International Evidence on the Efficacy of new-Keynesian Models of Inflation Persistence*

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Abstract

In this paper we take an agnostic view of the Phillips curve debate, and carry out an empirical investigation of the relative and absolute efficacy of Calvo sticky price (SP), sticky information (SI), and sticky price with indexation models (SPI), with emphasis on their ability to mimic inflationary dynamics. In particular, we look at evidence for a group of 13 OECD countries, and we consider three alternative measures of inflationary pressure, including the output gap, labor share, and unemployment. We find that the Calvo SP and the SI models essentially perform no better than a strawman constant inflation model, when used to explain inflation persistence. Indeed, virtually all inflationary dynamics end up being captured by the residuals of the estimated versions of these models. We find that SPI model is preferable because it captures the type of strong inflationary persistence that has in the past characterized the economies of the countries in our sample. However, two caveats to this conclusion are that improvement in performance is driven mostly by the time series part of the model (i.e. lagged inflation) and that the SPI model overemphasizes inflationary persistence. Thus, there appears to be room for improvement via either modified versions of the above models, or via development of new models, that better "track" inflation persistence.

JEL classification: E12, E3, C32

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1 Introduction

In this paper we take an agnostic view of the new-Keynesian Phillips curve debate, and carry out an empirical investigation of the relative and absolute efficacy of sticky price, sticky information, and sticky price with indexation models, with emphasis on their ability to mimic inflationary dynamics. In particular, we examine data for a group of 13 OECD countries, and we consider three alternative measures of inflationary pressure, including the output gap, labor share, and unemployment. Our findings suggest that two of the three formulations that we consider (i.e. the "non-hybrid" formulations) yield little improvement over a *constant* inflation model of inflation dynamics, while the other formulation tends to overemphasize inflationary persistence.

The impetus for our research stems from the fact that although a variety new-Keynesian Phillips curve formulations are used in the theoretical and empirical macroeconomics literatures (see e.g. Goodfriend and King (1997), Rotemberg and Woodford (1997), Clarida, Gali and Gertler (1999), Smets and Wouters (2003), Woodford (2003), Christiano, Eichenbaum, and Evans (2005), Kiley (2005), Korenok and Swanson (2005), and the references cited therein), there remains an ongoing debate concerning which model is preferable, particularly with regard to producing reasonable inflation dynamics. Of note is that from amongst the many alternative formulations, the Calvo (1983) random price adjustment characterization (i.e. the sticky price (SP) model) is oft cited as the most widely used.[1] In an important paper, Fuhrer and Moore (1995) show that the SP model falls short when used to explain inflation persistence, one of the stylized empirical facts describing US inflation.[2] To improve the sorts of inflation persistence implied by the SP model, two leading contenders incorporate additional frictions into the model. One is the sticky price with dynamic indexation (SPI) model proposed by Gali and Gertler (1999), Christiano, Eichenbaum and Evans (2001), Smets and Wouters (2003), and Del Negro and Schorfheide (2005). They add lags of inflation into the Calvo model, resulting in the so-called "hybrid" model; so-named because lags are introduced without theoretical justification. Another is the sticky information (SI) model proposed by Mankiw and Reis (2002). They posit

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[1] For example, Rotemberg and Woodford state that: "By far the most popular formulation of the new-Keynesian Phillips curve is based on Gulliermo Calvo's (1983) model of random price adjustment."; and Mankiw and Reis (2002) state that: "As the recent survey by Richard Clarida, Jordi Gali, and Mark Gertler (1999) illustrates, this model is widely used in theoretical analysis of monetary policy. Bennett McCallum (1997) has called it 'the closest thing there is to a standard specification.' "

[2] Additionally,Gali and Gertler (1999) find that the output gap is either not statistically significant, or even if it is statistically significant, has the wrong sign. Mankiw and Reis (2002) note that such models have trouble explaining why shocks to monetary policy have delayed and gradual effects on inflation (see also Bernanke and Gertler (1995) and Christiano, Eichenbaum and Evans (2000)). Ball (1994) finds that the SP model yields the controversial result that an announced credible disinflation causes booms rather than recessions.

that information about macroeconomic conditions spreads slowly because of information acquisition and/or re-optimization costs. Prices in their setup are always readjusted, but decisions about prices are not always based on the latest available information as is the case in the SP model.[3]

A further impetus for our research derives from a strand of the literature where it is argued on theoretical and empirical grounds that labor share is a more appropriate measure of inflationary pressure than the output gap: it is persistent; current inflation is positively correlated with future labor shares in the model and in the data; estimated models yield correct signs when it is used as a measure of inflationary pressure; and such models yield good in-sample fit (see Gali and Gertler (1999) and Sbordone (2002)). However, Rudd and Whelan (2005), among others, criticize the use of labor share as a poor measure of inflationary pressure. They point out that in a broad class of models, labor share moves procyclically (see e.g. Woodford (2003)) while observed labor shares have a clear countercyclical pattern. In addition they argue that labor share does not improve in-sample fit of the SP model. Thus, again, there is debate; this time concerning which measure is reasonable. Our approach is to examine the three measures mentioned above: output gap, labor share, and unemployment.

Our objective in this paper is also to be agnostic with respect to the economic structure outside of the inflation model. In particular, the rest of economy is approximated with a vector autoregression (VAR), an approach advocated by Fuhrer and Moore (1995). Of note is that a reduced-form VAR provides a good fit, and also reduces the number of maintained hypotheses concerning the structure of the economy, hence allowing us to focus solely on inflation. In addition to standard measures of model performance, such as a models' ability to match theoretical and historical inflation autocorrelations, and the overall goodness of fit, we compare the "closeness" of simulated and historical joint distribution functions of inflation and lagged inflation, and rank our three models.[4]

Our paper is probably closest to those of Fuhrer (2005), Kiley (2005), and Rudd and Whelan (2005), although all three papers consider only U.S. data; the first and the third papers do not examine sticky information formulations; the second paper forms hybrid versions of all of the formulations that it examines; and none of the papers jointly consider all three of the inflationary measures discussed above.

The lessons that we learn from our empirical investigation are quite clear-cut. First and foremost, the inflationary dynamics implied by the SP and SI models are very different from those of the SPI model as might be expected, given that the SPI model is our only hybrid model. What is perhaps surprising, though,

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[3] The model is representative of the wider class of rational inattention models developed by Phelps (1970), Lucas (1973), and more recently by Mankiw and Reis (2002), Sims (2003), and Woodford (2003).

[4] This is done using the distributional accuracy test of Corradi and Swanson (2005a,b).

is that our empirical evidence suggests that the SP model essentially performs no better than a strawman *constant* inflation model. Indeed, virtually all inflationary dynamics end up being captured by the residuals of the estimated versions of these models. This feature is not mitigated if either: (i) we use alternative measures of inflationary pressure such as labor share or unemployment, (ii) we use random information instead of price adjustment (i.e. if we use the SI model), or (iii) we consider a stable monetary policy period when defining our data sample.

The above finding extends current knowledge in several directions. First, the finding that the SP model yields a poor fit when labor share is used as a measure of inflationary pressure extends the results of Fuhrer(2005) and Rudd and Whealan (2005) to a multiple country dataset. Indeed, none of our inflationary pressure measures perform particularly well. There are no cases, across the countries investigated, where the sign of the inflationary pressure coefficients in our models are all correct, let alone statistically significant. Second, in contrast to numerous recent papers[5] concluding that the SI model is comparable to a current "benchmark", we argue that the close proximity between SP and SI models arises from the fact that virtually all inflationary dynamics end up being captured by the residuals of our fitted models. Third, contrary to the perceived notion that the SP and SI models perform better during stable monetary policy periods (for example Kiley (2005)), we suggest that the only improvement is due to the fact that recent history is consistent with inflation being very flat with little autocorrelation (i.e. recent history is closer to a constant inflation model). We argue that the data in this context are getting closer to the model, and the model is not getting closer to the data. In summary, the first conclusion that we draw is as follows. We believe that indeed the SP and SI models are similar with respect to their ability to capture inflation dynamics. However, this is not necessarily a good feature, given their failure to mimic inflation persistence.

Our second conclusion is that the sticky price model with indexation is clearly preferable in at least one dimension. While the other model exhibit little persistence, the SPI captures the type of strong inflationary persistence that has in the past characterized the economies of most of the countries in our sample. The key caveat to this conclusion, however, is that improvement in performance is driven mostly by the time series part of the model – lagged inflation. The coefficients on all measures of inflationary pressure are close to zero, and are not significant. In addition, we present evidence that the sticky price model with indexation overemphasizes inflationary persistence. Autocorrelations are generally larger than those observed in the

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[5] The comparison of the SP and SI models is a rich literature in its own right (see e.g. Mankiw and Reis (2002), Khan and Zhu (2004), Korenok (2005), Trabandt (2005), Korenok and Swanson (2005), Laforte (2005), Gorodnichenko (2006), and the papers cited therein).

historical record; although as shall be discussed below, autocorrelations vary (sometimes greatly) from decade to decade.

Finally, we note that the SPI model performs well everywhere except in the region of the joint distribution where current and lagged inflation is negative. This region is not populated at all in the historical record, but simulated SPI data sometimes are found here. This problem is clearly related to the excess persistence of the SPI model. On the other hand, based on our joint distributional analysis, and regardless of inflationary pressure measure used, the SP and SI models yield inflation that appears *i.i.d.*

Overall, we thus conclude that there appears to be room for improvement via either modified versions of the above models, or via development of new models, that better "track" inflation persistence.

The rest of the paper is organized as follows. In Section 2 we discuss the setup, while Section 3 discusses estimation. Details of the data used are contained in Section 4, and empirical results are gathered in Section 5. Concluding remarks are given in Section 6. All proofs and derivations are gathered in appendices.

2 Setup

Our modeling approach follows closely that of Fuhrer and Moore (1995). More recent papers that draw heavily upon the Fuhrer and Moore approach include Sbordone (2002) and Kiley (2005). For further details, the reader is referred to either of these papers.

In summary, we begin by estimating an unrestricted vector autoregression (VAR) model for (i) inflation, (ii) a given inflationary pressure measure, (iii) output, and (iv) interest rates, using maximum likelihood. Then we replace the reduced form equation for inflation with a new-Keynesian structural equation. Holding the rest of the system fixed, we proceed to estimate parameters of the structural equation by maximizing the appropriate restricted likelihood function.

In particular, we begin with a reduced form VAR model, say:

$$Z_t = A(L)Z_{t-1} + w_t, \quad Z_t = (\pi_t, g_t, \triangle y_t, r_t)',$$

where π_t is a measure of inflation, g_t is a measure of inflationary pressure, $\triangle y_t$ is the growth rate of real output, r_t is the nominal short-term interest rate, $A(L)$ is a polynomial coefficient matrix in the lag operator, L, and w_t is a conformably defined vector error term. Now, the only additional structure placed upon the economy is the form of the inflation equation; which replaces the reduced form inflation equation and is derived from one of the following three price models:

I. Sticky Price Model: Every period a fraction of firms, $(1-\theta_1)$, can set a new price, independent of the past history of price changes. This price setting rule implies that the expected time between price changes is $\frac{1}{1-\theta_1}$. The rest of firms that cannot set their prices optimally keep last periods' price $P_t(i) = P_{t-1}(i)$).

II. Sticky Price Model with Indexation: As in the SP model, in the model with dynamic indexation only a proportion of firms $(1-\theta_2)$ can reset their prices during the current period. But, instead of keeping last periods' price, the rest of firms set their price proportional to the current level of inflation $P_t(i) = \pi_t P_{t-1}(i)$.

III. Sticky Information Model: Unlike sticky price or sticky price with indexation model, in the sticky information model firms reset prices every period. But, only a fraction of firms $(1-\theta_3)$ use current information in pricing decisions. The rest of firms use past or outdated information when they set their prices.

In all three models the fact that a fraction of firms is not able to adjust prices optimally implies a difference between the actual y_t and the potential (natural) y_t^n level of output. We denote this difference by $y_t^g = y_t - y_t^n$, and refer to it as the output gap. Now, solving the associated optimization problems and using a log-linear transformation, we can write expressions for the new-Keynesian Phillips curve for each model.[6] The dynamics of inflation in the sticky price model follows:

$$\pi_t = \beta\, E_t\, \pi_{t+1} + \lambda_1\, y_t^g + v_t, \tag{1}$$

where $\lambda_1 = \frac{(1-\theta_1)\,(1-\beta\,\theta_1)\,\mu}{\theta_1}$, $\mu = \frac{\omega+\sigma}{1+\varepsilon\,\omega}$ and v_t is a structural shock to the Phillips Curve which can be interpreted as a cost-push shock (see Gali and Gertler (1999) or Fuhrer (2005) for further details on interpretation). In the sticky price model with indexation, the equation for inflation dynamics follows:

$$\pi_t = \frac{1}{1+\beta}\pi_{t-1} + \frac{\beta}{1+\beta}\, E_t\, \pi_{t+1} + \frac{\lambda_2}{1+\beta}\, y_t^g + v_t, \tag{2}$$

where $\lambda_2 = \frac{(1-\theta_2)\,(1-\beta\,\theta_2)\,\mu}{\theta_2}$. Finally, in the sticky information model, dynamics of inflation follows:

$$\pi_t = \frac{(1-\theta_3)\,\xi}{\theta_3}\, y_t^g + (1-\theta_3)\sum_{k=0}^{\infty} E_{t-k-1}\theta_3^k(\pi_t + \xi\,\triangle y_t^g) + v_t. \tag{3}$$

We investigate three alternative measures of inflationary pressure including the output gap, labor share and unemployment. Equations (2)-(4) are derived using approximate proportionality, and the assumption of a positive linear relation between labor share and the output gap; an assumption that holds in the standard model without variable capital.[7] Note that Okun's law postulates proportionality, and a negative linear

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[6] For a detailed derivation of the new-Keynesian Phillips curve in the sticky price models see Woodford (2003). For a detailed derivation of the Phillips curve in the sticky information model see Khan and Zhu (2004).

[7] See Sbordone (2002) for a detailed discussion of the proportionality between labor share and the output gap.

relation between the output gap and unemployment. Such proportionality allows us to investigate more general versions of (2)-(4) where we substitute the output gap y_t^g with g_t, where g_t is either the output gap, labor share, or (negative) unemployment.

Given the above setup, our approach is to form a final model from one of the alternative structural equations for inflation (i.e. (1), (2) or (3)) and reduced form equations for the measure of inflationary pressure, the growth rate of real output, and the nominal interest rate from the unconstrained VAR model. This gives us $m = 4$ equations. Namely:

$$\begin{aligned} \pi_t^{(i)} &= f^{(i)}(g_t, \pi_{t-1}, E_t\pi_{t+1}, E_{t-j}\pi_t, v_t), \quad i = 1, 2, 3, \quad j = 1, 2, ... \\ \tilde{Z}_t &= \tilde{A}(L)\tilde{Z}_{t-1} + \tilde{w}_t, \end{aligned} \tag{4}$$

where $\tilde{Z}_t = [g_t, \triangle y_t, r_t]$ is a $m - 1 \times 1$ vector, $\tilde{A}(L) = A(L)_{2..m,.}$, $\tilde{w}_t = [w_{2t}, w_{3t}, w_{4t}]'$, and $f^{(i)}$ denotes one of the three structural equations for inflation. The system is solved using Sims (2002) methodology, and is estimated using the Kalman filter (see Appendix A for further details).

3 Data

We consider quarterly variables including real GDP, unit labor costs, the output gap, unemployment, population, the GDP deflator, and short-term interest rates[8,9] for the period 1960.1-2005.4 reported in OECD Economic Outlook 77 database. The countries in our sample include Australia, Canada, Finland, France, the United Kingdom, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Sweden, and the United States. Of note is that the sample sizes used vary according to country, and according to inflationary pressure measure used.[10] We use logged data and remove the mean from all series prior to estimation.

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[8] see www.sourceoecd.org.

[9] Economic Outlook defines short-term interest rate as follows for our 13 countries: Australia - 90-day bank accepted bills; Canada - chartered bank rates for 90-day deposit receipts; Finland - 3-month inter-bank loan rate; France - 3-month PIBOR; the United Kingdom - 3-month inter-bank loan rate; Ireland - 3-month fixed inter-bank loan rate; Italy - 3-month inter-bank deposit rate; Japan - 3-6 month cd rate(from 1980 onwards) and the 3 month Gensaki rate (up to 1979); Netherlands - 90-day bank bill rate; Norway - 3-month inter-bank loan rate; New Zealand - 90-day bank bill rate; Sweden - 3-month treasury discount note rate; and the United States - 3-month inter-bank loan rate.

[10] Samples for models using the output gap have the following start daters: Australia - 1970.1, Canada - 1966.1, Finland - 1975.4, France - 1971.1, the United Kingdom - 1970.1, Ireland - 1978.2, Italy - 1971.1, Japan - 1975.1, Netherlands - 1971.4, Norway - 1979.1, New Zealand - 1979.4, Sweden - 1982.1, and the United States - 1964.2. Samples for models using labor share have the following start dates: Australia - 1968.1, Canada - 1961.1, Finland - 1970.1, France - 1970.1, the United Kingdom - 1969.1, Ireland - 1975.1, Italy - 1971.1, Japan - 1969.1, Netherlands - 1969.1, Norway - 1979.1, New Zealand - 1986.2, Sweden

Summary statistics for inflation across the different countries are given in Table 1. Noteworthy observations from this table are that means and standard deviations increase in the 1970s, and fall steadily thereafter, as has been well documented. Further, there appears little evidence of fat tails (relative to normal), there is positive skewness, and there is relatively substantive positive autocorrelation across all countries except Sweden. Furthermore, while the cross country evidence suggests that the countries are quite similar with respect to various estimates of mean and standard error, there is some disparity with respect to kurtosis and first order autocorrelation magnitudes. For example, autocorrelations range from negative to positive and close to unity. However, 10 of 13 countries exhibit autocorrelations in excess of 0.59 when the entire sample period is used. Finally, and again perhaps as expected, the degree of persistence varies greatly from decade to decade, except in the United States, where persistence remains very high regardless of sample period used.

Following the literature, we estimate our models using both the full sample and a sample from 1983-2005 (our 'stable monetary policy' period). The reader is referred to Kiley (2005) for motivation of this sample, and comments on estimation robustness across sample periods.

4 Comments on Estimation

4.1 Flat Likelihood

We follow the standard approach in the literature of fixing $\beta = 0.99$.[11] Thus, we estimated two parameters (λ_1 and σ_v) in the sticky price model; two parameters (λ_2 and σ_v) in the sticky price model with indexation; and three parameters (ξ, θ_3, and σ_v) in sticky information model.

Figure 1 reports the shape of likelihood functions over a reasonable parameter range (we report figures only for the output gap measure of inflationary pressure; for the other measures figures are similar) for the different models.[12] For all models, the likelihood functions are relatively flat for key structural parameters such as λ_1, λ_2, θ_3, and ξ. This suggests that various key structural parameters are relatively uninformative determinants of inflation dynamics. Furthermore, the likelihood functions for the sticky price model (see top left plot in Figure 1), and the sticky price model with indexation (see top right plot in Figure 1) are

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- 1982.1, and the United States - 1960.1. Samples for models using unemployment have the following start dates: Australia - 1968.1, Canada - 1961.1, Finland - 1970.1, France - 1970.1, the United Kingdom - 1969.1, Ireland - 1975.1, Italy - 1971.1, Japan - 1969.1, Netherlands - 1960.1, Norway - 1979.1, New Zealand - 1974.1, Sweden - 1982.1, and the United States - 1960.1.

[11] We tried to estimate β using constrained and unconstrained maximization. However, the likelihood is not informative (i.e. it is flat) for β. Furthermore, unconstrained estimates of β are very far from any reasonable range, while constrained estimates are often at the boundaries.

[12] One parameter is fixed at its MLE in all sticky information figures.

smooth, while the likelihood function for the sticky information model evaluated at $\hat{\sigma}_v^{MLE}$ has many local optima which makes estimation difficult.

4.2 Parameters

Parameter estimates are contained in Tables 2-4. Turning first to the US estimates (see rows 13 and 26 of Tables 2-4), note that estimated coefficients associated with each of our three measures of inflationary pressure is small in magnitude (e.g. for the SI and SPI models values are almost always below 0.02 in absolute value, regardless of measure and sample period). This conforms with the findings of Fuhrer (2005) and Gali and Gertler (1999).[13]

For several models/measures we reject the theoretical new-Keynesian Phillips curve because we find significant negative coefficients associated with our measures of inflationary pressure. A negative estimate means that an increase in inflationary pressures leads to a decline in inflation. In particular, we find significant negative coefficients in the sticky price model (full sample estimation period) for the coefficients associated with the output gap and unemployment, and in the sticky price model (1983-2005 sample) for the coefficient on unemployment. In the sticky information model the coefficient on the output gap is also significant and negative. This result echoes the finding of Rudd and Whelan (2005) that the coefficient on the output gap is negative. However, for the SP and SI models, the labor share usually has a significant positive coefficient associated with it, while the SPI model does not. This finding corresponds to the results of Gali and Gertler (1999), Rudd and Whelan (2005), and Kiley (2005).

Results for the other 12 countries in our sample are quite similar to those for the U.S. In particular, coefficients associated with our measures of inflationary pressure are generally small. Additionally, significant positive coefficients are not found when the output gap is used, although they are found in various cases when the labor share is used, with the exception of the SPI model, which appears to be rejected almost always when the incidence of a significant positive coefficient is used as a form of specification test.

In summary, when used in conjunction with the SP model, the output gap yield frequent rejection of the model, based on the incidence of significant negative coefficients, while labor share results in a failure to reject in many cases, with the notable exception of the SPI model. However, some caution needs to be taken in drawing firm conclusions, given the apparent uninformativeness of the likelihood functions associated with these models.

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[13] Coefficients are generally sufficiently small in magnitude so as to ensure that large changes in our measures of inflationary pressure produce only small changes of inflation.

5 Empirical Findings

In this section we evaluate the performance of the alternative models using various measures of in-sample fit, including residual autocorrelation, volatility, and simulated distributional accuracy.

5.1 Residual Autocorrelation Analysis

Turning first to the U.S., note that Figure 2 reports fitted and actual inflation and associated residuals for the full sample and the reduced sample from 1983-2005. For expository purposes, we add the mean back to the fitted values, and we convert quarterly changes into yearly. Note that we report only on the output gap; results for other measures of inflationary pressure are qualitatively the same. A number of conclusions emerge, upon inspection of the figures.

First, SP and SI models are exceptionally poor fits to the historical data. Indeed, the two models yield very similar (in-sample) predictions, but both are far from accurate. In fact, the SP and SI models move so little over time that we decided to also compare them with a naiive model with constant inflation (see Figure 2).[14] It is immediate from inspection of the lower plots in Figure 2 that estimated residuals from SP and SI models are very close to constant inflation residuals both in the full and reduced samples. This is quite surprising. Indeed, inspection of the plots for the smaller more recent sub-sample suggests that any perceived improvement in fit of the SP and SI models stems simply from the fact that the recent historical record is "closer" to "constant", i.e. note that the residuals from the constant model are essentially indistinguishable from those of the SP and SI models.

Table 5 summarizes the proximity between constant inflation residuals and residuals from our theoretical models by reporting correlation between residuals from the constant inflation model and residuals from theoretical models. Based on the full sample, for the SP and SI models, this correlation is above 88% for all 13 countries, and above 97% for 7 countries. Corresponding correlations are much lower for the SPI model, ranging as low as 26%.Results are largely the same for the reduced sample period. Clearly, based upon this metric, the SP and SI models are performing very poorly.

Table 6 reports estimated first order autocorrelations for the residuals from the models. Of note is that the SP and SI models have positive, significant autocorrelations that are close to U.S. estimates of autocorrelation for inflation from Table 1. In addition, the estimates decrease in the reduced sample; in a similar way that inflation autocorrelations decrease. This is as expected, given the results presented in

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[14] Of note is that our results in top left plot of Figure 2 for the SP model are similar to those presented in Figure 2 in Rudd and Whelan (2005).

Figures 2-7 and Table 5; the residuals of these two models essentially capture the entire dynamics of inflation! Note also that our results are in line with those of Kiley (2005), who reports that residual autocorrelation for the SP and SI models decline during stable monetary policy period; a result which must follow if the residuals capture all of the inflation dynamics. Also, Fuhrer and Moore (1995) report a similar result. Interestingly, the SPI model residuals have significant negative autocorrelation. This suggests a kind of "overshooting", in the sense that will be made clear in Table 7, where it is shown that the SPI model generates excessive autocorrelation, even in periods when historical autocorrelation is low. Thus, while the SP and SI models are clearly deficient, the SPI model is also imperfect. Evidently, none of these models are yielding white noise residuals, for example.

Turning now to the other 12 countries in our sample, it should be emphasized that all of the above conclusions are robust with respect to the other countries. This is illustrated via a selected set of figures that mimic the results of Figure 2 for 5 additional countries (i.e. see Figures 3-7). Additionally, the above discussion with regard to residual autocorrelation and the correlation between the residuals form our models and the strawman constant inflation model carries over to virtually all of the countries in our sample (see Table 5 and 6).

5.2 Theoretical Autocorrelation

Given MLE estimates of the structural parameters, we can calculate the autocorrelation of inflation in our theoretical models (see Appendix B for details). Results are gathered in Table 7 for the 2 sub-samples. Note that due to differences in available data for the GDP deflator and other series, results are not comparable to results in Table 1. To facilitate comparison with the dynamics of historical inflation, we report historical autocorrelations for the estimation period (see second column of the table). Various conclusions emerge from inspection of this table. First, and as discussed above, persistence is pervasive across countries. Autocorrelation is generally positive and significant for both samples, historically, and is above 60% for 10 of 13 countries in the full sample, for example. In the stable monetary policy sample (i.e. the smaller sample) it is above 30% for 8 of 13 countries. The SP and SI models fail to reproduce anything close to the historical autocorrelation of inflation, as they yield autocorrelations close to zero. This finding corresponds to that of Fuhrer and Moore (1995), who emphasize the problems the SP model has in matching historical U.S. autocorrelation, and Fuhrer(2005) points out that small autocorrelation in the SP model is not surprising, given that estimates on the coefficient associated with his measure of inflationary pressure is small, and given that in the theoretical model, all inflation autocorrelation comes from autocorrelation associated with the inflationary pressure measure. Indeed, even if autocorrelation for the measure is high, a small coefficient still implies that almost zero autocorrelation feeds through to inflation (as discussed above). Finally, observe that SPI autocorrelation is significant and positive for all cases. However, as pointed out above in a different context, the theoretically implied SPI autocorrelation is actually higher than the autocorrelation calculated using the historical data. Indeed, even in cases where the historical autocorrelation is close to zero, autocorrelation implied by the SPI model is around 80-90%.

5.3 Point Measures of Fit

The ratio of fitted and historical inflation standard errors is reported for the different countries and inflationary pressure measures in Panels A and B of Table 8. Of note is that fitted inflation in the SP and SI models has very low variability, while fitted inflation from the SPI model has variability that is close to historical levels, regardless of sub-sample used (compare Panels A and B in the table). Indeed, inflation standard errors implied by the SP and SI models are often as little as one third the magnitude of their historical counterparts. For example, the ratio is less than 0.30 for the SP model in 11 of 13 countries when the output gap is used, 10 of 13 countries when labor share is used, and 9 of 13 countries when unemployment is used, when models are estimated using the full sample of data. Results are similar based upon the reduced sample. On the other hand, the SPI model yield inflation standard errors within 10% of historical levels for 13 of 13 countries when the output gap is used, 7 of 13 countries when labor share is used, and 12 of 13 countries when unemployment is used, when models are estimated using the full sample of data. Again, results are similar based upon the reduced sample.

Root mean square error (RMSE) of the fitted models is reported for the different countries and inflationary pressure measures in Panels C and D of Table 8. Of note is that although the SPI model generally yields lower RMSE when the entire sample is used, this is not so when the 1983-2005 estimation period is used. In particular, RMSE is usually lower for the SP and SI models when the shorter sub-sample is used for estimation. While this result may appear to be contradictory with the results of Panels A and B of the table, it is not, as there is negative autocorrelation in the residuals coupled with an autoregressive model structure. This is a shortcoming of the SPI model, as is the same problem discussed above concerning too much persistence in the SPI model. However, it should be noted that using only RMSE to select the "best" model, hence resulting in the choice of either the SP or SI model in the recent sub-sample, completely ignores the feature of the SP and SI models that they have essentially no dynamics, and that essentially *all inflation dynamics* is captured in the errors in these models. Our evidence based upon Figures 2-7 and Tables 5-7 illustrates how damaging this feature of these models is, and accounts largely for our recommendation that RMSE comparison is potentially very misleading, and should be used with caution. Indeed, in the following sub-section we present formal evidence based upon the CS distributional accuracy test that the SP and SI models are not actually outperforming the SPI model, even in the more recent stable monetary policy regime.

5.4 Distributional Accuracy

Assume that there exists a joint distribution of inflation and lagged inflation implied by our different dynamic models, all of which are potentially misspecified. Our objective is to compare "true" joint distributions with ones generated by given models $1, ..., m$, say. This is accomplished via comparison of the empirical joint distributions (or confidence intervals) of historical and simulated time series. In particular, and following Corradi and Swanson (2005a,b), we are interested in testing the hypotheses that:

$$H_0: \max_{j=2,\dots,m} \int_U E\left(\left(F_0(u;\Theta_0) - F_1(u;\Theta_1^\dagger)\right)^2 - \left(F_0(u;\Theta_0) - F_j(u;\Theta_j^\dagger)\right)^2\right)\phi(u)du \leq 0$$

$$H_A: \max_{j=2,\dots,m} \int_U E\left(\left(F_0(u;\Theta_0) - F_1(u;\Theta_1^\dagger)\right)^2 - \left(F_0(u;\Theta_0) - F_j(u;\Theta_j^\dagger)\right)^2\right)\phi(u)du > 0.$$

where $F_0(u;\Theta_0)$ denotes the distribution of $Y_t = (\pi_t, \pi_{t-1})'$ evaluated at u and $F_j(u;\Theta_j^\dagger)$ denotes the distribution of $Y_{j,n}(\Theta_j^\dagger)$, where $\Theta_j^\dagger$ is the probability limit of $\widehat{\Theta}_{j,T}$, taken as $T \to \infty$, and where $u \in U \subset \Re^2$, possibly unbounded, for $\widehat{\Theta}_{j,T}$ our estimated parameter vector for model j . Thus, the rule is to choose Model 1 over Model 2, say, if

$$\int_U E\left(\left(F_1(u;\Theta_1^\dagger) - F_0(u;\Theta_0)\right)^2\right)\phi(u)du < \int_U E\left(\left(F_2(u;\Theta_2^\dagger) - F_0(u;\Theta_0)\right)^2\right)\phi(u)du,$$

where $\int_U \phi(u)du = 1$ and $\phi(u) \geq 0$ for all $u \in U \subset \Re^2$. For any evaluation point, this measure defines a norm and is a typical goodness of fit measure. Furthermore, by setting $Y_t = (\pi_t, \pi_{t-1})'$ we are constructing a test of whether any of the alternative models beats the "benchmark" model (i.e. model 1). In the current context, we set the benchmark equal to SP, so that SPI and SI are the alternative models. A summary of the details involved in constructing the statistic associated with testing the above hypotheses is given in Appendix C. For complete details, the reader is referred to Corradi and Swanson (2005b).

Table 9 reports CS distributional loss measures (i.e. $\frac{1}{T}\sum_{t=1}^{T}\left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{i,n}(\widehat{\Theta}_{i,T}) \leq u\}\right)^2$) for $i = SP$, SPI, and SI, which are in turn used in construction of the statistics used to test the above hypotheses. (In the preceding expression, S denotes the simulation sample size, where data are simulated according to model i, and is set equal to $50T$ in our calculations, where T is the sample size used in estimation of the model.) Starred entries indicate cases where H_0 is rejected in favor of H_A (i.e. the benchmark model is rejected in favor of at least one of the alternatives).

Two clear-cut observations can be made based upon the results reported in the table. First, note that the SPI model yields the lowest CS distributional loss (entries in bold are "lowest") for all but 2 or 3 countries if output gap or labor share is used as the inflation pressure measure, when the full sample is used for model estimation. On the other hand, the SPI model "wins" for around one half of the countries when the shorter sub-sample is used for model estimation. Thus, contrary to our evidence based on RMSE analysis (see Table 8, Panels C and D), when the joint distribution of π_t and π_{t-1} is evaluated there is some evidence favoring the SPI model, even for the shorter sample period. This supports our earlier arguments based upon the results presented in Figures 2-7 and Tables 5-7, where the SP and SI models are shown to be inferior, suggesting again that focusing our analysis on RMSE is misleading.

Second, the null hypothesis fails to be rejected, regardless of inflation pressure measure and sample period, a result which may in part be due to finite sample power reduction stemming from the use of our relatively small samples of historical data. Another possible reason for the failure to reject the null for any countries is illustrated in Figure 8, where a scatter plot of simulated π_t and π_{t-1} values is given. In particular, note that in the dense central region of the plot, all simulated SPI as well as historical observations are highly overlapping. Furthermore, in the bottom left quadrant of the plot, there are SPI simulated values that do not have corresponding historical counterparts. This extra mass in the negative region of the joint distribution is a result of the excess persistence of the SPI model, and in terms of CS distributional loss, may account for the failure of the SPI model to be statistically superior to the other models based upon application of the CS test. At the same time, the rather circular cluster of points in the scatter that depicts the data simulated using the SP and SI models indicates clearly that these data are essentially *i.i.d*, as discussed above. Even given the poor "left tail" performance of the SPI model, its clear dominance in all other regions of the joint distribution results in the relatively superior point CS measure performance of the SPI model discussed in the preceding paragraph, particularly when the full sample is used to estimate and compare the models. Overall, we thus again conclude that all of the models need to be improved, although this might be more easily done with the SPI model, as it is the only model that appears dynamically rich enough to capture any sort of inflation dynamics.

6 Concluding Remarks

We have taken an agnostic view of the Phillips curve debate, and carry out an empirical investigation of the relative and absolute efficacy of sticky price, sticky information, and sticky price with indexation models, with emphasis on their ability to mimic inflationary dynamics. In particular, we looked at evidence for a group of 13 OECD countries, and we considered three alternative measures of inflationary pressure, including the output gap, labor share, and unemployment.

Our findings are that: (i) Empirical evidence suggests that the Calvo SP and the SI models essentially perform no better than a strawman *constant inflation* model, when used to explain inflation persistence. (ii) The SPI is preferable in the sense that the other models have little dynamics, while the SPI captures the type of strong inflationary persistence that has in the past characterized the economies of the countries in our sample. Two key caveats to this conclusion, however, are that improvement in performance is driven only by the time series part of the model (i.e. lagged inflation) and that the SPI model overemphasizes inflationary persistence. (iii) The SPI model performs well everywhere except in the region of the joint distribution where current and lagged inflation is negative. This problem is clearly related to the excess persistence. Overall, we thus conclude that there appears to be room for improvement via either modified versions of the above models, or via development of new models, that better "track" inflation persistence. We conjecture that this might be more easily done with the SPI model, as it is the only model that appears dynamically rich enough to capture inflation dynamics.

Two directions for future research that may be of particular interest, given our findings, are the following. First, more emphasis should be put on theories that provide theoretical justification for incorporating past inflation through learning, different expectations formation, non-zero steady state inflation, and general models of price stickiness (see e.g. Wolman (1999), Orphanides and Williams (2005), and Sbordone and Cogley (2005)). Second, additional work needs to be done in order to find more appropriate measures of inflationary pressure.

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Appendix A: Model Solution and Estimation

I. The Sticky Price Model: The Phillips curve in the sticky price model can be written as

$$\pi_t = \beta\,\pi_{t+1} + \lambda_1\,g_t + v_t + \beta\eta^{\pi}_{t+1},$$

where η^{π}_{t+1} is expectation error for inflation, it satisfies $E_t\eta^{\pi}_{t+1} = 0$. Defining $Y_t = [\pi_t, g_t, \triangle y_t, r_t, v_t]'$ and assuming one lag in VAR model $A(L) = A(1)$ the system of equations for sticky price model can be written as

$$\Gamma_0 Y_t = \Gamma_1 Y_{t-1} + \Pi\eta_t + \Phi\epsilon_t,$$

where $\eta_t = [\eta^{\pi}_t]$ is a vector of expectation errors and $\epsilon_t = [v_t, \tilde{w}_t']'$ is a vector of exogenous error terms, and

$$\Gamma_0 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ \beta & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix},\ \Gamma_1 = \begin{bmatrix} a_{2,1} & a_{2,2} & a_{2,3} & a_{2,4} & 0 \\ a_{3,1} & a_{3,2} & a_{3,3} & a_{3,4} & 0 \\ a_{4,1} & a_{4,2} & a_{4,3} & a_{4,4} & 0 \\ 1 & -\lambda_1 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix},\ \Phi = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix},\ \Pi^{15} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ -\beta \\ 0 \end{bmatrix}$$

II. The Sticky Price Model with Indexation: The Phillips curve in the sticky price model with indexation can be written as

$$\pi_t = \frac{1}{1+\beta}\pi_{t-1} + \frac{\beta}{1+\beta}\,\pi_{t+1} + \frac{\lambda_2}{1+\beta}\,g_t + v_t + \frac{\beta}{1+\beta}\eta^{\pi}_{t+1},$$

where η^{π}_{t+1} is expectation error for inflation. Similarly to sticky price model, defining $Y_t = [\pi_t, g_t, \triangle y_t, r_t, \pi_{t-1}, v_t]'$ and assuming one lag in VAR model $A(L) = A(1)$ the system of equations for sticky price model with indexation can be written as

$$\Gamma_0 Y_t = \Gamma_1 Y_{t-1} + \Pi\eta_t + \Phi\epsilon_t,$$

where $\eta_t = [\eta^{\pi}_t]$ is a vector of expectational errors and $\epsilon_t = [v_t, \tilde{w}_t']'$ is a vector of exogenous error terms, and

$$\Gamma_0 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ \frac{\beta}{1+\beta} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},\ \Gamma_1 = \begin{bmatrix} a_{2,1} & a_{2,2} & a_{2,3} & a_{2,4} & 0 & 0 \\ a_{3,1} & a_{3,2} & a_{3,3} & a_{3,4} & 0 & 0 \\ a_{4,1} & a_{4,2} & a_{4,3} & a_{4,4} & 0 & 0 \\ 1 & -\frac{\lambda_2}{1+\beta} & 0 & 0 & \frac{1}{1+\beta} & -1 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\Phi = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix},\ \Pi = \begin{bmatrix} 0 \\ 0 \\ 0 \\ \frac{\beta}{1+\beta} \\ 0 \\ 0 \end{bmatrix}$$

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[15] Here actual coefficients do not change computation, so in program I put 1 instead of them.

III. The Sticky Information model: The Phillips curve for the sticky information model can be written as

$$\pi_t = \frac{(1-\theta_3)\,\xi}{\theta_3}\, g_t + (1-\theta_3) \sum_{k=0}^{k_{max}} E_{t-k-1}\theta_3^k(\pi_t + \xi \bigtriangleup g_t) + v_t,$$

where truncation k_{max} is introduced for computational purpose. We show how to transform the system for $k_{max} = 1$, similarly system can be transformed for higher k_{max}.

$$\pi_t = \frac{(1-\theta_3)\,\xi}{\theta_3}\, g_t + (1-\theta_3)E_{t-1}(\pi_t + \xi \bigtriangleup g_t) + (1-\theta_3)E_{t-2}\theta_3(\pi_t + \xi \bigtriangleup g_t) + v_t,$$

We introduce new variables $e_t = \pi_t + \xi \bigtriangleup g_t$, $e_{0,t-1} = E_{t-1}e_t$, $e_{1,t-1} = E_{t-1}e_{0,t}$, $e_{1,1,t} = e_{1,t-1}$. Given these definitions, $e_{1,1,t-1} = E_{t-2}E_{t-1}e_t = E_{t-2}e_t$. Then we can rewrite sticky price Phillips curve as

$$\pi_t = \frac{(1-\theta_3)\,\xi}{\theta_3}\, g_t + (1-\theta_3)e_{0,t-1} + (1-\theta_3)\theta_3 e_{1,1,t-1} + v_t.$$

Similarly to sticky price model, defining $Y_t = [\pi_t, g_t, \bigtriangleup y_t, r_t, e_t, e_{0,t}, e_{1,1,t}, e_{1,t}]'$ and assuming one lag in VAR model $A(L) = A(1)$ the system of equations for sticky price model with indexation can be written as

$$\Gamma_0 Y_t = \Gamma_1 Y_{t-1} + \Pi\eta_t + \Phi\epsilon_t,$$

where $\eta_t = [\eta_t^\pi]$ is a vector of expectation errors and $\epsilon_t = [v_t, \tilde{w}_t']'$ is a vector of exogenous error terms, and

$$\Gamma_0 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & -\xi & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & \frac{(1-\theta_3)\,\xi}{\theta_3} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}, \quad \Gamma_1 = \begin{bmatrix} a_{2,1} & a_{2,2} & a_{2,3} & a_{2,4} & 0 & 0 & 0 & 0 \\ a_{3,1} & a_{3,2} & a_{3,3} & a_{3,4} & 0 & 0 & 0 & 0 \\ a_{4,1} & a_{4,2} & a_{4,3} & a_{4,4} & 0 & 0 & 0 & 0 \\ 0 & -\xi & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & (1-\theta_3) & (1-\theta_3)\theta_3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\Phi = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \quad \Pi = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}$$

Solution for all three models will have the following form

$$X_t = \Theta X_{t-1} + \Psi\epsilon_t, \tag{A1}$$

where X_t is a $n \times 1$ vector of state variables, generally $n > m$, Θ is $n \times n$ and Ψ is $n \times m$ solution matrices respectively, which are functions of the structural parameters of the models, reduced form parameters $\tilde{A}(L)$, and ϵ_t is a $m \times 1$ vector of exogenous disturbances.

The model is estimated using the Kalman filter, which in the current context can be written in general form as:

$$\begin{aligned} Z_t &= HX_t, && \text{(A2)} \\ X_t &= \Theta X_{t-1} + \Psi \epsilon_t, && \text{(A3)} \end{aligned}$$

where $H_{m \times n}$ is a matrix of zeros and ones that picks the observable variables from the state vector, X_t, $\Theta_{n \times n}$ and $\Psi_{n \times m}$ are functions of structural parameters, and $\epsilon_t \sim N(0, \Sigma_\epsilon)$. The above state space representation takes into account that in general not all variables in X_t are observable even though in our model all variables in X_t are observable. The Kalman filter is used to calculate the value of likelihood function which is optimized. Namely, we optimize:

$$LL(H, \Theta, \Psi) = \sum_{t=1}^{T} \ln f_{Z_t|\mathcal{Z}_{t-1}}(Z_t|\mathcal{Z}_{t-1}),$$

where $\mathcal{Z}_{t-1} = (Z'_{t-1}, Z'_{t-2}, ..., Z'_1)$ and

$$\begin{aligned} f_{Z_t|\mathcal{Z}_{t-1}}(Z_t|\mathcal{Z}_{t-1}) &= (2\pi)^{-\frac{n}{2}} |HP_{t|t-1}H'|^{-\frac{1}{2}} \\ &\times \exp\{-\frac{1}{2}(Z_t - H\hat{X}_{t|t-1})'(HP_{t|t-1}H')^{-1} \\ &\times (Z_t - H\hat{X}_{t|t-1})\}, \quad \text{for } t = 1, 2, ...T, \end{aligned}$$

where $P_{t|t}$ and $\hat{X}_{t|t}$ can be obtained from Kalman recursion:

$$\begin{aligned} \hat{X}_{t|t} &= \hat{X}_{t|t-1} + P_{t|t-1}H'(HP_{t|t-1}H')^{-1}(Z_t - HX_{t|t-1}), \\ \hat{X}_{t|t-1} &= \Theta \hat{X}_{t-1|t-1}, \\ P_{t|t} &= P_{t|t-1} - P_{t|t-1}H'(HP_{t|t-1}H')^{-1}HP_{t|t-1}, \\ P_{t|t-1} &= \Theta P_{t-1|t-1}\Theta' + \Sigma_\epsilon. \end{aligned}$$

Appendix B: Theoretical Autocorrelation Function

To compute the autocorrelation functions, we need to calculate the unconditional autocovariance matrices of X_t, Σ_0, Σ_1,...,Σ_L. The computation of autocorrelation functions is conducted using the approach of Fuhrer and Moore (1995). Using recursive substitution, we write equation (A1) as:

$$X_{t+k} = \Theta^k X_t + \sum_{i=1}^{k} \Theta^{k-i} \Psi \epsilon_t$$

Because ϵ_t are uncorrelated over time, the covariance matrix of k-period ahead forecast of y_t is

$$Var_t(y_{t+k}) = \sum_{i=0}^{k-1} \Theta^i \tilde{\Omega} {\Theta'}^i$$

where $Var(\epsilon_t) = \Omega$, $\tilde{\Omega} = \Psi\Omega\Psi'$. In a stationary model, the conditional variance of y_{t+k} converges to the unconditional variance of y_t, Σ_0. Therefore, we compute the conditional variances $Var_t(y_{t+k})$ until they converge to constants and take as the estimate of unconditional variance matrix. Next, the autocovariance matrices are computed recursively as:

$$\Sigma_l = \Theta\Sigma_{l-1}, \quad l = 1, 2, ..., L$$

Autocorrelations are then computed using a standard formula $\rho_{ij}^l = \frac{\sigma_{ij}^l}{(\sigma_{ii}^0\sigma_{jj}^0)^{1/2}}$, where σ_{ij}^l is the lth autocovariance between variables i and j.

Appendix C: Corradi and Swanson (CS) Distributional Accuracy Test

In this appendix, we discuss the CS distributional accuracy test in somewhat more detail. Recall that the hypotheses of interest are:

$$H_0 : \max_{j=2,...,m} \int_U E\left(\left(F_0(u;\Theta_0) - F_1(u;\Theta_1^\dagger)\right)^2 - \left(F_0(u) - F_j(u;\Theta_j^\dagger)\right)^2\right)\phi(u)du \leq 0$$

versus

$$H_A : \max_{j=2,...,m} \int_U E\left(\left(F_0(u;\Theta_0) - F_1(u;\Theta_1^\dagger)\right)^2 - \left(F_0(u) - F_j(u;\Theta_j^\dagger)\right)^2\right)\phi(u)du > 0.$$

If interest focuses on confidence intervals, so that the objective is to "approximate" $\Pr(\underline{u} \leq Y_t \leq \overline{u})$, then the null and alternative hypotheses can be stated as:

$$H_0' : \max_{j=2,...,m} E\left(\left(\left(F_1(\overline{u};\Theta_1^\dagger) - F_1(\underline{u};\Theta_1^\dagger)\right) - (F_0(\overline{u};\Theta_0) - F_0(\underline{u};\Theta_0))\right)^2\right.$$
$$\left. - \left(\left(F_j(\overline{u};\Theta_k^\dagger) - F_j(\underline{u};\Theta_k^\dagger)\right) - (F_0(\overline{u};\Theta_0) - F_0(\underline{u};\Theta_0))\right)^2\right) \leq 0.$$

versus

$$H_A' : \max_{j=2,...,m} E\left(\left(\left(F_1(\overline{u};\Theta_1^\dagger) - F_1(\underline{u};\Theta_1^\dagger)\right) - (F_0(\overline{u};\Theta_0) - F_0(\underline{u};\Theta_0))\right)^2\right.$$
$$\left. - \left(\left(F_j(\overline{u};\Theta_k^\dagger) - F_j(\underline{u};\Theta_k^\dagger)\right) - (F_0(\overline{u};\Theta_0) - F_0(\underline{u};\Theta_0))\right)^2\right) > 0.$$

The relevant statistic for testing H_0 is $\sqrt{T}Z_{T,S}$, as discussed below.[16] The following assumptions are used in our first proposition.

Assumption A1: Y_t is stationary-ergodic $\beta-$mixing processes with size -4, for $j = 1, ..., m$. [17]

Assumption A2: For $j = 1, ..., m : \sqrt{T}\left(\widehat{\Theta}_{j,T} - \Theta_j^\dagger\right) = A_j(\Theta_j^\dagger)\frac{1}{\sqrt{T}}\sum_{t=2}^T q_j(Y_t, \Theta_j^\dagger) + o_P(1)$, where $\frac{1}{\sqrt{T}}\sum_{t=2}^T q_j(Y_t, \Theta_j^\dagger)$ satisfies a central limit theorem and $A_j(\Theta_j^\dagger)$ is positive definite.[18]

Assumption A3: For $j = 1, ..., m$: (i) $\forall\Theta_j \in \Xi_j$, with Ξ_j a compact set in $\Re^{p_j}$ and $Y_{j,n}(\Theta_j)$ is a strictly stationary ergodic $\beta-$mixing process with size -4, where p_j is the number of estimated parameters in model j; (ii) $Y_{j,n}(\Theta_j)$ is continuously differentiable in the interior of Ξ_j, for $n = 1, ..., S$; (iii) $\nabla_{\Theta_j} Y_{j,n}(\Theta_j)$ is $2r-$dominated in Ξ_j, uniformly in n for $r > 2$;[19] (iv) $F_j(u;\Theta_j^\dagger)$ is twice continuously differentiable in u;

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[16] H_0' versus H_A' can be tested in a similar manner (see e.g. Corradi and Swanson (2005a)).

[17] $\beta-$mixing is a memory requirement stronger than $\alpha-$mixing, but weaker than (uniform) $\phi-$mixing.

[18] Given the size condition in A1, A2 is satisfied by the LS, NLS, QMLE estimator, under mild conditions, such as finite $(4 + \delta)$th moments and unique identifiability.

[19] This means that $|\nabla_{\theta_j} Y_{j,n}(\theta_j)| \leq D_{j,n}$, with $\sup_n E(D_{j,n}^{2r}) < \infty$ (see e.g. Gallant and White (1988), p.33).

and (v) for at least one j, $F_j(u;\Theta_j^\dagger) \neq F_1(u;\Theta_1^\dagger)$ for $u \in \widetilde{U}$, where $\widetilde{U}$ is a subset of U of non-zero Lebesgue measure.

A2 requires that $\sqrt{T}\left(\widehat{\Theta}_{j,T} - \Theta_j^\dagger\right)$ is asymptotically normal with a positive definite covariance matrix. Thus, given the size condition in **A1**, **A2** is satisfied by OLS, NLS, and QMLE, under mild conditions, such as finite $(4+\delta)$th moments and unique identifiability. It is satisfied for the GMM-type estimator of Christiano and Eichenbaum (1992) and the estimator of Bierens (2005). With regard to **A3**(i), whenever the production function is a Cobb-Douglas type, and the shock to technology follows a unit root process in logs, then output follows a unit root process in logs, and the growth rate is stationary. This is not necessarily true in the case of more general CES production functions.[20] **A3**(ii) need only hold for estimated parameters. When solving RBC models, we often obtain a (linear) ARMA representations for the variables of interest, in terms of final (or reduced form) parameters. Therefore, because of linearity, **A3**(ii) holds straightforwardly for the final parameters. Hence, if the structural (deep) parameters are smooth functions of the final parameters, as is often the case **A3**(ii) is satisfied. **A3**(iii) is a standard assumption (see e.g. Duffie and Singleton (1993)), and **A3**(iv) is always satisfied for linearized solutions of RBC models. Finally, **A3**(v) ensures that at least one competing model is nonnested with the benchmark model. This in turn ensures that the covariance matrix of the statistic is positive semi-definite. Hereafter, for notational simplicity, let $F_j(u) = F_j(u;\Theta_j^\dagger)$.
Proposition 1 (CS (2005b)): Let Assumptions A1-A3 hold. (i) Assume that as $T,S \to \infty : T/S \to \delta$, $0 < \delta < \infty$, then:

$$\max_{j=2,\ldots,m} \sqrt{T}\int_U \left(Z_{j,T,S}(u) - \left((F_0(u)-F_1(u))^2 - (F_0(u)-F_j(u))^2\right)\right)\phi(u)du \tag{A4}$$
$$\xrightarrow{d} \max_{j=2,\ldots,m}\int_U Z_j(u)\phi(u)du,$$

where $Z_j(u)$ is a zero mean Gaussian process with covariance kernel, $K_j(u,u')$, and where

$$Z_{T,S} = \max_{j=2,\ldots,m}\int_U Z_{j,T,S}(u)\phi(u)du, \tag{A5}$$

and

$$\begin{aligned} Z_{j,T,S}(u) &= \frac{1}{T}\sum_{t=1}^{T}\left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S}1\{Y_{1,n}(\widehat{\Theta}_{1,T}) \leq u\}\right)^2 \\ &\quad -\frac{1}{T}\sum_{t=1}^{T}\left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S}1\{Y_{j,n}(\widehat{\Theta}_{j,T}) \leq u\}\right)^2, \end{aligned}$$

with $\widehat{\Theta}_{j,T}$ an estimator of $\Theta_j^\dagger$ that satisfies Assumption 2 above (see also CS (2005b)).
(ii) Assume that as $T,S \to \infty : S/T^2 \to 0$ and $T/S \to 0$, then:

$$\max_{j=2,\ldots,m} \sqrt{T}\int_U \left(Z_{j,T,S}(u) - \left((F_0(u)-F_1(u))^2 - (F_0(u)-F_j(u))^2\right)\right)\phi(u)du$$
$$\xrightarrow{d} \max_{j=2,\ldots,m}\int_U \widetilde{Z}_j(u)\phi(u)du,$$

where $\widetilde{Z}_j(u)$ is a zero mean Gaussian process with covariance kernel, $\widetilde{K}_j(u,u')$, as given in CS (2005b).

Notice that when $T/S \to 0$, then $\frac{1}{\sqrt{S}}\sum_{n=1}^{S}\left(1\{Y_{j,n}(\Theta_1^\dagger) \leq u\} - F_j(u)\right) \xrightarrow{pr} 0$, uniformly in u, and so the covariance kernel of the limiting distribution does not reflect the contribution of the error term due to the

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[20] It remains to establish whether or not **A3**(i) can be relaxed to weak stationarity. Given this fact, and given that strict stationarity is not generally ensured, results of the test should be viewed with caution.

fact we replace the “true” distribution of the simulated series with its empirical counterpart; in other words, in this case, the simulation error vanishes. Also, notice that we require S to grow at a rate slower than T^2; such a condition is used in order to show the stochastic equicontinuity of the statistic.

From Proposition 1, we see that when all competing models provide an approximation to the true joint distribution that is as accurate (in terms of square error) as that provided by the benchmark, then the limiting distribution is a zero mean Gaussian process with a covariance kernel that reflects the contribution of parameter estimation error, the time series structure of the data and, for $\delta > 0$, the contribution of simulation error. This is the case where

$$\int_U \left((F_0(u) - F_1(u))^2 - (F_0(u) - F_j(u))^2 \right) \phi(u) du = 0, \text{ for all } j.$$

It follows that in this case, the limiting distribution of

$$\max_{j=2,\dots,m} \sqrt{T} \int_U \left(Z_{j,T,S}(u) - \left((F_0(u) - F_1(u))^2 - (F_0(u) - F_j(u))^2 \right) \right) \phi(u) du$$

is the same as that of $\sqrt{T} Z_{T,S}$, and so the critical values of the limiting distribution on the RHS of equation (A4) provide valid asymptotic critical values for $\sqrt{T} Z_{T,S}$. On the other hand, when $\int_U \left((F_0(u) - F_1(u))^2 - (F_0(u) - F_j(u))^2 \right) \phi(u) du < 0$ for some j, so that at least one alternative model is less accurate than the benchmark, then these critical values provide upper bounds for critical values for $\sqrt{T} Z_{T,S}$. Also, when all competing models are less accurate than the benchmark model, then the statistic diverges to minus infinity.

Finally, under the alternative, $\int_U \left((F_0(u) - F_1(u))^2 - (F_0(u) - F_j(u))^2 \right) \phi(u) du > 0$ for some j, so that $\sqrt{T} Z_{T,S}$ diverges to infinity. Therefore, the test has correct asymptotic size if all models are equally good, is conservative when some model is strictly dominated by the benchmark, and has unit power under the alternative. Note that the above testing procedure can in principle be modified to allow for the evaluation of predictive densities under rolling and/or recursive estimation strategies (see e.g. Corradi and Swanson (2005c,2006)).

Bootstrap critical values for the above test can be obtained in straightforward manner, as outlined in CS. Namely, one can rely on an empirical process version of the block bootstrap that properly captures the contribution of parameter estimation error, simulation error, when present, and the time series structure of the data to the covariance kernel given in Proposition 1.

Begin by resampling b blocks of length l, $bl = T-1$, from the actual sample. Let $Y_t^* = (\log \Delta X_t^*, \log \Delta X_{t-1}^*)$ be the resampled series, such that $Y_2^*, ..., Y_{l+1}^*, Y_{l+2}^*, ..., Y_{T-l+2}^*, ..., Y_T^*$ is equal to $Y_{I_1+1}, ..., Y_{I_1+l}, Y_{I_2+1}, ..., Y_{I_b+1}, ..., Y_{I_b+l}$, where I_i, $i = 1, ..., b$ are independent, discrete uniform on $1, ..., T - l + 1$, that is $I_i = i$, $i = 1, ..., T - l$ with probability $1/(T-l)$. We use the resampled series Y_t^* to compute the bootstrap estimator $\widehat{\Theta}_{j,T}^*$ for $j = 1, ..., m$.

We now use $\widehat{\Theta}_{j,T}^*$ to simulate samples under model j, $j = 1, ..., m$; let $Y_{j,n}(\widehat{\Theta}_{j,T}^*)$, $n = 2, ..., S$ be the series simulated under model j. At this point, we need to distinguish between the case of $\delta = 0$, vanishing simulation error and $\delta > 0$, nonvanishing simulation error. In the former case, we do not need to resample the simulated series, as there is no need of mimicking the contribution of simulation error to the covariance kernel. On the other hand, in the latter case, we do need to resample the simulated series. More precisely, we draw $\widetilde{b}$ blocks of length $\widetilde{l}$, with $\widetilde{b}\widetilde{l} = S-1$, let $Y_{j,n}^*(\widehat{\Theta}_{j,T}^*)$, $j = 1, ..., m$, $n = 2, ..., S$ denote the resample series under model j. Notice that $Y_{j,2}^*(\widehat{\Theta}_{j,T}^*), ..., Y_{j,l+1}^*(\widehat{\Theta}_{j,T}^*), ..., Y_{j,S}^*(\widehat{\Theta}_{j,T}^*)$ is equal to $Y_{j,\widetilde{I}_1}(\widehat{\Theta}_{j,T}^*), ..., Y_{j,\widetilde{I}_1+l}(\widehat{\Theta}_{j,T}^*), ..., Y_{j,\widetilde{I}_{\widetilde{b}}+l}(\widehat{\Theta}_{j,T}^*)$, where $\widetilde{I}_i$, $i = 1, ..., \widetilde{b}$ are independent discrete uniform on $1, ..., S - \widetilde{l}$. Notice that, for each of the m models, and for each bootstrap replication, we draw $\widetilde{b}$ discrete uniform $\widetilde{I}_i$ on $1, ..., S - \widetilde{l}$, draws are independent across models, we have just suppressed the dependence of $\widetilde{I}_i$ on j, for notational simplicity.

We consider two different bootstrap analogs of $Z_{T,S}$, the first of which is valid when $T/S \to \delta > 0$ and the second of which is valid when $T/S \to 0$. Notice that in the second version, simulation error vanishes so that $Y_{j,n}^*(\widehat{\Theta}_{j,T}^*)$ in the first statistic is replaced with $Y_{j,n}(\widehat{\theta}_{j,T}^*)$, $j = 1, ..., m$. Define:

$$Z^{**}_{T,S} = \max_{j=2,\dots,m} \int_U Z^{**}_{j,T,S}(u)\phi(u)du,$$

where

$$\begin{aligned}
Z^{**}_{j,T,S}(u) \quad = \quad & \frac{1}{T}\sum_{t=1}^{T}\left(\left(1\{Y_t^* \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y^*_{1,n}(\widehat{\Theta}^*_{1,T}) \leq u\}\right)^2\right. \\
& \left. - \left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{1,n}(\widehat{\Theta}_{1,T}) \leq u\}\right)^2\right) \\
& - \frac{1}{T}\sum_{t=1}^{T}\left(\left(1\{Y_t^* \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y^*_{j,n}(\widehat{\Theta}^*_{j,T}) \leq u\}\right)^2\right. \\
& \left. - \left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{j,n}(\widehat{\Theta}_{j,T}) \leq u\}\right)^2\right)
\end{aligned}$$

and

$$Z^{*}_{T,S} = \max_{j=2,\dots,m} \int_U Z^{*}_{j,T,S}(u)\phi(u)du,$$

where

$$\begin{aligned}
Z^{*}_{j,T,S}(u) \quad = \quad & \frac{1}{T}\sum_{t=1}^{T}\left(\left(1\{Y_t^* \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{1,n}(\widehat{\Theta}^*_{1,T}) \leq u\}\right)^2\right. \\
& \left. - \left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{1,n}(\widehat{\Theta}_{1,T}) \leq u\}\right)^2\right) \\
& - \frac{1}{T}\sum_{t=1}^{T}\left(\left(1\{Y_t^* \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{j,n}(\widehat{\Theta}^*_{j,T}) \leq u\}\right)^2\right. \\
& \left. - \left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{j,n}(\widehat{\Theta}_{j,T}) \leq u\}\right)^2\right).
\end{aligned}$$

CS (2005b) prove the first order validity of critical values constructed using the above bootstrap statistics; and they suggest proceeding in the following manner. For any bootstrap replication, compute the bootstrap statistic, $\sqrt{T}Z^{**}_{T,S}$ $\left(\sqrt{T}Z^{*}_{T,S}\right)$. Perform B bootstrap replications (B large) and compute the quantiles of the empirical distribution of the B bootstrap statistics. Reject H_0 if $\sqrt{T}Z_{T,S}$ is greater than the $(1-\alpha)th$-quantile. Otherwise, do not reject. Now, for all samples except a set with probability measure approaching zero, $\sqrt{T}Z_{T,S}$ has the same limiting distribution as the corresponding bootstrapped statistic, when $\int_U \left((F_0(u) - F_1(u))^2 - (F_0(u) - F_j(u))^2\right)\phi(u)du = 0$ for all $j = 2, ..., m$. In this case, the above approach ensures that the test has asymptotic size equal to α. On the other hand, when one (or more) competing models is (are) strictly dominated by the benchmark, the approach ensures that the test has an asymptotic size between 0 and α. Finally, under the alternative, $Z_{T,S}$ diverges to (plus) infinity, while the corresponding bootstrap statistic has a well defined limiting distribution. This ensures unit asymptotic power.

Table 1: Summary Statistics - Historical Inflation

	AUS	CAN	FIN	FRA	UK	IRL	ITA	JPN	HOL	NOR	NZL	SWE	USA
A. Mean													
60-70	3.12	3.69	5.83	4.24	3.87	5.02	4.22	5.71	5.07	3.95	7.43	4.22	2.52
70-80	10.43	8.20	11.03	9.42	13.31	13.32	13.97	7.85	7.56	8.26	14.52	9.40	6.68
80-90	7.95	5.62	7.21	6.76	7.07	8.13	11.32	2.45	2.22	7.13	10.61	8.22	4.50
90-05	2.28	1.96	2.07	1.66	3.04	3.39	3.68	-0.24	2.40	3.39	1.90	2.33	2.15
60-05	5.51	4.54	5.99	5.11	6.38	6.98	7.76	3.43	4.08	5.42	7.82	5.60	3.75
83-05	3.68	2.54	3.36	2.69	3.79	3.91	5.14	0.44	1.92	3.83	4.30	3.87	2.46
B. Standard Deviation													
60-70	3.42	2.81	3.01	3.45	3.58	3.29	3.01	4.11	2.52	3.12	37.35	10.27	1.59
70-80	5.89	3.76	5.68	2.92	7.95	5.32	7.83	6.08	2.29	7.38	21.27	10.76	2.24
80-90	3.09	3.38	3.82	3.67	4.57	5.42	5.99	2.43	3.65	7.74	7.24	5.08	2.50
90-05	2.05	2.41	3.04	0.96	2.44	3.87	2.40	1.84	1.87	8.41	3.31	4.88	0.92
60-05	5.00	3.87	5.15	4.11	6.24	5.86	6.69	4.93	3.34	7.42	20.10	8.36	2.55
83-05	3.04	2.39	3.74	2.22	2.87	3.65	3.55	2.11	2.35	8.08	6.23	5.13	1.01
C. Kurtosis													
60-70	0.06	6.82	3.20	2.83	2.33	0.21	0.15	0.19	0.93	2.68	11.31	-0.37	-0.88
70-80	0.22	-0.35	1.55	-0.49	1.14	0.74	0.21	2.21	0.64	3.57	1.10	-0.61	0.36
80-90	0.57	0.01	2.40	-1.10	1.22	-0.99	0.08	1.53	-0.38	1.86	0.32	3.54	0.85
90-05	1.49	1.45	2.55	2.81	1.95	2.60	0.97	0.91	3.22	0.54	0.33	3.50	1.44
60-05	2.01	1.08	2.46	-0.60	4.05	-0.01	1.87	4.02	-0.50	1.94	26.27	0.57	0.90
83-05	-0.46	1.45	-0.04	3.21	0.32	1.77	1.34	-0.16	1.58	0.77	1.65	0.86	0.02
D. Skewness													
60-70	-0.24	-1.83	1.64	1.63	0.42	0.76	0.63	-0.65	-0.53	0.40	2.53	0.05	0.67
70-80	0.74	0.39	1.18	0.12	0.65	-0.14	0.53	1.52	-1.08	0.95	-0.22	-0.07	0.52
80-90	-0.23	0.85	0.05	0.47	0.94	0.44	0.83	0.91	0.15	-0.62	-0.25	1.33	1.31
90-05	0.58	-0.49	1.09	1.30	1.06	0.96	0.90	0.85	0.91	0.12	0.05	1.08	1.11
60-05	1.12	0.52	1.12	0.78	1.69	0.72	1.40	1.56	-0.01	0.15	3.07	0.40	1.18
83-05	0.46	-0.49	0.54	1.78	0.68	0.62	1.11	0.56	-0.17	-0.12	1.11	0.49	0.67
E. First Order Autocorrelation													
60-70	-0.03	0.13	0.84	-0.02	-0.36	0.83	0.46	-0.09	0.83	0.23	-0.20	-0.50	0.83
70-80	0.27	0.64	0.73	0.52	0.44	0.84	0.41	0.75	0.81	-0.18	-0.17	-0.36	0.65
80-90	0.33	0.71	0.11	0.85	0.49	0.96	0.68	0.26	0.29	0.25	0.19	-0.13	0.89
90-05	0.26	0.33	0.18	0.38	0.20	-0.11	0.56	0.31	0.01	0.05	-0.05	-0.08	0.46
60-05	0.59	0.70	0.72	0.80	0.61	0.79	0.74	0.69	0.67	0.12	-0.11	-0.17	0.88
83-05	0.58	0.36	0.36	0.81	0.19	0.12	0.69	0.38	0.04	0.06	0.39	0.11	0.52

Notes: Historical inflation is measured by the GDP deflator. Mean, standard deviation, kurtosis, skewness and autocorrelation summary statistics are given for the 13 countries in our dataset. All samples used end in 2005.4, are based upon quarterly data. Sample start dates vary as follows: Canada - 1961.1, France - 1963.1, New Zealand - 1961.1, and all other countries 1960.1. Country mnemonics used are: AUS - Australia, CAN - Canada, FIN - Finland, FRA - France, IRL - Ireland, ITA - Italy, JPN - Japan, HOL - Holland, NOR - Norway, NZL -New Zealand, and SWE - Sweden.

Table 2: Parameter Estimates - Sticky Price Model

A. Full Sample Estimation Period

	Measure of Inflationary Pressure								
	Output Gap			*Labor Share*			*Unemployment*		
	λ_1	σ_v	LL	λ_1	σ_v	LL	λ_1	σ_v	LL
Australia	-0.0211	0.0117	2616	0.0027	0.0111	2436	0.0036	0.0120	2632
	(0.0065)	(0.0007)		(0.0000)	(0.0006)		(0.0016)	(0.0007)	
Canada	-0.0052	0.0090	3053	0.0020	0.0085	3136	-0.0018	0.0091	3288
	(0.0000)	(0.0005)		(0.0000)	(0.0005)		(0.0008)	(0.0005)	
Finland	-0.0055	0.0105	2263	0.0015	0.9060	1833	0.0067	0.0123	2505
	(0.0019)	(0.0007)		(0.0000)	(0.0000)		(0.0014)	(0.0007)	
France	-0.0253	0.0090	2767	0.0022	0.0205	2566	0.0056	0.0086	2777
	(0.0048)	(0.0005)		(0.0000)	(0.0000)		(0.0010)	(0.0005)	
UK	-0.0177	0.0139	2635	0.0034	0.0136	2401	0.0015	0.0151	2589
	(0.0000)	(0.0000)		(0.0000)	(0.0000)		(0.0015)	(0.0008)	
Ireland	0.0017	0.0125	1870	0.0000	0.0136	1924	0.0005	0.0141	2035
	(0.0030)	(0.0008)		(0.0000)	(0.0009)		(0.0002)	(0.0009)	
Italy	-0.0309	0.0136	2577	0.0025	0.0126	2332	0.0101	0.0155	2467
	(0.0000)	(0.0008)		(0.0000)	(0.0000)		(0.0023)	(0.0009)	
Japan	0.0016	0.0072	2456	-0.0061	0.0111	2487	0.0092	0.0089	2842
	(0.0033)	(0.0005)		(0.0017)	(0.0007)		(0.0006)	(0.0005)	
Netherlands	-0.0003	0.0083	2543	0.0016	0.0076	2475	0.0029	0.0072	3385
	(0.0030)	(0.0005)		(0.0000)	(0.0004)		(0.0006)	(0.0004)	
Norway	-0.0039	0.0199	1744	-0.0316	0.2441	1428	0.0151	0.0198	1852
	(0.0050)	(0.0014)		(0.0000)	(0.0000)		(0.0130)	(0.0014)	
New Zealand	-0.0210	0.0154	1639	0.0034	0.0111	1250	0.0107	0.0236	2029
	(0.0097)	(0.0011)		(0.0000)	(0.0009)		(0.0040)	(0.0015)	
Sweden	-0.0118	0.0114	1827	-0.0102	0.0120	1585	-0.0028	0.0122	1701
	(0.0034)	(0.0009)		(0.0050)	(0.0009)		(0.0033)	(0.0009)	
US	-0.0066	0.0054	3218	0.0054	0.0052	3322	-0.0038	0.0055	3513
	(0.0000)	(0.0000)		(0.0000)	(0.0003)		(0.0000)	(0.0000)	
				B. 1983-2005 Estimation Period					
Australia	-0.0149	0.0062	1821	0.0069	0.0067	1603	-0.0058	0.0070	1717
	(0.0024)	(0.0005)		(0.0004)	(0.0005)		(0.0021)	(0.0005)	
Canada	-0.0002	0.0059	1802	0.0007	0.0058	1699	-0.0019	0.0058	1768
	(0.0027)	(0.0004)		(0.0003)	(0.0004)		(0.0016)	(0.0005)	
Finland	-0.0040	0.0086	1725	0.0010	0.0082	1547	-0.0013	0.0089	1620
	(0.0014)	(0.0006)		(0.0000)	(0.0000)		(0.0015)	(0.0007)	
France	-0.0148	0.0033	1997	0.0081	0.0029	1813	-0.0090	0.0041	1877
	(0.0017)	(0.0002)		(0.0008)	(0.0002)		(0.0021)	(0.0003)	
UK	-0.0013	0.0068	1810	0.0032	0.0067	1672	-0.0020	0.0064	1775
	(0.0036)	(0.0005)		(0.0000)	(0.0000)		(0.0000)	(0.0000)	
Ireland	0.0000	0.0086	1568	0.0000	0.0086	1447	0.0007	0.0092	1554
	(0.0020)	(0.0006)		(0.0001)	(0.0006)		(0.0001)	(0.0007)	
Italy	-0.0178	0.0058	1895	0.0037	0.0058	1647	-0.0098	0.0067	1730
	(0.0022)	(0.0004)		(0.0004)	(0.0004)		(0.0022)	(0.0005)	
Japan	0.0047	0.0048	1880	-0.0104	0.0040	1745	0.0048	0.0066	1883
	(0.0003)	(0.0004)		(0.0021)	(0.0003)		(0.0000)	(0.0000)	
Netherlands	0.0014	0.0057	1842	-0.0010	0.0058	1706	0.0036	0.0054	1811
	(0.0013)	(0.0004)		(0.0014)	(0.0005)		(0.0009)	(0.0004)	
Norway	0.0003	0.0197	1489	-0.0004	0.0198	1402	0.0080	0.0197	1581
	(0.0046)	(0.0015)		(0.0014)	(0.0015)		(0.0123)	(0.0015)	
New Zealand	-0.0119	0.0142	1458	0.0034	0.0111	1250	-0.0056	0.0141	1511
	(0.0073)	(0.0010)		(0.0000)	(0.0009)		(0.0034)	(0.0010)	
Sweden	-0.0117	0.0115	1767	-0.0128	0.0117	1527	-0.0042	0.0121	1637
	(0.0037)	(0.0009)		(0.0054)	(0.0008)		(0.0036)	(0.0009)	
US	0.0049	0.0024	1921	0.0097	0.0021	1803	-0.0080	0.0023	1930
	(0.0000)	(0.0002)		(0.0000)	(0.0002)		(0.0020)	(0.0002)	

Notes: Parameters are estimated by maximum likelihood (for details see Appendix A). Standard errors for parameter estimates are given in parentheses. Standard errors are taken from the inverted Hessian of a log-likelihood function. λ_1 is the coefficient that multiplies the measure of inflationary pressure in the sticky price model, σ_v is the standard deviation of the structural error term, and LL denotes the maximum value of the log-likelihood function over the parameter range.

Table 3: Parameter Estimates - Sticky Price with Indexation Model

A. Full Sample Estimation Period

				Measure of Inflationary Pressure					
		Output Gap			*Labor Share*			*Unemployment*	
	λ_2	σ_v	LL	λ_2	σ_v	LL	λ_2	σ_v	LL
Australia	-0.0153	0.0054	2634	-0.0045	0.0056	2447	0.0030	0.0053	2649
	(0.0086)	(0.0004)		(0.0025)	(0.0004)		(0.0019)	(0.0003)	
Canada	0.0047	0.0034	3102	-0.0017	0.0038	3163	0.0026	0.0038	3328
	(0.0025)	(0.0002)		(0.0011)	(0.0002)		(0.0016)	(0.0002)	
Finland	-0.0052	0.0056	2260	-0.0022	0.0053	2404	-0.0020	0.0052	2533
	(0.0031)	(0.0004)		(0.0014)	(0.0003)		(0.0016)	(0.0003)	
France	0.0018	0.0022	2862	-0.0011	0.0024	2721	0.0013	0.0024	2861
	(0.0016)	(0.0001)		(0.0008)	(0.0001)		(0.0008)	(0.0001)	
UK	0.0094	0.0065	2653	-0.0055	0.0066	2422	0.0043	0.0064	2619
	(0.0055)	(0.0004)		(0.0032)	(0.0004)		(0.0026)	(0.0004)	
Ireland	0.0114	0.0056	1891	-0.0004	0.0051	1963	0.0020	0.0052	2077
	(0.0062)	(0.0004)		(0.0003)	(0.0004)		(0.0014)	(0.0003)	
Italy	0.0049	0.0058	2600	-0.0008	0.0059	2343	0.0015	0.0057	2505
	(0.0039)	(0.0004)		(0.0007)	(0.0004)		(0.0013)	(0.0003)	
Japan	-0.0033	0.0030	2480	-0.0044	0.0039	2549	-0.0008	0.0037	2867
	(0.0027)	(0.0002)		(0.0020)	(0.0002)		(0.0008)	(0.0002)	
Netherlands	-0.0049	0.0038	2557	-0.0024	0.0038	2488	0.0020	0.0034	3401
	(0.0036)	(0.0002)		(0.0015)	(0.0002)		(0.0011)	(0.0002)	
Norway	0.0138	0.0135	1716	-0.0007	0.0130	1611	-0.0245	0.0134	1823
	(0.0086)	(0.0009)		(0.0007)	(0.0008)		(0.0178)	(0.0009)	
New Zealand	-0.0235	0.0087	1631	-0.0103	0.0079	1229	-0.0128	0.0153	1999
	(0.0138)	(0.0007)		(0.0060)	(0.0006)		(0.0085)	(0.0010)	
Sweden	-0.0166	0.0086	1796	-0.0445	0.0092	1562	-0.0180	0.0086	1676
	(0.0101)	(0.0007)		(0.0195)	(0.0007)		(0.0100)	(0.0006)	
US	0.0026	0.0016	3316	-0.0010	0.0015	3422	0.0028	0.0015	3630
	(0.0015)	(0.0001)		(0.0008)	(0.0001)		(0.0014)	(0.0001)	

B. 1983-2005 Estimation Period

Australia	0.0016	0.0034	1811	-0.0027	0.0034	1600	-0.0104	0.0036	1720
	(0.0017)	(0.0002)		(0.0025)	(0.0003)		(0.0063)	(0.0003)	
Canada	-0.0116	0.0035	1791	-0.0012	0.0034	1686	0.0008	0.0033	1752
	(0.0065)	(0.0003)		(0.0010)	(0.0003)		(0.0009)	(0.0002)	
Finland	-0.0063	0.0054	1711	-0.0022	0.0053	1530	-0.0063	0.0054	1609
	(0.0035)	(0.0004)		(0.0015)	(0.0004)		(0.0037)	(0.0004)	
France	-0.0038	0.0017	1998	0.0016	0.0016	1801	-0.0012	0.0016	1897
	(0.0026)	(0.0001)		(0.0013)	(0.0001)		(0.0013)	(0.0001)	
UK	0.0064	0.0044	1788	-0.0150	0.0047	1653	0.0023	0.0044	1747
	(0.0048)	(0.0004)		(0.0087)	(0.0004)		(0.0019)	(0.0003)	
Ireland	0.0146	0.0062	1544	-0.0011	0.0060	1421	0.0018	0.0060	1535
	(0.0085)	(0.0005)		(0.0008)	(0.0005)		(0.0014)	(0.0005)	
Italy	-0.0064	0.0034	1883	-0.0010	0.0033	1638	-0.0103	0.0034	1733
	(0.0053)	(0.0002)		(0.0008)	(0.0002)		(0.0064)	(0.0002)	
Japan	-0.0041	0.0030	1861	-0.0203	0.0032	1715	-0.0056	0.0030	1867
	(0.0032)	(0.0002)		(0.0103)	(0.0003)		(0.0041)	(0.0002)	
Netherlands	-0.0147	0.0043	1815	-0.0036	0.0041	1675	-0.0053	0.0041	1776
	(0.0079)	(0.0003)		(0.0030)	(0.0003)		(0.0037)	(0.0003)	
Norway	0.0089	0.0138	1460	-0.0004	0.0134	1370	-0.0435	0.0141	1554
	(0.0079)	(0.0010)		(0.0004)	(0.0010)		(0.0288)	(0.0011)	
New Zealand	0.0057	0.0077	1449	-0.0103	0.0079	1229	0.0012	0.0076	1498
	(0.0058)	(0.0006)		(0.0060)	(0.0006)		(0.0011)	(0.0006)	
Sweden	-0.0205	0.0088	1736	-0.0551	0.0094	1502	-0.0216	0.0088	1612
	(0.0122)	(0.0007)		(0.0211)	(0.0008)		(0.0118)	(0.0007)	
US	-0.0075	0.0013	1922	-0.0014	0.0012	1790	0.0019	0.0012	1922
	(0.0045)	(0.0001)		(0.0014)	(0.0001)		(0.0021)	(0.0001)	

Notes: See notes to Table 2. λ_2 is the coefficient that multiplies the measure of inflationary pressure in the sticky price with indexation model.

Table 4: Parameter Estimates - Sticky Information Model

A. Full Sample Estimation Period

						Measure of Inflationary Pressure						
		Output Gap				*Labor Share*				*Unemployment*		
	θ_3	ξ	σ_v	LL	θ_3	ξ	σ_v	LL	θ_3	ξ	σ_v	LL
Australia	0.5310	-0.0007	0.0121	2611	0.5520	0.0062	0.0099	2454	0.4845	0.0030	0.0109	2646
	(0.0381)	(0.0037)	(0.0007)		(0.0332)	(0.0022)	(0.0006)		(0.0399)	(0.0021)	(0.0006)	
Canada	0.4419	0.0002	0.0093	3050	0.7369	0.0518	0.0086	3135	0.4501	0.0004	0.0092	3288
	(0.0934)	(0.0007)	(0.0005)		(0.0493)	(0.0274)	(0.0004)		(0.1169)	(0.0010)	(0.0006)	
Finland	0.5246	0.0002	0.0108	2258	0.5727	0.0032	0.0126	2372	0.5720	0.0093	0.0107	2526
	(0.0768)	(0.0013)	(0.0007)		(0.0304)	(0.0009)	(0.0004)		(0.0184)	(0.0015)	(0.0006)	
France	0.5073	0.0008	0.0102	2751	0.8636	0.3876	0.0083	2635	0.4765	0.0031	0.0062	2820
	(0.0506)	(0.0009)	(0.0006)		(0.0193)	(0.0896)	(0.0004)		(0.0095)	(0.0007)	(0.0004)	
UK	0.8103	-0.0602	0.0152	2624	0.5438	0.0076	0.0120	2423	0.6148	0.0197	0.0140	2600
	(0.1051)	(0.0233)	(0.0009)		(0.0174)	(0.0014)	(0.0007)		(0.0318)	(0.0052)	(0.0007)	
Ireland	0.6278	0.0110	0.0123	1872	0.4591	0.0000	0.0137	1924	0.5211	0.0013	0.0138	2037
	(0.0655)	(0.0047)	(0.0008)		(0.0266)	(0.0000)	(0.0010)		(0.0306)	(0.0005)	(0.0009)	
Italy	0.6921	-0.1185	0.0154	2561	0.5232	0.0038	0.0102	2358	0.4834	0.0064	0.0110	2512
	(0.0228)	(0.0064)	(0.0011)		(0.0216)	(0.0012)	(0.0006)		(0.0215)	(0.0025)	(0.0005)	
Japan	0.5668	0.0022	0.0072	2457	0.5657	-0.0060	0.0108	2488	0.5572	0.0242	0.0093	2835
	(0.1604)	(0.0032)	(0.0005)		(0.0250)	(0.0010)	(0.0007)		(0.0090)	(0.0020)	(0.0005)	
Netherlands	0.4820	0.0013	0.0081	2545	0.6777	0.0205	0.0072	2484	0.4405	0.0010	0.0066	3399
	(0.0628)	(0.0018)	(0.0004)		(0.0331)	(0.0074)	(0.0004)		(0.0518)	(0.0011)	(0.0003)	
Norway	0.7372	0.0890	0.0196	1746	0.5022	0.0016	0.0197	1643	0.9747	0.2314	0.0198	1852
	(0.0376)	(0.0065)	(0.0013)		(0.0172)	(0.0013)	(0.0013)		(0.0520)	(0.0161)	(0.0016)	
New Zealand	0.9992	-0.0888	0.0159	1637	0.7560	-0.0012	0.0118	1246	0.5749	0.0213	0.0218	2038
	(0.0336)	(0.0000)	(0.0013)		(0.1615)	(0.0015)	(0.0010)		(0.0203)	(0.0040)	(0.0011)	
Sweden	0.9573	-0.0166	0.0122	1820	1.0000	0.0407	0.0121	1582	0.5228	0.0041	0.0114	1705
	(0.3772)	(0.0133)	(0.0009)		(1.3888)	(0.1085)	(0.0009)		(0.0729)	(0.0072)	(0.0006)	
US	0.6949	-0.0233	0.0059	3206	0.5390	0.0079	0.0049	3335	0.4376	-0.0006	0.0059	3504
	(0.0548)	(0.0079)	(0.0003)		(0.0110)	(0.0010)	(0.0003)		(0.0690)	(0.0005)	(0.0003)	
						B. 1983-2005 Estimation Period						
Australia	0.6230	-0.0173	0.0070	1811	0.4658	0.0034	0.0065	1604	0.8547	0.0018	0.0073	1713
	(0.0711)	(0.0097)	(0.0004)		(0.0334)	(0.0023)	(0.0005)		(8.3394)	(0.0585)	(0.0006)	
Canada	0.7758	0.0726	0.0058	1803	0.4989	0.0003	0.0059	1698	0.8637	0.0019	0.0059	1767
	(0.0861)	(0.0462)	(0.0004)		(0.1255)	(0.0008)	(0.0005)		(0.8984)	(0.0052)	(0.0006)	
Finland	0.5208	0.0001	0.0089	1722	0.5522	0.0016	0.0085	1545	0.6179	0.0035	0.0086	1621
	(0.0486)	(0.0005)	(0.0006)		(0.1025)	(0.0020)	(0.0007)		(0.1418)	(0.0042)	(0.0006)	
France	0.8569	-0.4025	0.0043	1974	0.5884	0.0108	0.0035	1793	0.4051	0.0003	0.0046	1867
	(0.0413)	(0.1593)	(0.0003)		(0.0309)	(0.0035)	(0.0003)		(0.2751)	(0.0027)	(0.0003)	
UK	0.4937	0.0021	0.0066	1814	0.5741	0.0018	0.0069	1671	0.5007	-0.0013	0.0068	1772
	(0.0589)	(0.0019)	(0.0006)		(0.2281)	(0.0036)	(0.0005)		(0.1279)	(0.0024)	(0.0006)	
Ireland	0.5242	0.0003	0.0086	1568	0.5500	-0.0001	0.0086	1447	0.5076	0.0012	0.0089	1557
	(0.4613)	(0.0049)	(0.0006)		(0.0335)	(0.0002)	(0.0007)		(0.0501)	(0.0009)	(0.0007)	
Italy	0.7998	-0.3991	0.0069	1878	0.5494	0.0033	0.0065	1639	0.5244	-0.0001	0.0079	1714
	(0.0415)	(0.1957)	(0.0005)		(0.1700)	(0.0063)	(0.0012)		(0.3735)	(0.0005)	(0.0006)	
Japan	0.8318	0.2409	0.0048	1878	0.7789	-0.2490	0.0044	1736	0.6516	0.0362	0.0042	1895
	(0.0672)	(0.1715)	(0.0003)		(0.0201)	(0.0171)	(0.0003)		(0.0691)	(0.0221)	(0.0003)	
Netherlands	0.5477	0.0054	0.0054	1846	0.5894	-0.0060	0.0057	1706	0.5599	0.0043	0.0054	1811
	(0.0688)	(0.0051)	(0.0005)		(0.0746)	(0.0043)	(0.0004)		(0.4238)	(0.0151)	(0.0006)	
Norway	0.9307	0.0944	0.0196	1489	0.9933	-0.0142	0.0197	1402	0.9909	0.2638	0.0198	1581
	(0.0321)	(0.0068)	(0.0017)		(0.0521)	(0.0046)	(0.0017)		(0.0612)	(0.0271)	(0.0014)	
New Zealand	0.8933	0.0568	0.0144	1457	0.7560	-0.0012	0.0118	1246	0.6635	0.0232	0.0141	1511
	(0.2058)	(0.0276)	(0.0010)		(0.1615)	(0.0015)	(0.0010)		(0.0821)	(0.0111)	(0.0010)	
Sweden	0.9460	-0.0185	0.0122	1760	0.9280	-0.0102	0.0120	1522	0.5655	0.0076	0.0115	1641
	(0.3372)	(0.0141)	(0.0009)		(0.5202)	(0.0103)	(0.0009)		(0.0662)	(0.0052)	(0.0009)	
US	0.6021	0.0187	0.0022	1927	0.5952	0.0126	0.0022	1798	0.8952	-0.5188	0.0024	1927
	(0.0503)	(0.0114)	(0.0002)		(0.0340)	(0.0047)	(0.0002)		(0.0382)	(0.4105)	(0.0002)	

Notes: See notes to Table 2. ξ is the coefficient that multiplies the measure of inflationary pressure in the sticky information model and θ_3 is the fraction of firms that make pricing decisions based on past information.

Table 5: Theoretical and Constant Inflation Model Residual Correlations

A. Full Sample Estimation Period

	Measure of Inflationary Pressure								
	Output Gap			*Labor Share*			*Unemployment*		
	SP	SPI	SI	SP	SPI	SI	SP	SPI	SI
Australia	0.97	0.46	1.00	1.00	0.57	0.84	0.98	0.42	0.90
Canada	0.98	0.42	1.00	0.98	0.48	0.93	0.99	0.44	0.99
Finland	0.97	0.48	1.00	0.98	0.49	0.97	0.96	0.47	0.83
France	0.89	0.26	1.00	0.99	0.37	0.89	0.83	0.20	0.63
UK	0.96	0.50	1.00	1.00	0.57	0.83	1.00	0.42	0.92
Ireland	1.00	0.48	0.99	1.00	0.42	1.00	0.99	0.37	0.98
Italy	0.88	0.41	0.95	0.93	0.45	0.66	0.95	0.34	0.69
Japan	1.00	0.44	1.00	0.94	0.37	0.93	0.78	0.35	0.81
Netherlands	1.00	0.47	0.98	0.99	0.55	0.88	0.88	0.37	0.83
Norway	1.00	0.66	0.98	0.48	0.66	0.99	0.99	0.68	1.00
New Zealand	0.98	0.55	1.00	0.99	0.72	1.00	0.98	0.67	0.91
Sweden	0.94	0.67	1.00	0.99	0.78	1.00	1.00	0.73	0.96
US	0.98	0.38	0.98	0.99	0.34	0.81	0.99	0.40	0.98
B. 1983-2005 Estimation Period									
Australia	0.86	0.49	0.96	0.98	0.51	0.89	0.96	0.51	1.00
Canada	1.00	0.64	0.99	0.99	0.60	0.99	0.99	0.58	1.00
Finland	0.97	0.61	1.00	0.95	0.65	0.96	1.00	0.65	0.99
France	0.76	0.19	0.92	0.60	0.15	0.79	0.91	0.22	0.98
UK	1.00	0.63	0.96	0.99	0.71	1.00	0.95	0.67	0.97
Ireland	1.00	0.71	1.00	1.00	0.69	1.00	0.94	0.68	0.94
Italy	0.73	0.27	0.87	0.74	0.44	0.82	0.89	0.36	1.00
Japan	0.98	0.62	0.95	0.82	0.52	0.87	0.95	0.67	0.87
Netherlands	1.00	0.76	0.95	1.00	0.69	0.99	0.94	0.75	0.94
Norway	1.00	0.68	1.00	1.00	0.67	1.00	1.00	0.71	1.00
New Zealand	0.99	0.54	1.00	0.99	0.72	1.00	0.99	0.53	0.99
Sweden	0.95	0.69	1.00	0.98	0.79	1.00	1.00	0.75	0.96
US	0.99	0.59	0.90	0.89	0.53	0.92	0.93	0.53	0.95

Notes: Correlations between the residuals series from the estimated versions of the three structural models (SP, SI, and SPI) and the constant inflation model are given for the 13 countries in the dataset.

Table 6: Residual Autocorrelations Based on the Three Theoretical Models

A. Full Sample Estimation Period

	Measure of Inflationary Pressure								
	Output Gap			*Labor Share*			*Unemployment*		
	SP	SPI	SI	SP	SPI	SI	SP	SPI	SI
Australia	0.61*	-0.40*	0.63*	0.55*	-0.42*	0.42*	0.58*	-0.45*	0.49*
Canada	0.71*	-0.33*	0.73*	0.62*	-0.32*	0.62*	0.67*	-0.33*	0.68*
Finland	0.44*	-0.47*	0.48*	0.66*	-0.43*	0.67*	0.64*	-0.43*	0.53*
France	0.86*	-0.31*	0.89*	0.86*	-0.33*	0.85*	0.83*	-0.34*	0.72*
UK	0.59*	-0.43*	0.65*	0.61*	-0.39*	0.45*	0.65*	-0.42*	0.59*
Ireland	0.63*	-0.54*	0.62*	0.71*	-0.53*	0.71*	0.72*	-0.53*	0.71*
Italy	0.64*	-0.34*	0.71*	0.56*	-0.31*	0.37*	0.70*	-0.34*	0.46*
Japan	0.65*	-0.50*	0.64*	0.75*	-0.36*	0.75*	0.63*	-0.38*	0.66*
Netherlands	0.59*	-0.38*	0.57*	0.56*	-0.36*	0.50*	0.57*	-0.34*	0.50*
Norway	0.13	-0.43*	0.11	0.84*	-0.44*	0.12	0.13	-0.42*	0.14
New Zealand	0.41*	-0.49*	0.45*	0.04	-0.54*	0.13	0.18*	-0.36*	0.04
Sweden	-0.0	-0.59*	0.11	0.08	-0.52*	0.11	0.11	-0.59*	0.01
US	0.84*	-0.30*	0.86*	0.83*	-0.29*	0.79*	0.85*	-0.29*	0.86*
B. 1983-2005 Estimation Period									
Australia	0.41*	-0.48*	0.53*	0.47*	-0.48*	0.47*	0.53*	-0.43*	0.57*
Canada	0.35*	-0.26*	0.34*	0.31*	-0.30*	0.33*	0.34*	-0.31*	0.35*
Finland	0.28*	-0.46*	0.33*	0.22*	-0.49*	0.27*	0.33*	-0.47*	0.30*
France	0.49*	-0.44*	0.67*	0.32*	-0.45*	0.52*	0.64*	-0.48*	0.70*
UK	0.20*	-0.58*	0.13	0.14	-0.53*	0.18	0.08	-0.57*	0.14
Ireland	0.08	-0.53*	0.08	0.08	-0.54*	0.08	0.19	-0.55*	0.15
Italy	0.33*	-0.36*	0.55*	0.35*	-0.37*	0.50*	0.52*	-0.36*	0.65*
Japan	0.24*	-0.62*	0.26*	-0.08	-0.59*	0.13	-0.01	-0.61*	0.05
Netherlands	0.01	-0.45*	-0.08	0.04	-0.49*	0.02	-0.08	-0.47*	-0.09
Norway	0.06	-0.45*	0.06	0.06	-0.46*	0.06	0.05	-0.42*	0.06
New Zealand	0.40*	-0.56*	0.42*	0.04	-0.54*	0.13	0.41*	-0.56*	0.40*
Sweden	-0.0	-0.59*	0.06	0.01	-0.52*	0.06	0.06	-0.58*	-0.03
US	0.47*	-0.40*	0.39*	0.33*	-0.45*	0.40*	0.43*	-0.45*	0.44*

Notes: First order autocorrelations of the residuals series from the estimated versions of the three structural models (SP, SI, and SPI) are given for the 13 countries in the dataset. Entries with superscript * denote autocorrelation estimates that are significantly different from zero at a 10% significance level.

Table 7: Inflation Autocorrelations Based on the Three Theoretical Models

A. Full Sample Estimation Period										
		Measure of Inflationary Pressure								
		Output Gap			*Labor Share*			*Unemployment*		
	h	SP	SPI	SI	SP	SPI	SI	SP	SPI	SI
Australia	0.60*	0.05	0.98*	0.00	0.01	0.89*	0.25*	0.02	0.97*	0.11
Canada	0.68*	0.03	0.94*	0.00	0.04	0.94*	0.15*	0.02	0.95*	0.00
Finland	0.69*	0.05	0.97*	0.00	0.01	0.92*	0.06	0.10	0.95*	0.32*
France	0.88*	0.20*	0.98*	0.00	0.01	0.94*	0.18*	0.12	0.97*	0.30*
UK	0.66*	0.09	0.93*	0.00	0.01	0.88*	0.23*	0.00	0.95*	0.11
Ireland	0.72*	0.00	0.88*	0.01	0.01	0.97*	0.01	0.09	0.95*	0.09
Italy	0.75*	0.24*	0.96*	0.05	0.18*	0.95*	0.67*	0.06	0.98*	0.38*
Japan	0.79*	0.00	0.97*	0.00	0.03	0.89*	0.06	0.45*	0.99*	0.41*
Netherlands	0.66*	0.00	0.97*	0.03	0.03	0.90*	0.24*	0.11	0.96*	0.17*
Norway	0.14	0.00	0.96*	0.04	0.04	0.99*	0.08	0.01	0.96*	0.00
New Zealand	0.23*	0.02	0.99*	0.00	0.02	0.87*	0.00	0.03	0.99*	0.13
Sweden	0.11	0.13	0.90*	0.00	0.02	0.76*	0.00	0.00	0.89*	0.15
US	0.87*	0.04	0.94*	0.02	0.04	0.95*	0.27*	0.02	0.93*	0.01
B. 1983-2005 Estimation Period										
Australia	0.57*	0.24*	0.97*	0.04	0.04	0.96*	0.15	0.06	0.95*	0.00
Canada	0.36*	0.00	0.93*	0.02	0.05	0.96*	0.01	0.01	0.98*	0.00
Finland	0.33*	0.04	0.93*	0.00	0.11	0.93*	0.06	0.00	0.90*	0.03
France	0.71*	0.37*	0.95*	0.12	0.57*	0.97*	0.29*	0.19	0.97*	0.05
UK	0.20	0.00	0.93*	0.04	0.01	0.86*	0.00	0.10	0.96*	0.04
Ireland	0.08	0.00	0.86*	0.00	0.00	0.94*	0.00	0.49*	0.96*	0.50*
Italy	0.62*	0.41*	0.97*	0.18	0.23*	0.96*	0.15	0.23*	0.93*	0.00
Japan	0.36*	0.04	0.94*	0.10	0.33*	0.87*	0.19	0.03	0.93*	0.16
Netherlands	0.04	0.01	0.87*	0.20	0.01	0.97*	0.04	0.04	0.93*	0.03
Norway	0.06	0.00	0.97*	0.00	0.00	0.99*	0.00	0.00	0.93*	0.00
New Zealand	0.42*	0.01	0.97*	0.00	0.02	0.87*	3.65	0.02	0.98*	0.04
Sweden	0.06	0.11	0.88*	0.00	0.04	0.74*	0.00	0.00	0.88*	0.19
US	0.52*	0.02	0.89*	0.18	0.20*	0.96*	0.12	0.03	0.97*	0.02

Notes: See notes to Table 6. First order inflation autocorrelations from the estimated versions of the three structural models (SP, SI, and SPI) are given for the 13 countries in the dataset. The column denote "H" contains historical autocorrelations that are calculated only for estimation sample periods described in Section 3 above (and hence the historical autocorrelations above differ from those in Table 1.

Table 8: Measures of Fit – Theoretical Models

A. Ratio of of Fitted to Historical Inflation Standard Deviations: Full Sample Estimation Period

	Measure of Inflationary Pressure								
	Output Gap			*Labor Share*			*Unemployment*		
	SP	SPI	SI	SP	SPI	SI	SP	SPI	SI
Australia	0.2388	0.9693	0.0226	0.1149	0.8694	0.5373	0.1882	1.0164	0.4409
Canada	0.1835	0.9459	0.0709	0.2061	0.9275	0.3614	0.1519	0.9590	0.1254
Finland	0.2558	1.0207	0.0255	0.2170	0.9067	0.2476	0.2942	0.9326	0.5581
France	0.4533	0.9818	0.0496	0.1702	0.9320	0.4674	0.5650	1.0135	0.7774
UK	0.2702	0.9162	0.0532	0.1001	0.8559	0.5616	0.0894	0.9871	0.3839
Ireland	0.0584	0.9333	0.1698	0.0431	0.9521	0.0354	0.1332	0.9841	0.1729
Italy	0.4676	0.9566	0.3222	0.4033	0.9267	0.7559	0.3260	1.0110	0.7245
Japan	0.0401	0.9755	0.0718	0.3380	0.9582	0.3636	0.6302	0.9715	0.5832
Netherlands	0.0074	0.9777	0.1839	0.1719	0.8791	0.4737	0.4703	1.0204	0.5527
Norway	0.0766	0.9761	0.2007	2.6972	0.9936	0.1488	0.1056	0.9517	0.0038
New Zealand	0.1942	0.9566	0.0001	0.1664	0.8598	0.0047	0.2141	0.9194	0.4145
Sweden	0.3361	0.9715	0.0016	0.1587	0.7905	0.0000	0.0628	0.8714	0.2939
US	0.2110	0.9314	0.2161	0.2019	0.9515	0.5835	0.1555	0.9208	0.2150

B. Ratio of Fitted to Historical Inflation Standard Deviations: 1983-2005 Estimation Period

Australia	0.5157	0.9722	0.2776	0.2336	0.9521	0.4487	0.2786	0.9419	0.0013
Canada	0.0070	0.8985	0.1691	0.1686	0.9541	0.1005	0.1334	0.9908	0.0015
Finland	0.2480	0.9445	0.0152	0.3172	0.9022	0.2710	0.0759	0.8971	0.1543
France	0.6553	1.1033	0.3991	0.7989	1.1273	0.6096	0.4254	1.0843	0.1751
UK	0.0374	0.9800	0.2775	0.1189	0.8743	0.0751	0.3216	0.9437	0.2357
Ireland	0.0007	0.9222	0.0350	0.0148	0.9801	0.0400	0.3682	0.9890	0.3512
Italy	0.6802	1.1093	0.4867	0.6719	0.9749	0.5724	0.4677	1.0353	0.0045
Japan	0.1987	0.9249	0.3176	0.5715	1.0183	0.4967	0.3490	0.8598	0.4976
Netherlands	0.0716	0.8741	0.3083	0.0874	0.9990	0.1555	0.3279	0.9081	0.3328
Norway	0.0062	0.9943	0.0116	0.0287	1.0195	0.0002	0.0665	0.9466	0.0013
New Zealand	0.1377	0.9967	0.0129	0.1664	0.8598	0.0047	0.1486	1.0099	0.1577
Sweden	0.3133	0.9588	0.0024	0.2080	0.8035	0.0015	0.0908	0.8682	0.2955
US	0.1257	0.8912	0.4352	0.4677	0.9601	0.4009	0.3644	0.9613	0.2986

C. In-sample RMSE: Full Sample Estimation Period

Australia	5.0341	**4.3975**	5.1773	4.7342	4.3560	**4.1521**	4.9684	**4.4495**	4.5477
Canada	3.8158	**2.7265**	3.8943	3.5424	**2.9833**	3.5685	3.8212	**2.9748**	3.8353
Finland	**4.2090**	4.3713	4.3394	5.2651	**4.2176**	5.4071	5.2206	**4.2572**	4.5462
France	3.7697	**1.8625**	4.2534	3.8133	**1.9438**	3.5610	3.5504	**1.9422**	2.6282
UK	6.2124	**5.2333**	6.6264	6.0934	**5.2139**	5.2439	6.5370	**5.2437**	6.0550
Ireland	5.2537	**4.2376**	5.1941	5.8065	4.1855	5.8608	5.9606	**4.1211**	5.8915
Italy	6.2019	**5.0598**	6.7637	5.3325	5.0891	**4.4879**	6.6581	5.0947	**4.8374**
Japan	2.9439	**2.4030**	2.9391	4.6380	**2.9667**	4.5678	3.7444	**3.0575**	3.9273
Netherlands	3.4160	**3.0188**	3.3595	3.1545	**2.8769**	2.9657	2.9660	**2.6617**	2.7607
Norway	8.1860	10.4646	**8.0348**	24.9131	10.6877	**8.1089**	**8.1397**	10.6058	8.2036
New Zealand	**6.5208**	6.7811	6.7107	**4.6675**	6.0595	4.9361	10.1319	12.7993	**9.3456**
Sweden	**4.6377**	6.5191	5.0622	**4.9952**	6.3964	5.0629	5.0347	6.4872	**4.7968**
US	2.2957	**1.2381**	2.4587	2.1827	**1.2300**	2.0157	2.3568	**1.2149**	2.4702

D. In-sample RMSE: 1983-2005 Estimation Period

Australia	**2.5931**	2.7924	2.8908	2.7036	2.7912	**2.6856**	2.8762	**2.7226**	3.0254
Canada	2.3963	2.6526	**2.3510**	**2.3309**	2.7039	2.3818	**2.3692**	2.7185	2.3962
Finland	**3.5788**	4.1470	3.6674	**3.4047**	4.1516	3.5086	3.6707	4.1231	**3.5942**
France	1.3385	**1.3050**	1.7314	1.1447	**1.3105**	1.4794	1.6758	**1.3125**	1.8720
UK	2.8454	3.5130	**2.7184**	**2.7399**	3.4890	2.8244	**2.6669**	3.5501	2.7558
Ireland	3.5411	4.6152	**3.5394**	3.5448	4.7906	**3.5421**	3.7794	4.7776	**3.6907**
Italy	**2.2492**	2.6827	2.8089	**2.2718**	2.7007	2.6654	2.6811	**2.6225**	3.2633
Japan	**1.9042**	2.3045	1.9366	**1.6385**	2.2163	1.7882	**1.6528**	2.2951	1.7169
Netherlands	2.3149	3.1450	**2.2029**	2.3430	3.2233	**2.3170**	2.2064	3.1933	**2.2018**
Norway	8.0143	10.8236	**8.0046**	8.0293	11.0262	8.0150	**7.9744**	10.8157	8.0133
New Zealand	**6.0146**	6.4588	6.0640	**4.6675**	6.0595	4.9361	5.9961	6.5056	**5.9853**
Sweden	**4.5657**	6.5578	4.9565	**4.8433**	6.4378	4.9580	4.9044	6.5306	**4.6892**
US	0.9680	0.9682	**0.9069**	**0.8463**	0.9864	0.9225	**0.9490**	0.9830	0.9665

Notes: See notes to Table 7. Panels A and B report the ratio of fitted and historical inflation standard deviations for the 13 countries in the dataset. Panels C and D report in-sample root mean squared error. Bold font entries in Panels C and D denote models with minimum RMSE, for a given inflation pressure measure.

Table 9: CS Distributional Accuracy Tests Based on the Joint Distribution of π_t and π_{t-1}

A. Full Sample Estimation Period

	Measure of Inflationary Pressure								
	Output Gap			*Labor Share*			*Unemployment*		
	SP	SPI	SI	SP	SPI	SI	SP	SPI	SI
Australia	2.9055	**2.7551**	2.9301	2.9720	**2.7153**	2.8619	2.9801	**2.8696**	2.9854
Canada	3.0669	**2.8525**	3.0572	3.2197	**3.0347**	3.1767	3.1710	**3.0602**	3.2084
Finland	2.6509	**2.4747**	2.6461	2.8556	**2.6274**	2.8177	**2.7841**	2.8163	2.7912
France	3.2490	**2.7972**	3.3662	3.3601*	**2.8391**	3.0603	3.2624	**2.8155**	3.4129
UK	2.9471	**2.6808**	2.9790	2.9798	**2.6629**	2.8135	2.9834	**2.7302**	2.9850
Ireland	2.6373	**2.3683**	2.6201	2.7841	**2.5660**	3.0481	3.0567	**2.5499**	3.1064
Italy	3.0273	**2.7320**	3.1608	3.1965	**2.7369**	3.0044	3.1595	**2.7816**	3.0498
Japan	2.6108	**2.4710**	2.6485	3.0306	**2.6794**	3.0160	2.7605	3.0098	**2.6798**
Netherlands	2.6368	**2.5374**	2.6060	2.8287	**2.6835**	2.7699	3.1294	3.1015	**3.0515**
Norway	1.6929	2.1561	**1.6929**	1.8324	2.3408	**1.6931**	**1.6914**	2.0662	1.6917
New Zealand	2.4149	**2.3651**	2.4214	**1.7332**	1.7941	1.7432	2.6883	4.9482	**2.6368**
Sweden	**2.0618**	2.1549	2.0673	**2.0666**	2.0777	2.1039	2.0601	2.2125	**2.0517**
US	3.5251	**3.0247**	3.5459	3.6636*	**3.1435**	3.5375	3.6865*	**3.1016**	3.7148

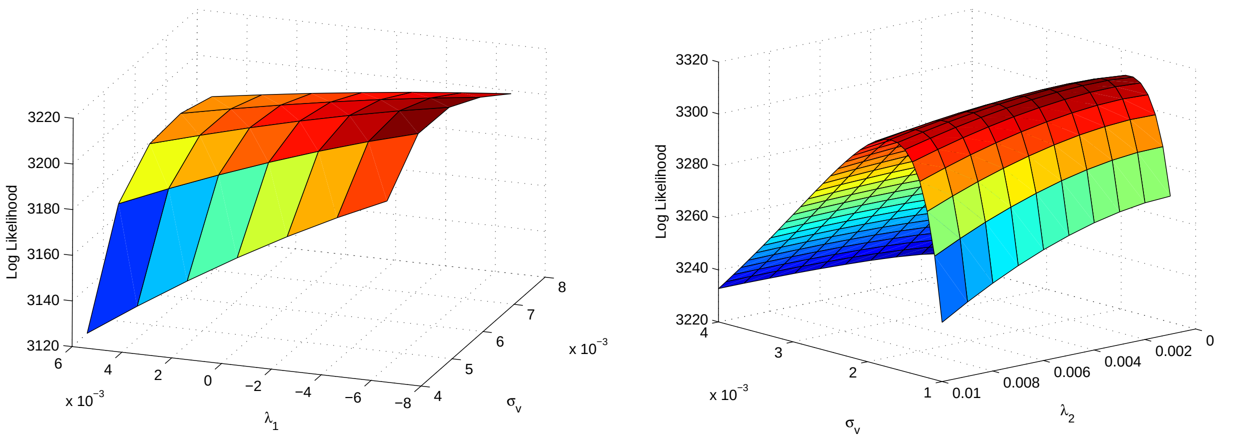
B. 1983-2005 Estimation Period

Australia	2.2356	2.2238	**2.1706**	2.1483	2.1384	**2.1263**	2.2460	**2.0825**	2.1978
Canada	**1.8465**	1.9632	1.8479	**1.8614**	2.0746	1.8902	1.8598	2.2817	**1.8531**
Finland	2.2384	**2.2219**	2.2749	2.2565	**2.1536**	2.2387	2.2956	**2.1360**	2.2853
France	2.4159	**2.3439**	2.6477	**2.3155**	2.3957	2.5721	2.5838	**2.2043**	2.6600
UK	1.8624	2.0667	**1.8610**	1.8675	1.9793	**1.8594**	**1.8597**	2.2085	1.8788
Ireland	2.0994	**2.0864**	2.0894	**2.0810**	2.1924	2.1084	**2.0448**	2.1441	2.3406
Italy	2.3272	**2.2356**	2.3768	2.4030	**2.2056**	2.4257	2.4979	**2.2300**	2.5073
Japan	2.1253	**2.0939**	2.1766	2.0782	2.1404	**2.0716**	2.1133	2.1107	**2.0854**
Netherlands	**1.5853**	1.8526	1.6238	**1.5963**	2.1488	1.5994	1.6103	2.0523	**1.5909**
Norway	**1.5197**	1.8154	1.5273	1.5263	2.0416	**1.5251**	**1.5237**	1.6973	1.5275
New Zealand	2.1749	**2.1557**	2.1691	**1.7234**	1.7903	1.7452	2.1924	2.3487	**2.1707**
Sweden	**1.9306**	2.0493	1.9682	**1.9841**	2.0119	2.0123	**1.9752**	2.0714	1.9927
US	2.1236	**2.0475**	2.1077	**2.0418**	2.0765	2.1467	**2.1059**	2.3233	2.1241

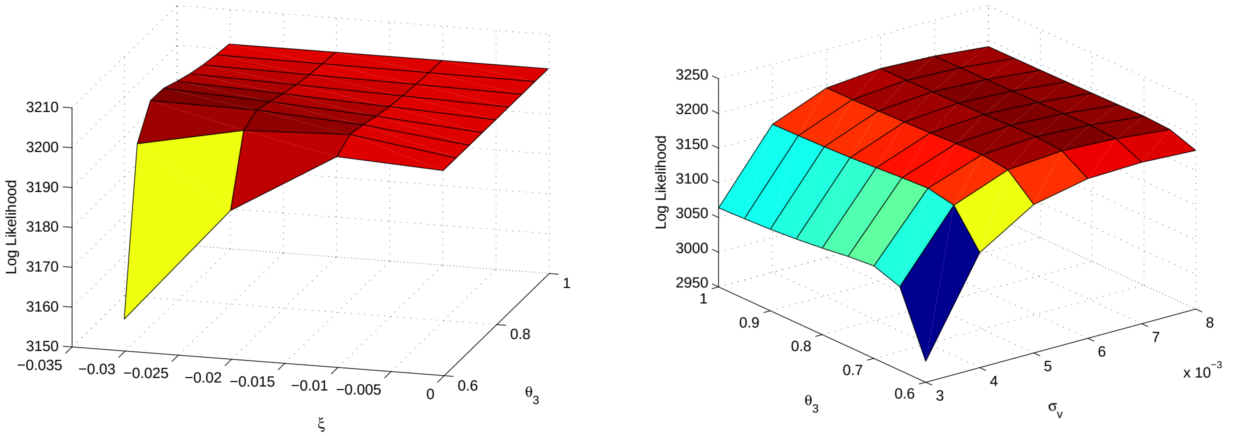
Notes: Entries in the table are Corradi and Swanson (CS: 2005b) distributional loss statistics associated with the three structural models, and are estimates of: $E\left(F_i(u;\theta_i^{\dagger}) - F_0(u;\theta_0)\right)^2$. In particular, entries are of $CS = \int_U \frac{1}{T}\sum_{t=1}^{T}\left(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{i,n}(\widehat{\theta}_{1,T}) \leq u\}\right)^2 \phi(u)du$ (see above for complete details). Bold font entries denote models with a minimum CS distribution loss, for a given inflation pressure measure. We test whether the alternative models have significantly lower CS loss than the benchmark SP model. The test is based on bootstrap critical values constructed using 100 bootstrap replications. Entries with superscript * indicate models for which the CS loss measure is significantly higher for the benchmark model using 10% significance level critical values. All statistics are based on a grid of 20x20 values of u, where u is distributed uniformly between the 25% and 75% quantiles of the historical range of inflation. Further details are given above.

Figure 1: Likelihood Surfaces Structural Models Estimated Using U.S. Data and the Output Gap

SP Model SPI Model



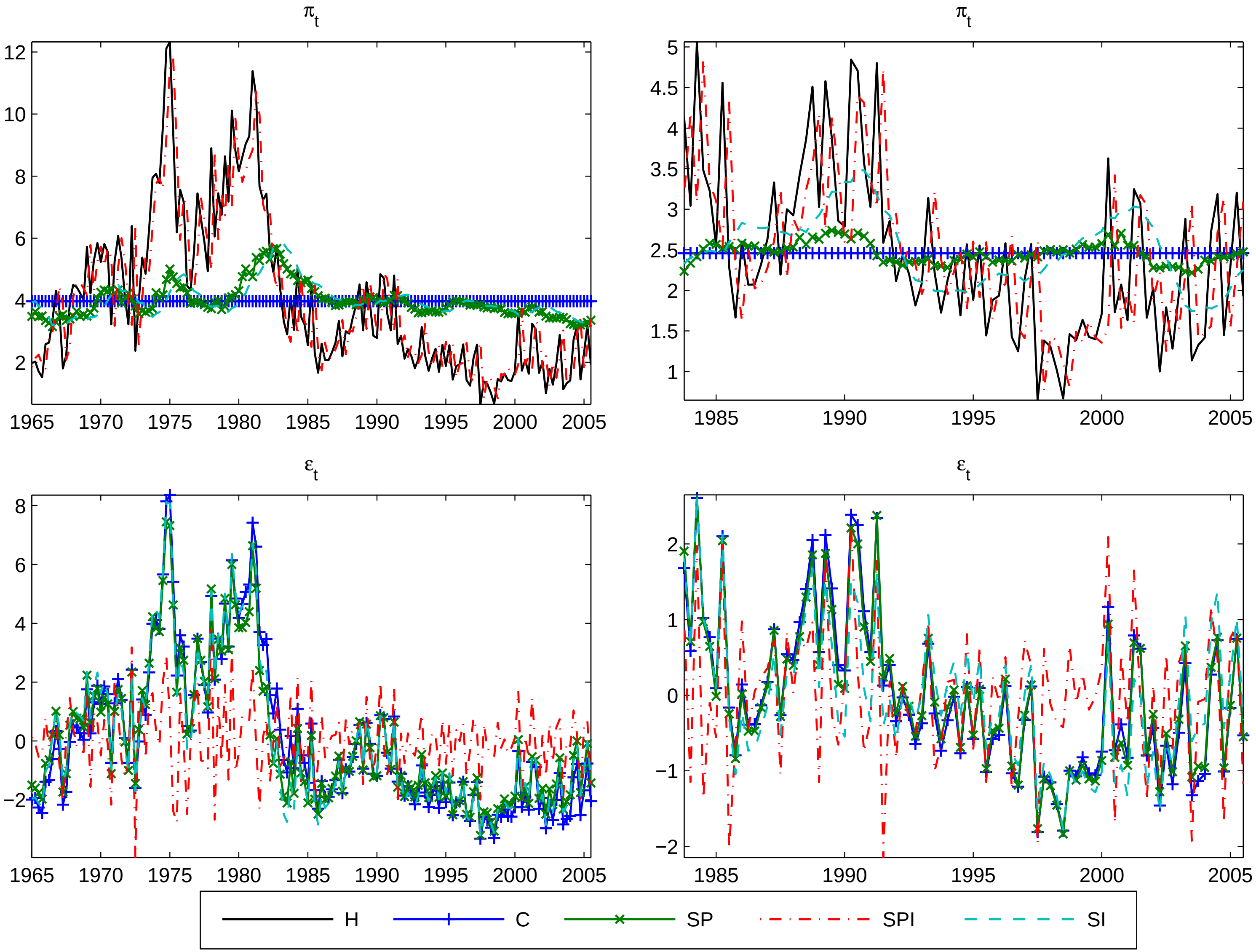
SI Model Evaluated at $\hat{\sigma}_v$ SI Model Evaluated at $\hat{\xi}$



Notes: λ_1 is the coefficient on the measure of inflationary pressure in the SP model, λ_2 - in the SPI model, and ξ - in the SI model; θ_3 is the proportion of firms in the economy that make decisions based on past information; σ_v is the error term in the structural model of inflation.

Figure 2: In-sample Fit and Residuals for Structural Models Estimated Using U.S. Data and the Output Gap

Full Sample *Sample 1983-2005*



Notes: H denotes historical inflation; C denotes the constant inflation model; and SP, SPI and SI are the structural models discussed above. For expository purposes, we add the mean back to the fitted values, and we convert quarterly changes into yearly. Fitted and actual values are plotted in the upper two graphs, while residuals are plotted in the lower two graphs.

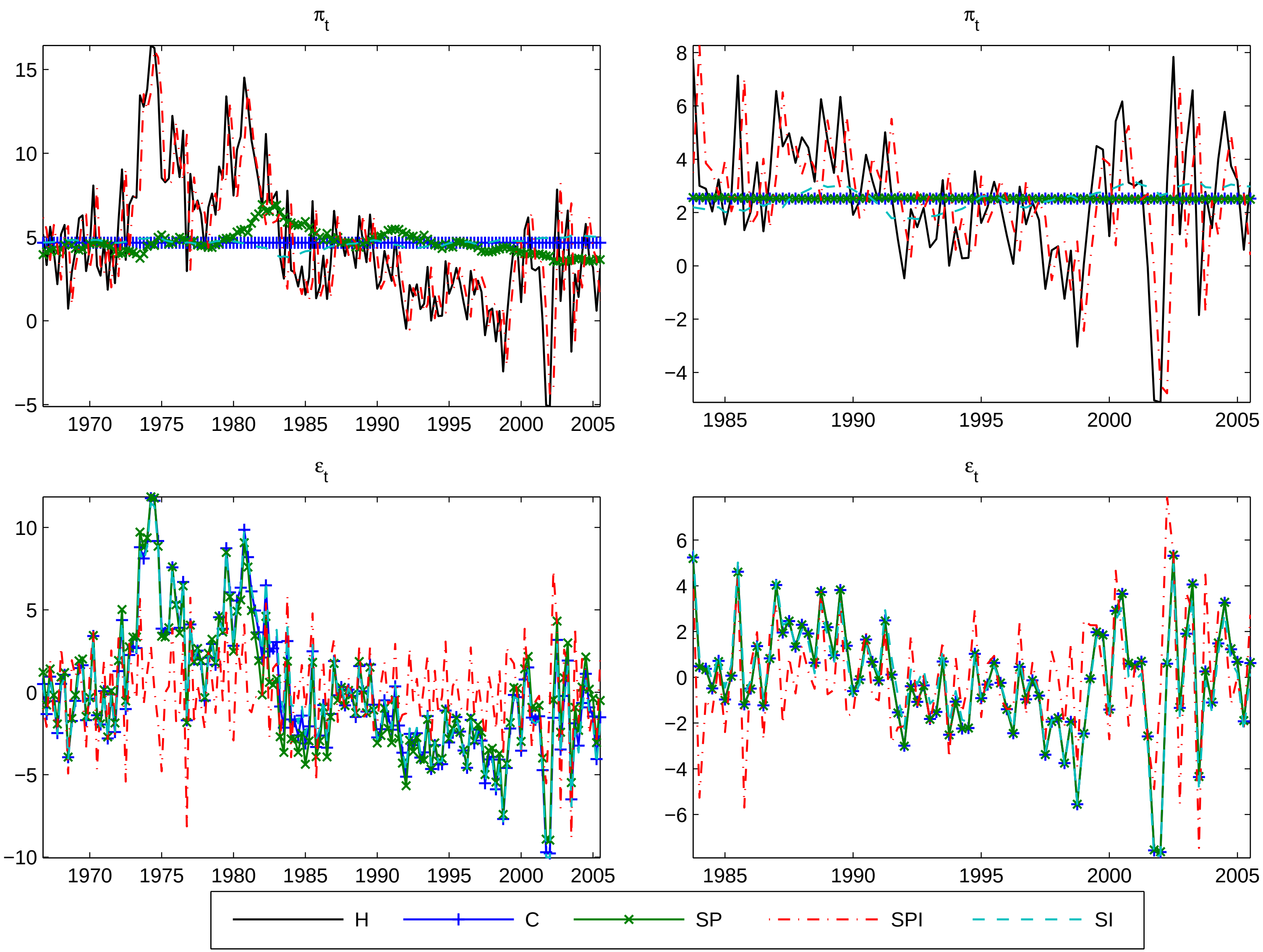
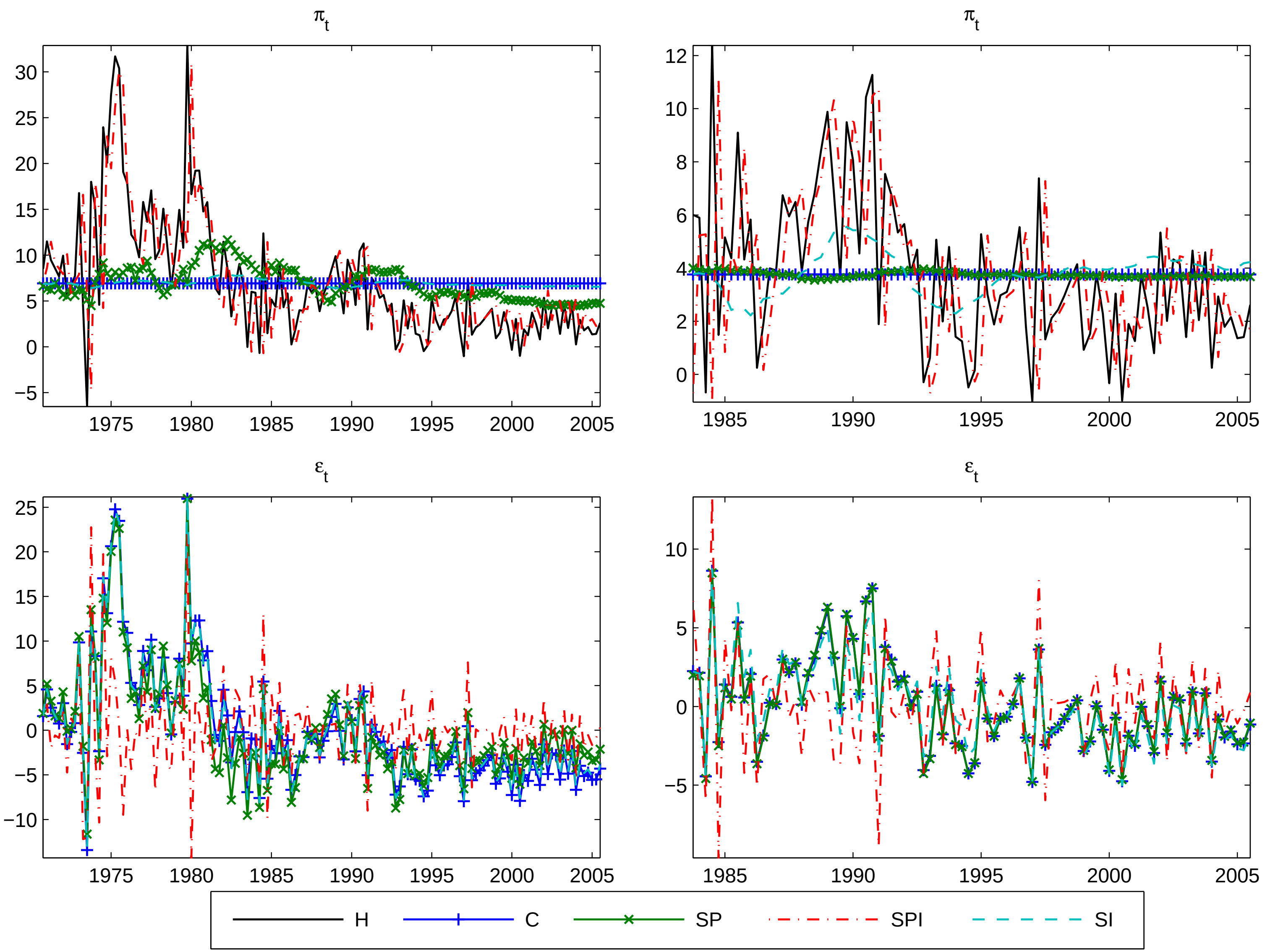


Figure 3: In-sample Fit and Residuals for Structural Models Estimated Using Canada Data and the Output Gap

Full Sample *Sample 1983-2005*

Notes: See notes to Figure 2.

Figure 4: In-sample Fit and Residuals for Structural Models Estimated Using the United Kingdom Data and the Output Gap

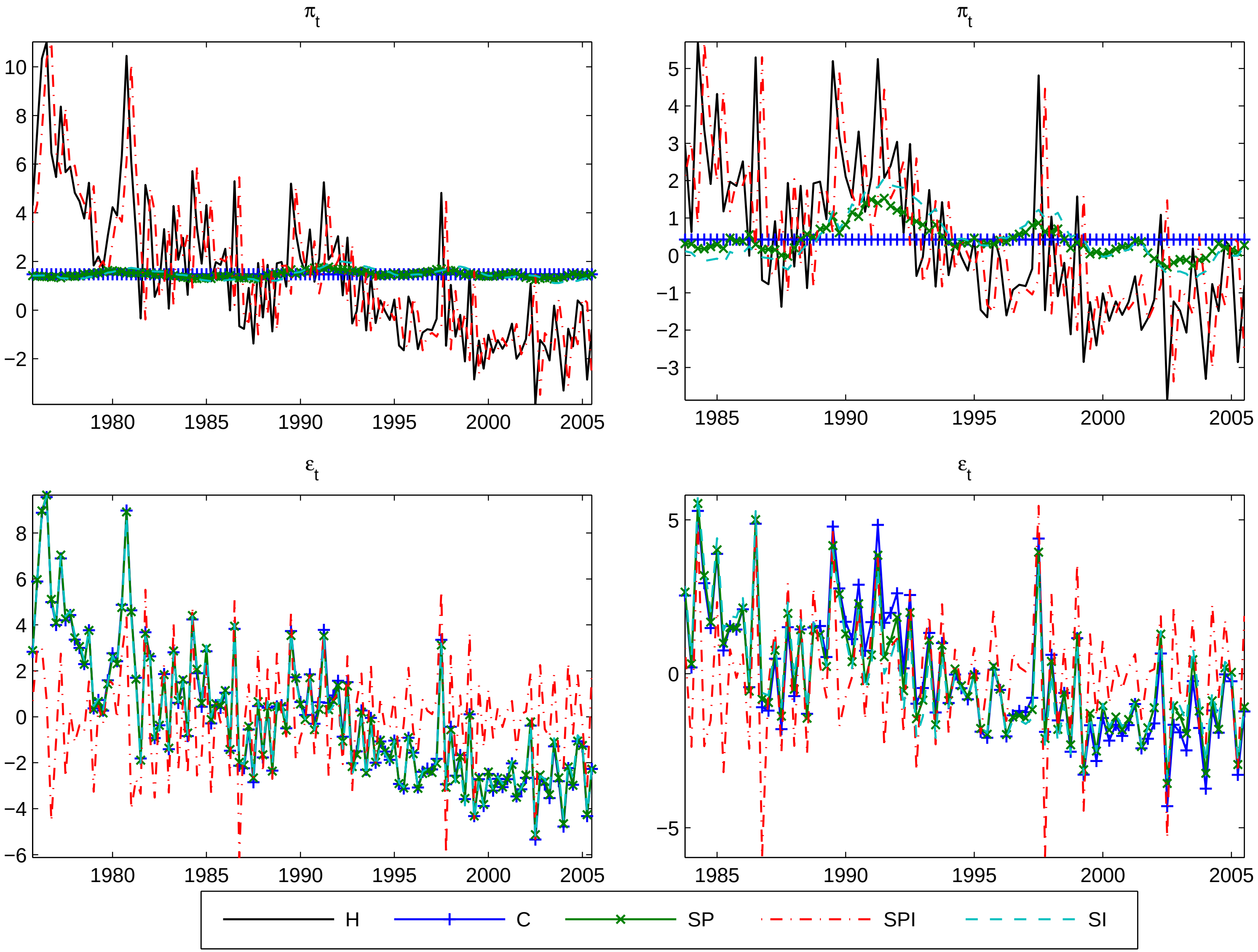


Full Sample *Sample 1983-2005*

Notes: See notes to Figure 2.

Figure 5: In-sample Fit and Residuals for Structural Models Estimated Using Japan Data and the Output Gap

Full Sample *Sample 1983-2005*

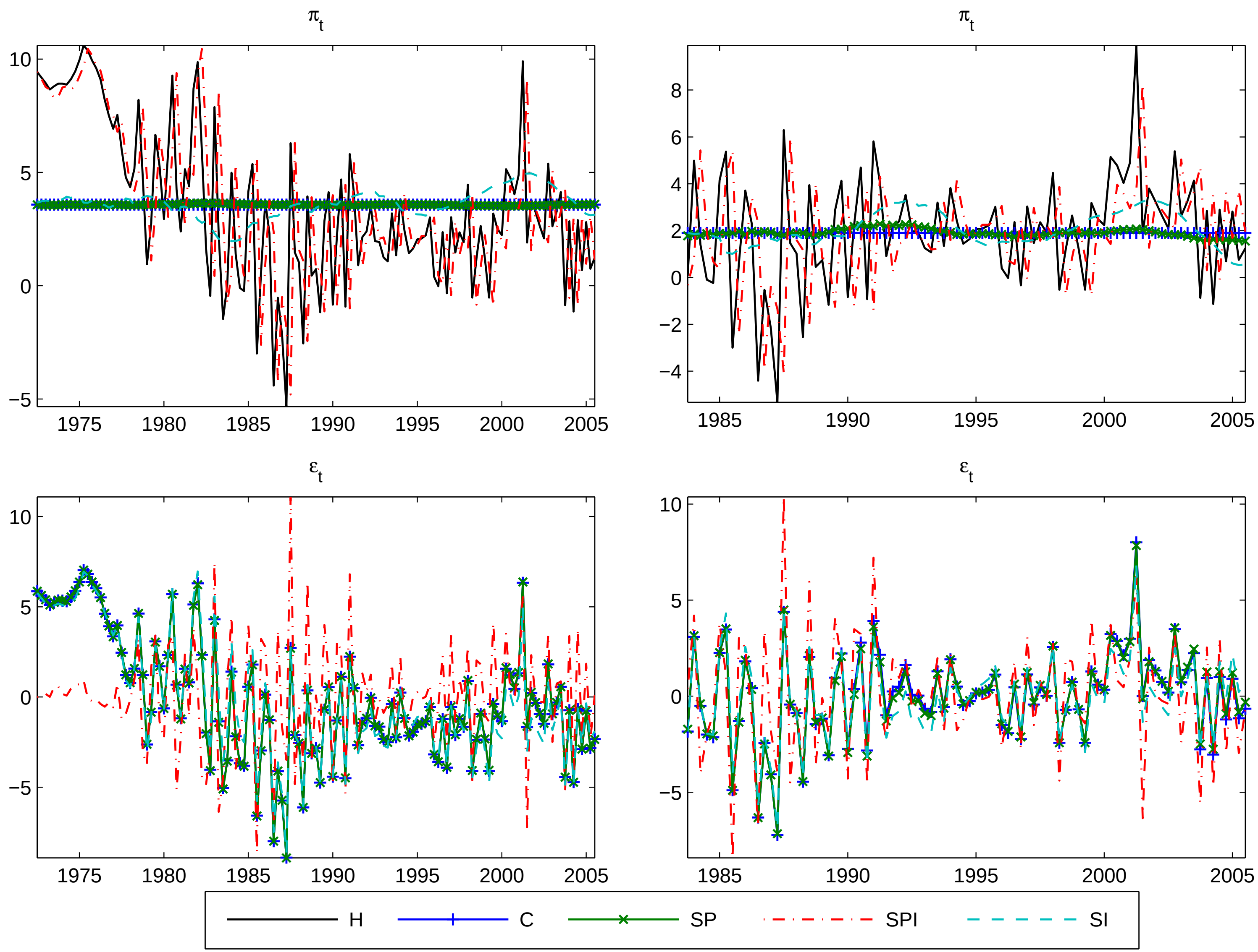


Full Sample *Sample 1983-2005*

Notes: See notes to Figure 2.

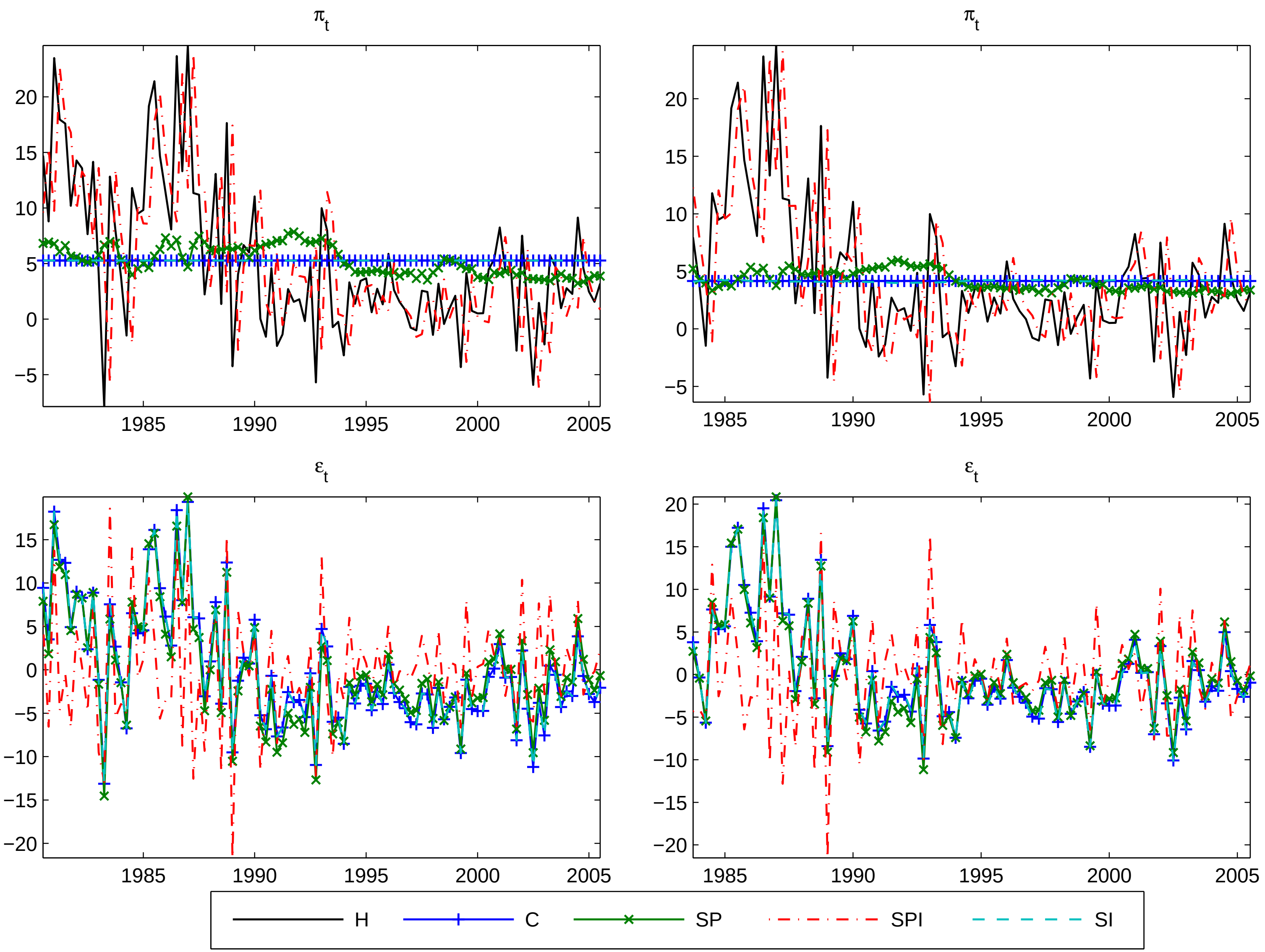
Figure 6: In-sample Fit and Residuals for Structural Models Estimated Using Netherlands Data and the Output Gap

Full Sample *Sample 1983-2005*



Notes: See notes to Figure 2.

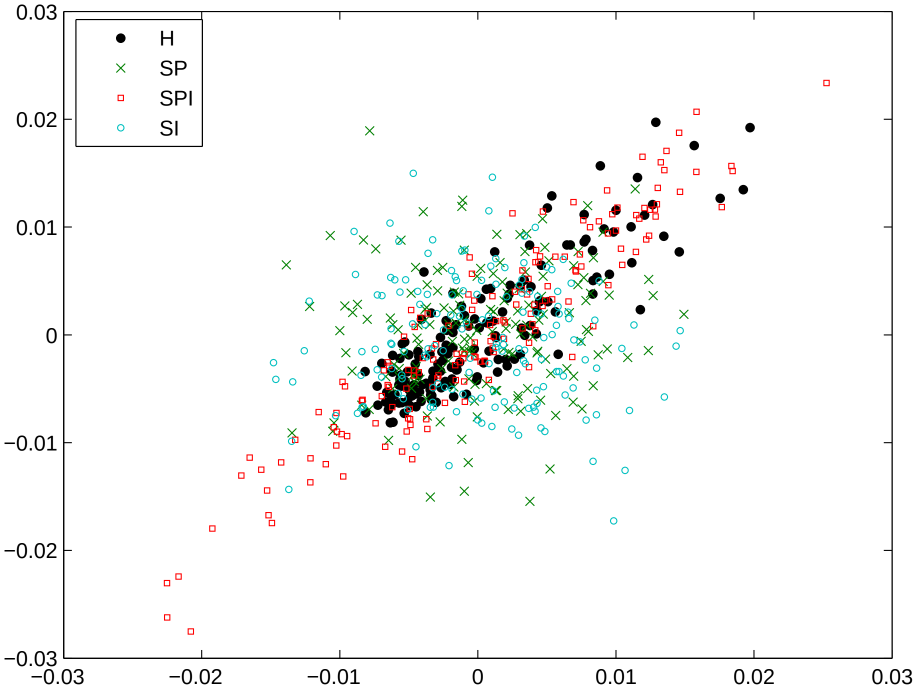
Figure 7: In-sample Fit and Residuals for Structural Models Estimated Using New Zealand Data and the Output Gap



Full Sample *Sample 1983-2005*

Notes: See notes to Figure 2.

Figure 8: Scatter Plot of Simulated π_t and π_{t-1} Observations for the Structural Models



Notes: See notes to Figure 2. The simulated sample size is 50T, where T denotes the number of observations used to estimate the model. In the graph, every 50th value of the simulated samples are plotted, in order to make the graph visually coherent.