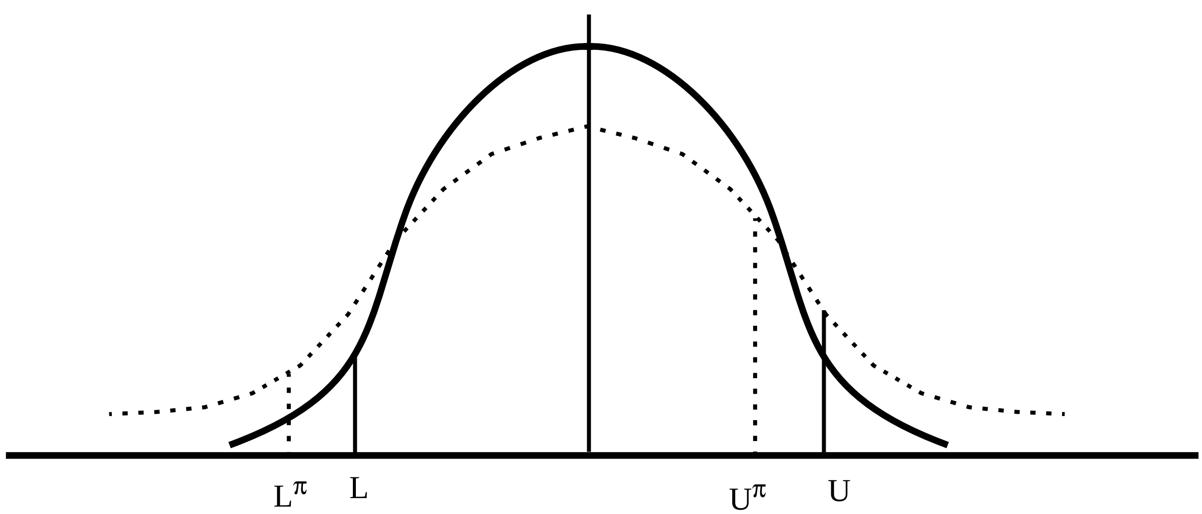
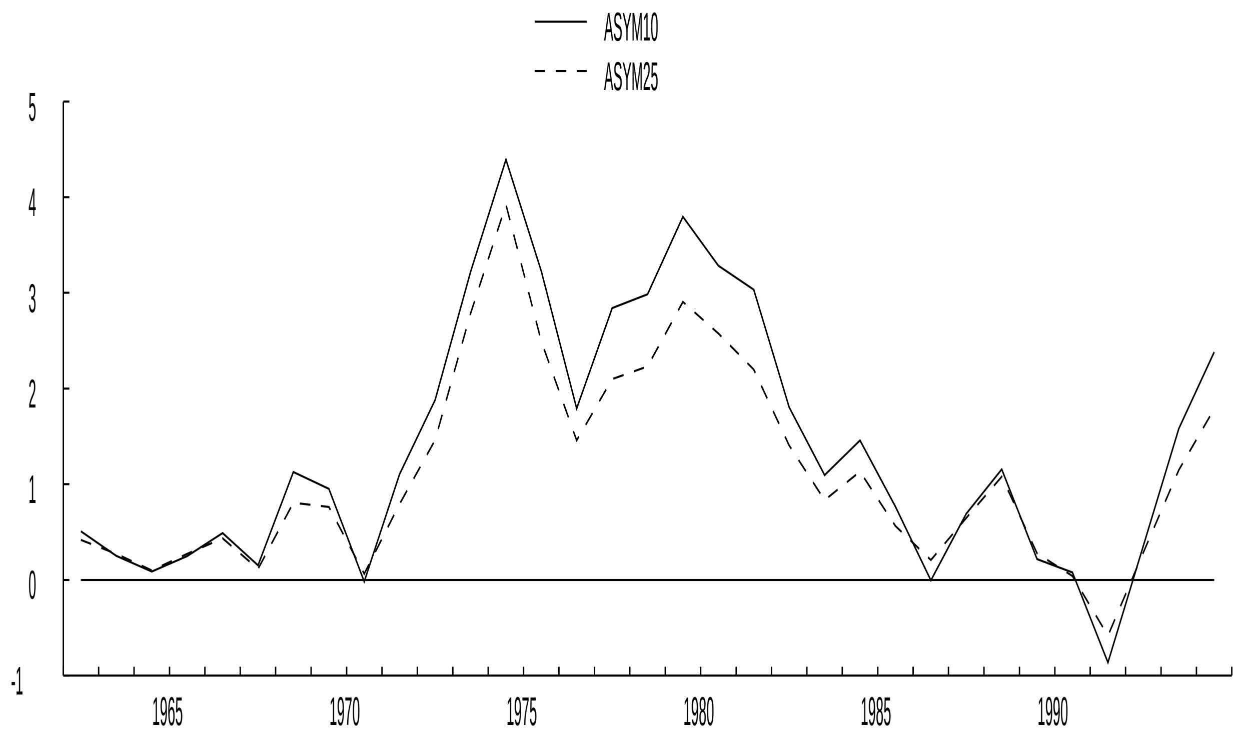


Figure 5: Comparisons of ASYM10 and ASYM25

Annual Measures



Quarterly Measures

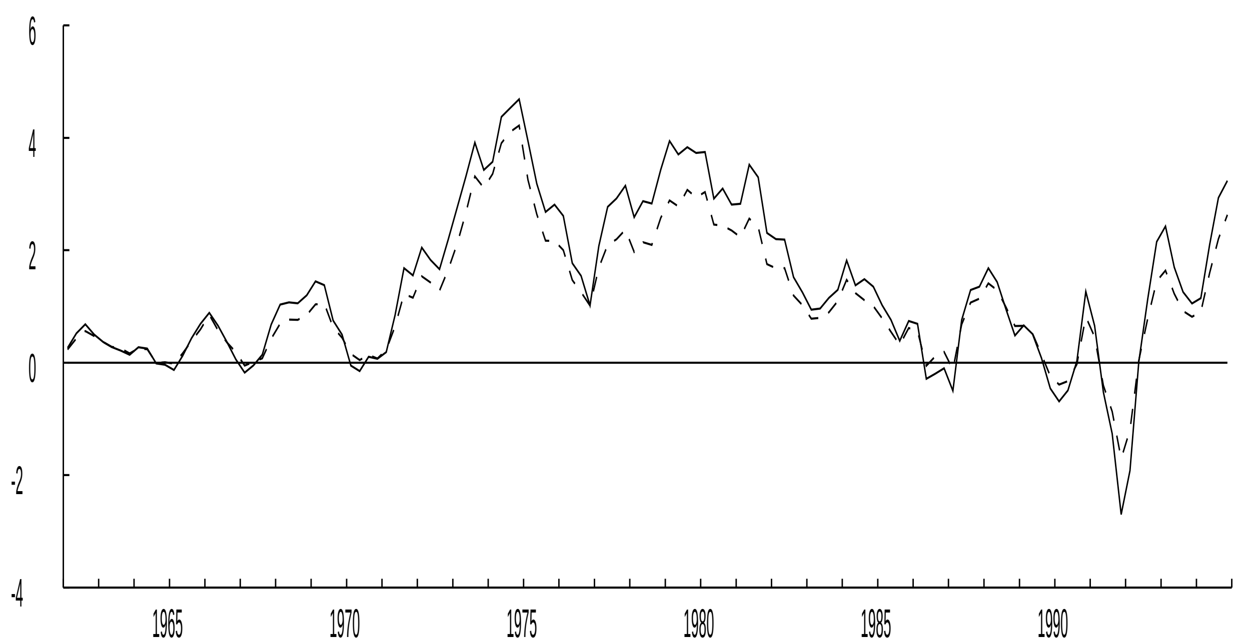
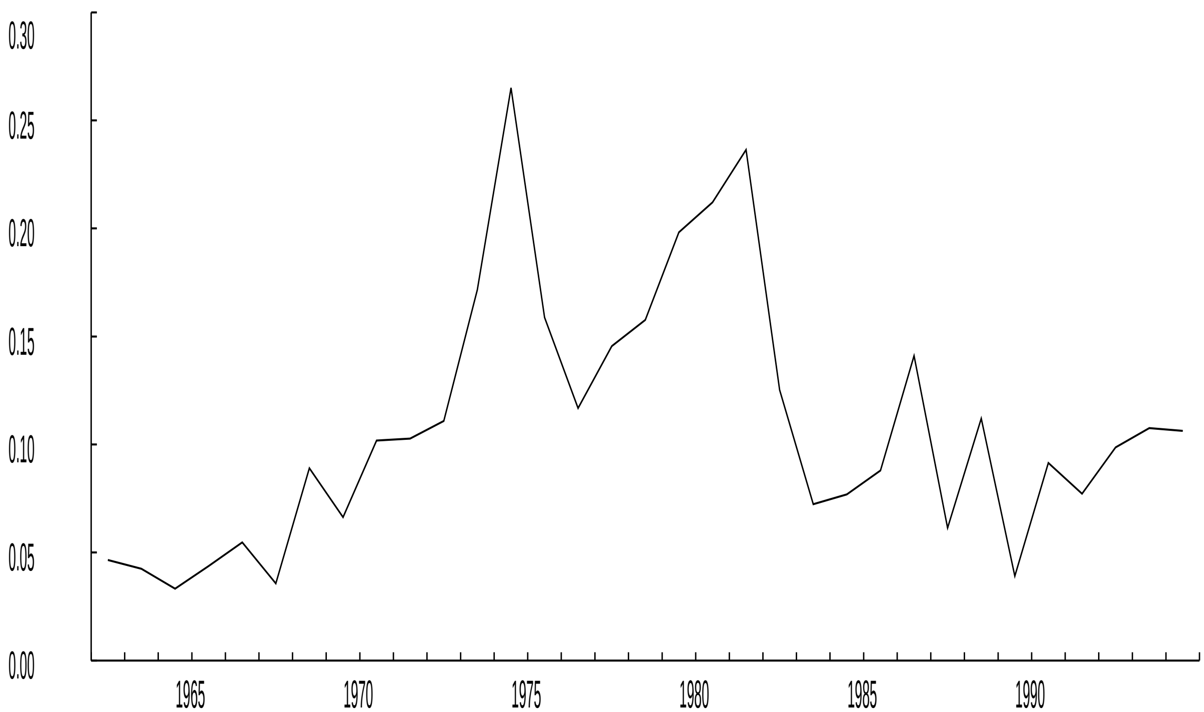


Figure 6: Standard Deviations of the IPPI Distribution
Annual Measures



Quarterly Measures

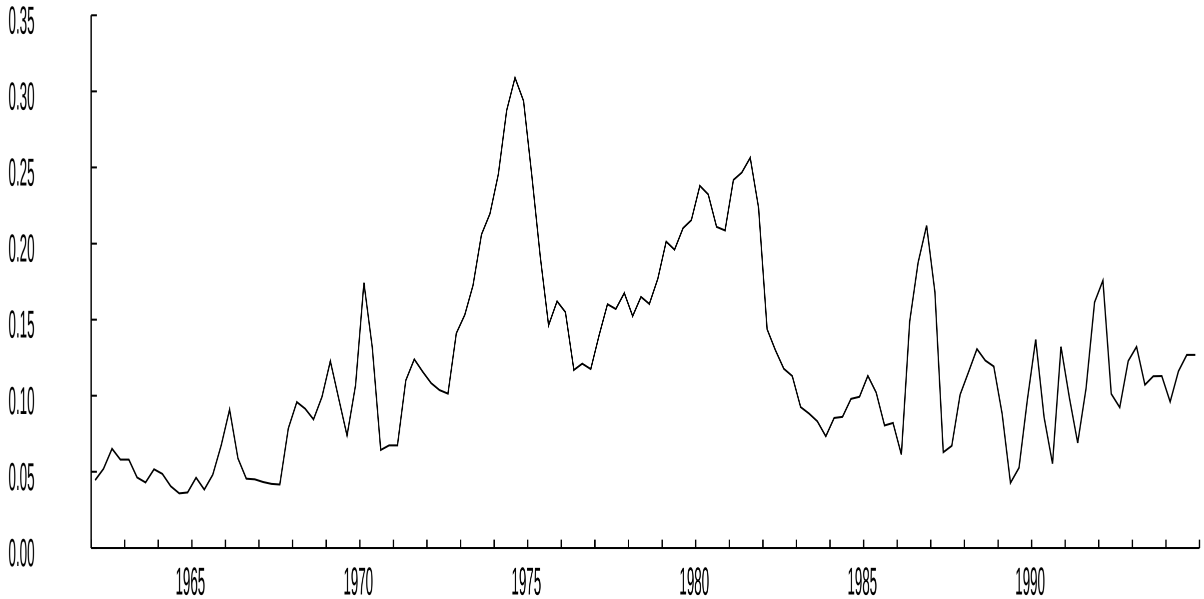
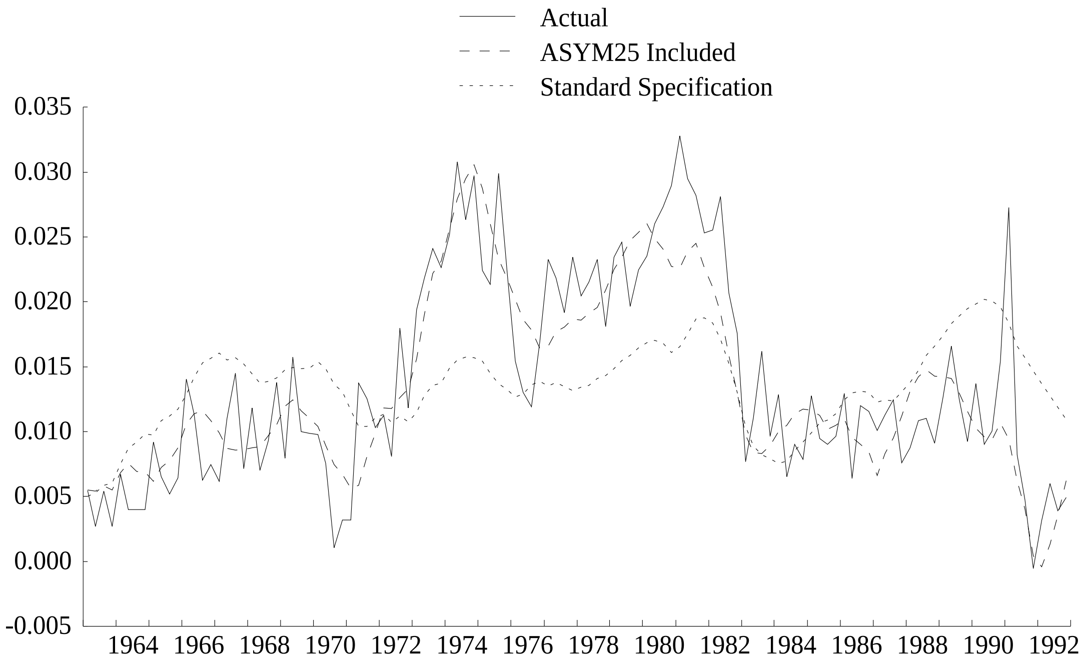
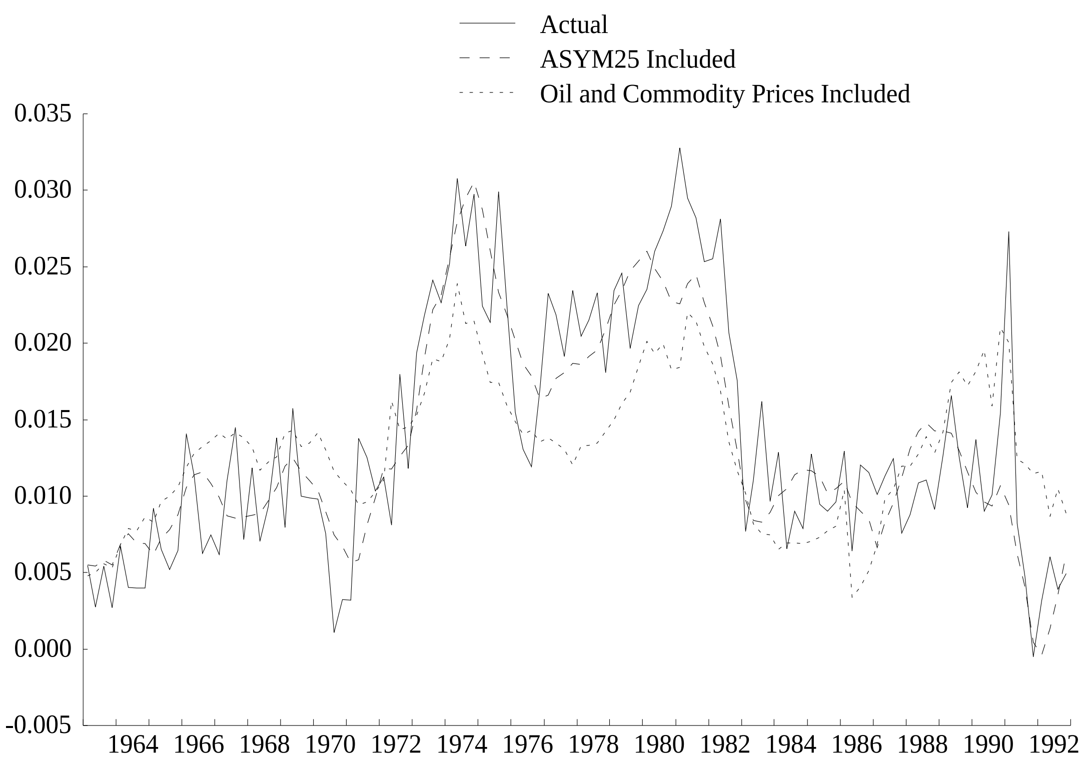


Figure 7: Comparisons of Dynamic Simulations
Quarterly CPI Inflation





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