

Evolving International Inflation Dynamics: World and Country Specific Factors*

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Abstract

The decline in the level and persistence of inflation over the 1980s is a *common* feature of the most industrialized economies in the world. The rise in inflation volatility of the late 1970s and the subsequent fall of the 1980s, in contrast, is *country specific*. During the last two decades, inflation predictability has declined sharply across the industrialized world. Our conclusions are based on a novel dynamic factor model with time-varying parameters and stochastic volatility.

JEL classification: C32, E30, E52.

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1 Introduction

Many industrialized countries across the world have shared a similar inflation experience over the last thirty years. Inflation was typically high and volatile during the second half of the 1970s and the first half of the 1980s but low and stable in the most recent period. This pattern is apparent in Figure 1, which plots the annual rates of inflation for 13 developed economies. Two features of the graph are worth emphasizing. First, national inflation rates move together for most of the sample. Second, the years that extend from 1975 to 1987 are fairly different from the rest of the sample. Figure 1 suggests a few questions. What are the common features of national inflation rates? How have the international influences on domestic inflation evolved over time?

These questions are important in that alternative interpretations of events carry different policy implications. If the rise and fall in the level and volatility of inflation are an international common feature, then national policy makers would have an incentive to focus on global developments. If country specific economic policies were responsible for the high volatility of the 1970s and early 1980s, then inspecting the policy decision process and the design of national institutions could reveal insights which would help prevent repeating the mistakes of the past.

This paper decomposes movements in national inflation rates into world and country specific features. Using a dynamic factor model with time-varying coefficients and stochastic volatility, we find that the historical decline in the level and persistence of inflation is shared by most G7 economies, Australia, New Zealand and Spain. The volatility of the late 1970s and early 1980s, in contrast, is associated with national conditions. The contribution of national and international factors to the variance of inflation has decreased over time. The fall in inflation predictability, which earlier contributions have documented for the U.K and the U.S. since the mid-80s, is in fact a common feature of the industrialized world.

A large empirical literature surveyed by Bernanke (2004) has investigated the relative contributions of good luck and good policy to the fall

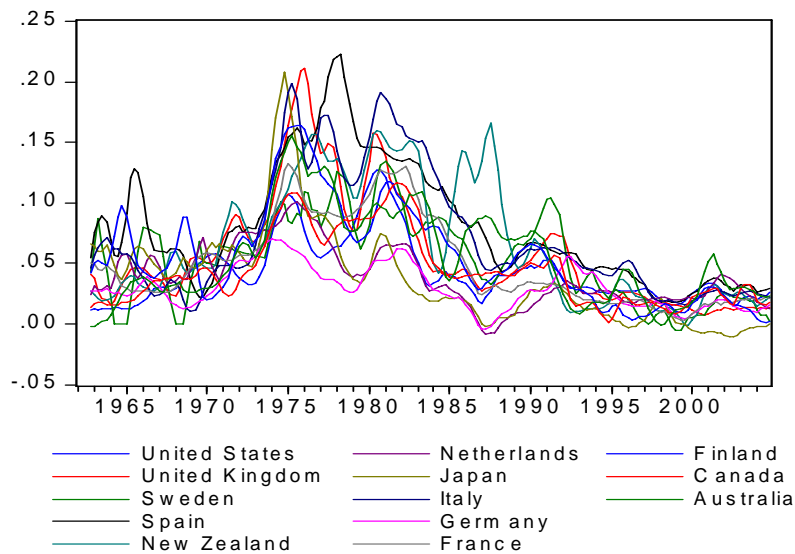


Figure 1: Inflation in 13 Developed Economies

in inflation volatility. According to the good luck interpretation, smaller macroeconomic shocks are behind the inflation stability observed since the end of the 1980s. Advocates of the good policy hypothesis interpret the reduction in the variance of inflation as the result of improved monetary policy management.

The good luck-good policy debate has been studied so far at national level. And, most of the international evidence is simply based on comparing the experiences of different countries (see Canova, Gambetti and Pappa, 2007, and Borio and Filardo, 2007). To the best of our knowledge, no paper has yet attempted to identify jointly the temporal evolution of national and international contributions to movements in inflation.

Our work is related to two important strands of the literature. The first strand builds upon the methods developed by Stock and Watson (1998) and Forni, Hallin, Lippi and Reichlin (2001), and employs *fixed coefficient* factor models to study the international comovements of macroeconomic variables

(see Kose, Otrok and Whiteman, 2003, for real activity, and Ciccarelli and Mojon, 2005, for inflation).

The second strand uses small-scale VARs to show that time-varying coefficients and stochastic volatility are important features of inflation dynamics in a few western economies (see Cogley and Sargent, 2005, Canova and Gambetti, 2005, and Benati and Mumtaz, 2007).

Our work links the research on fixed coefficient factor models and the research on time-varying VARs by introducing time variation in a panel of 164 inflation indicators for the G7, Australia, New Zealand and Spain. In so doing, we characterize the temporal evolution of both international and national common features of inflation.

The paper is organized as follows. In Section 2, we present the empirical model and the international panel of data. Section 3 describes the evolution of world and country contributions to the level and persistence of national inflation rates. In Section 4, we present a variance decomposition analysis and a measure of inflation predictability over time and across countries. The Appendix provides details on the estimation technique and the data.

2 Modelling world wide inflation

This section provides some background on the notion of global inflation, and it describes the empirical model, the strategy for identifying world and country specific common features, and the estimation procedure. The idea is that *movements* in inflation are effectively described by a few factors and that these factors reflect national and international *comovements*. The geographic characteristics of the comovements are unobserved but they can be inferred via the factor loadings. In particular, an international feature is common to the inflation series of all countries while a national feature is only common to the inflation series of a single country. A number of recent contributions including Cogley and Sargent (2005) and Canova and Gambetti (2005) have suggested that the inflation process may have significantly changed over time: we are interested in assessing the relative contributions

of national and international factors to any possible time variation.

2.1 Background

There are several reasons why one might expect strong co-movement in national inflation rates. A change in the practice of monetary policy, for instance, is consistent with the large changes in the level of inflation depicted in Figure 1. Clarida, Galí and Gertler (1998) argue that the central banks of Japan, Germany and the U.S. have pursued an implicit form of inflation targeting since the beginning of the 1980s. During the 1990s, inflation targeting has been explicitly adopted in a number of countries, including the U.K., New Zealand, Sweden, Canada and Australia. The evolution in the intellectual climate and policy framework is consistent with the close movements of national inflation rates observed over the recent past. Country-specific components of inflation, on the other hand, are more likely important when the conduct of monetary policy differed across countries.

The view that improved monetary policy was the driving force behind movements in inflation has not gone unchallenged. A number of empirical contributions, including Sims and Zha (2006) and Benati and Mumtaz (2007) for the U.S., and Mumtaz (2005) for the U.K., argue that the most recent experience of low and stable inflation can be explained by a favourable macroeconomic environment, in the form of small adverse shocks across the countries in our panel. Moreover, a common event, such as an oil price shock, may explain the observation that most industrialized economies experienced high and volatile inflation during the 1970s.

Globalisation may contribute to make inflation a more international phenomenon. Rogoff (2003) discusses two channels through which globalisation may have an impact on national inflation rates. First, increased competition in the good markets reduces the wedge between the monopoly level of output and the benchmark competitive level and, in turn, it reduces private sector's inflation expectations. Second, increased competition leads to greater price flexibility, and therefore it reduces the impact of monetary policy on real

activity.¹

The discussion above suggests that national inflation rates may well share a common international feature. Furthermore, the importance of any global factor is likely to evolve over time as the changes in policy and the economic environment become widespread. Our empirical analysis focuses on the experience of the most industrialized countries in the world. We decompose national inflation rates into a country-specific and a world-wide component. The dynamics of the two components are allowed to change over time, implying that their relative importance in accounting for movements in national inflation rates is time-varying.

2.2 The empirical model

Each national inflation series, $\pi_{i,t}$, is described by the following model:

$$\pi_{i,t} = \beta_i^c F_t^c + \beta_i^w F_t^w + \varepsilon_{i,t} \quad (1)$$

where F_t^c denotes a country specific factor, while F_t^w is a world factor with the associated factor loadings denoted by β_i^c and β_i^w .

The two factors are assumed to follow autoregressive processes of order (p):

$$F_t^j = \alpha_t^j + \sum_{k=1}^P \rho_{k,t}^j F_{t-k}^j + v_t^j \quad (2)$$

where $j = \{c, w\}$. The coefficients in the AR model, $\Phi_t^j = [\alpha_t^j, \rho_{k,t}^j]$, are time varying and evolve as random walks²

$$\Phi_t^j = \Phi_{t-1}^j + \eta_t^j \quad (3)$$

¹Bean (2006) suggests that the impact of globalisation on inflation may come about by flattening the short-run tradeoff between inflation and the output-gap. This occurs, for example, as increased competition from economies with a large supply of labour reduces cyclical sensitivity of profit margins. Similarly, if it becomes increasingly easier to off-shore activities to economies with low wages, domestic workers have less of an incentive to push for higher wages when unemployment falls and employers are in a better position to resist such claims.

²The estimates below are robust to specifying an autoregressive process for the coefficients in the AR model with parameter equal to 0.99. Results are available upon request.

In addition, we assume that $E\left(v_t^j\right)^2 = \Sigma_t^j$ evolve as geometric random walks

$$\ln\left(\Sigma_t^j\right) = \ln\left(\Sigma_{t-1}^j\right) + \mu_t^j \quad (4)$$

We allow for serial correlation and heteroscedasticity in the idiosyncratic component and model the dynamics of $\varepsilon_{i,t}$ via the following time-varying AR(1) model:

$$\varepsilon_{i,t} = \rho_{i,t} + r_{i,t} \quad (5)$$

where

$$\begin{aligned} \rho_{i,t} &= \rho_{i,t-1} + u_{i,t} \\ \ln(R_{i,t}) &= \ln(R_{i,t-1}) + \varsigma_{i,t} \end{aligned}$$

with $R_{i,t} = E\left(r_{i,t}\right)^2$.

Finally, the vector $[\pi_{i,t}, \varsigma_t, \eta_t^j, \mu_t^j]'$ is distributed as

$$\begin{bmatrix} u_{i,t} \\ \varsigma_{i,t} \\ \eta_t^j \\ \mu_t^j \end{bmatrix} \sim N(0, V), \text{ with } V = \begin{bmatrix} q & 0 & 0 & 0 \\ 0 & g & 0 & 0 \\ 0 & 0 & Q & 0 \\ 0 & 0 & 0 & G \end{bmatrix} \quad (6)$$

2.3 Identification

For notational convenience, we rewrite equation (1) as:

$$\pi_{i,t} = \beta F_t + \varepsilon_{i,t} \quad (7)$$

where $F_t = [F_t^c; F_t^w]$. The country and the world factors are identified by the structure of the factor loading matrix. We label ‘world factor’ the unobserved component that is loaded by all variables in the panel. We label ‘country specific factors’ the unobserved components that are exclusively loaded by the variables of each individual countries. This implies that, in

addition to the world factor, we estimate as many factors as the number of nations. The matrix of factor loading has the following structure:

$$\beta = \begin{pmatrix} \beta_1^{country1} & 0 & 0 & 0 & \beta_1^{world} \\ \cdot & 0 & 0 & 0 & \cdot \\ \beta_{g1}^{country1} & 0 & 0 & 0 & \beta_{g1}^{world} \\ 0 & \beta_1^{country2} & 0 & 0 & \beta_{g1+1}^{world} \\ 0 & \cdot & 0 & 0 & \cdot \\ 0 & \beta_{g2}^{country2} & 0 & 0 & \cdot \\ 0 & 0 & \beta_i^{countryJ} & 0 & \cdot \\ 0 & 0 & 0 & \beta_1^{countryN} & \cdot \\ 0 & 0 & 0 & \cdot & \cdot \\ 0 & 0 & 0 & \beta_{gN}^{countryN} & \beta_{g1+..\+gN}^{world} \end{pmatrix}$$

This model is subject to the rotational indeterminacy problem. For any $k \times k$ orthogonal matrix P , there is an equivalent specification such that the rotations $F_t^* = PF_t$ and $\beta^* = \beta P'$ produce the same distribution for $\pi_{i,t}$ as in the original factor model (7). The implication is that the sign of the factor loadings and the sign of the factors are not separately identified. Following Geweke and Zhou (1996) and Bernanke, Boivin, Elias (2005), we impose further restrictions on the factor loadings. In particular, for each country we require the first $k \times k$ block of the factor loadings to be an identity matrix, where k denotes the number of factors per country. In our model $k = 2$.

2.4 Sources of time variation

The autoregressive process of the factors is modelled as time-varying. The factor loadings, in contrast, are fixed. Allowing simultaneously for time variation in the factor autoregressive coefficients, the factor variances, the factor loadings and the variance of the idiosyncratic component would greatly inflate the number of parameters in the model and hence would substantially increase the computational burden. A feasible alternative to the specification used in this paper is a fixed model for the factors but time-varying factor loadings (see Del Negro and Otrok, 2005).

In the current application, we do not consider such an alternative model

for two reasons. First, a fixed coefficient factor model implies time-invariant inflation dynamics for each country in the panel. Recent empirical evidence, however, questions this assumption (see, for instance, Cogley and Sargent, 2005, and Canova and Gambetti, 2005). Second, even with a time invariant AR process for the factors, the model with time-varying factor loadings involves substantially more computation, with N passes through the Kalman filter and smoother at each iteration of the Gibbs sampler.

2.5 Estimation

The model in equations (1) to (6) is estimated using the Bayesian methods described by Kim and Nelson (2000). In particular, we employ a Gibbs sampling algorithm that approximates the posterior distribution. A detailed description of the prior distributions and the sampling method is given in Appendix A. Here, we summarise the basic algorithm in four steps:

1. Conditional on a draw for the factors, we simulate the AR parameters and hyperparameters.
 - The AR coefficients Φ_t^j are simulated by using the methods described in Carter and Kohn (2000). Note that we only retain draws with roots inside the unit circle.
 - The volatilities of the shocks to the factor equations, Σ_t^j , are drawn using the date by date blocking scheme introduced by Jacquier, Polson and Rossi (2004).
 - The hyperparameters Q are drawn from an inverse Wishart distribution while the elements of G are simulated from an inverse gamma distribution.
2. Conditional on a draw of the factors, we draw the factor loadings (β) and the covariance matrix R .
 - Given data on F_t^j and $\pi_{i,t}$, standard results for regression models

can be used, and the coefficients and the variances are simulated from a normal and inverse gamma distribution.

3. Simulate the factors conditional on all the other parameters.
 - This step is carried out in a straightforward way by employing the procedures described by Bernanke, Boivin and Elias (2005), and Kim and Nelson (2000).
4. Go to step 1.

We use 34000 Gibbs sampling replications and discard the first 30000 as burn-in. Convergence is assessed by examining the variation of the posterior moments across the retained draws. In particular, we compare the posterior estimates calculated over subsets of the 4000 draws. The results from this exercise, available upon request, show that the estimates are virtually identical across the subsets indicating convergence to the ergodic distribution.

2.6 Data

The panel includes 164 quarterly series of prices for 13 countries: United Kingdom, United States, Sweden, Spain, Netherlands, New Zealand, Japan, Italy, Germany, France, Finland, Canada and Australia.

The full sample is 1961:1-2004:3 and we use the first twelve years of data to calibrate the priors. Data are seasonally adjusted and standardized. CPI inflation, which is available for all countries, is the variable that we choose to explain. Appendix B provides a detailed description of the series.

3 Results

This section presents the results of the empirical model and disentangles geographically the sources of movements in inflation. In particular, we construct world and country ‘indicators’ for measuring the fit of the model, and

decompose the persistence and the variance of inflation into national and international contributions.³

3.1 World and country indicators

The country indicators are constructed as the product of the country factor and the corresponding factor loading for CPI inflation. Similarly, the world indicators are constructed as the product of the world factor and the corresponding factor loading for each national CPI inflation.

We compute 8 country indicators, which are reported in Figure 2, and 8 world indicators, which are available upon request. The bottom-right chart of Figure 2 summarizes the information in the international factor by plotting, at each point in time, the average value of the world indicators across all countries. The dark lines are median values and red lines represent the central 68th posterior bands.

The indicators represent a measure of fit for assessing the significance of the world and country factors for national inflation. A number of interesting results emerge. The loadings of the international factor for CPI inflation are very similar across all countries but Canada, where it is far smaller. An interpretation of this result is that the world factor captures the *level* of the national rates: when the world factor increases by $x\%$, national inflation rates increase by similar proportions.⁴ The decline in the international factor is consistent with the notion of *global disinflation* put forward by Rogoff (2003).

Figure 2 reveals that the world indicator is more persistent than the country indicators. The panel in the bottom right corner shows that the world factor has the highest contribution to national inflation rates before

³The U.K., U.S., New Zealand, Japan and Canada are more represented than other countries for number of series. To make sure that over-representation does not affect our results, we also estimate a *balanced* panel with 7 series per nation. The results of the smaller panel are similar to those of the full panel, though the world and country factors are less precisely estimated. Our analysis will hence be based on the full panel.

⁴In the macrofinance literature, analogously, the factor that is loaded with similar weights by yields of different maturities is referred to as ‘the level of the yield curve’.

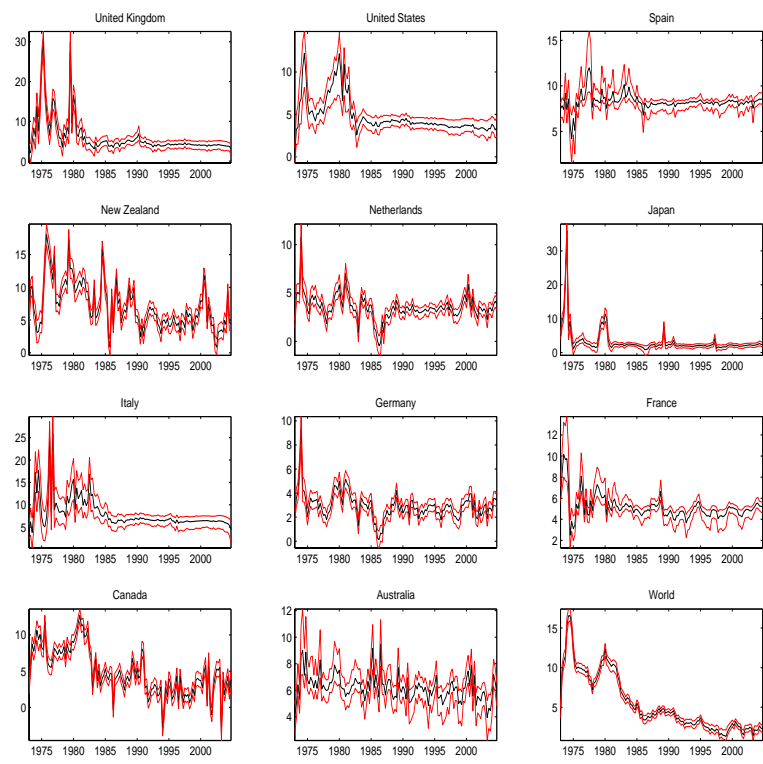


Figure 2: World and country indicators

1985. The first peak in the world factor coincides with the oil price increase in 1974 and appears to be statistically and economically more important than the second peak at the end of 1979.

The correlation between the oil price change and the world factor one year later is 0.43. Excluding the oil price shock in 1973 and the subsequent inflation rise in 1974, however, reduces the correlation to only 0.04.⁵ This implies that the world factor captures other international common features beyond the oil price.⁶ In assessing the robustness of our results to alternative specifications of the model, we found no significant evidence for a second world factor.

Turning to the country indicators, we notice differences and similarities across nations. The domestic factors were relatively more volatile in the 1970s and early 1980s. Movements in the country specific factors are associated with movements in national inflation rates in a few historical periods, typically concentrated at the beginning of the sample.

For the U.K., the first two peaks corresponded to the breakdown of income policies over the years 1975-1977. Various national factors contributed to the rise in UK inflation in 1979-1980: another breakdown of income policies, high pay awards in the public sector including those coming from the Clegg Commission, and the one-off effect of the increase in V.A.T. from 8% to 15%. Subsequently, a strong exchange rate, a sharp slowdown in economic activity, and the macroeconomic discipline implied by the Medium-Term Financial Strategy helped to reverse the rise. The last significant peak occurred in 1990, and was followed by a sizable decline in inflation and economic activity during the UK membership of the ERM. Since the introduction of the inflation targeting framework at the end of 1992, country specific conditions have no longer fed into higher inflation.

The relevant episodes for the U.S. occurred in 1974 and during the period 1978-1982, which includes the experiment of non-borrowed reserve targeting

⁵The measure of oil price is the IMF synthetic Brent crude oil series.

⁶A similar result for output can be found in Kose, Otrok and Whiteman (2003).

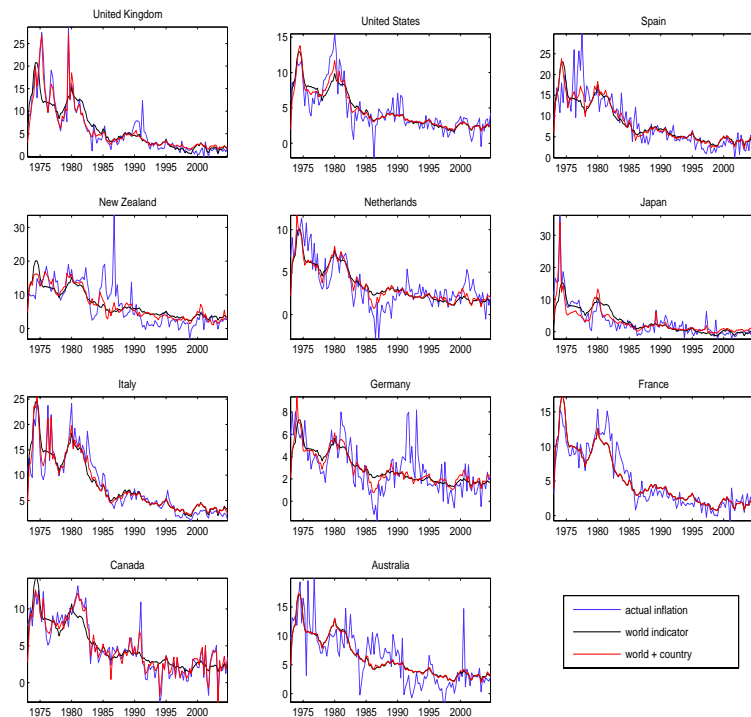


Figure 3: Actual inflation and indicators

of the newly appointed Fed Chairman Paul Volcker. Country specific conditions appear important for Spain and Italy until 1985, and for New Zealand until 1989 when explicit targets for inflation were agreed in the Reserve Bank Act. National factors contributed to movements in inflation during 1973 and around 1980 in Japan, Germany and the Netherlands. Lastly, while the country indicator for Canada was important over most of the sample with the exception of the second half of the 1980s, for Australia and France domestic conditions had little influence on inflation.

In Figure 3, we present a simple way to evaluate the contribution of the country indicators. Following Canova, Ciccarelli and Ortega (2005), for

each country we report the median values of the world indicator (in dark) together with the sum of the world and country indicators (in red), and actual inflation (in blue). Differences between the dark and red lines reflect movements in domestic conditions.

National and international factors track CPI inflation remarkably well. Country indicators are important determinants of national inflation during the second half of the 1970s and the first years of the 1980s, consistent with the conventional wisdom that national incomes policies were insufficient to achieve durable control of inflation in the U.K., Spain, Italy, Germany and New Zealand.

Except for Canada and Japan, the inflation peaks in 1974 are typically associated with small gaps between dark and red lines, implying that a worldwide event, such as the first oil price shock, was behind the rise in inflation. The second peak in US inflation is clearly country specific; similarly, the pick up in UK inflation at the beginning of the 1990s is shared by no other country.

Canada and the Netherlands on the one hand, and Australia and France on the other hand represent two extremes: in the former, inflation is mainly driven by domestic conditions; in the latter, by the world factor. In the last two decades, the difference between world indicators (dark line) and the sum of world and country indicators (red line) has virtually disappeared in most countries.

3.2 Inflation persistence

A number of authors including Cogley and Sargent (2002), Canova, Gambetti and Pappa (2007), and Benati and Mumtaz (2007) have argued that during the 1980s inflation persistence has declined remarkably in the U.S.. Our model allows us to identify the national and the international components of inflation persistence, which are defined as the normalized spectrum of the national and the international factors at frequency zero.

In Figure 4, we display the persistence of actual inflation (in blue) to-

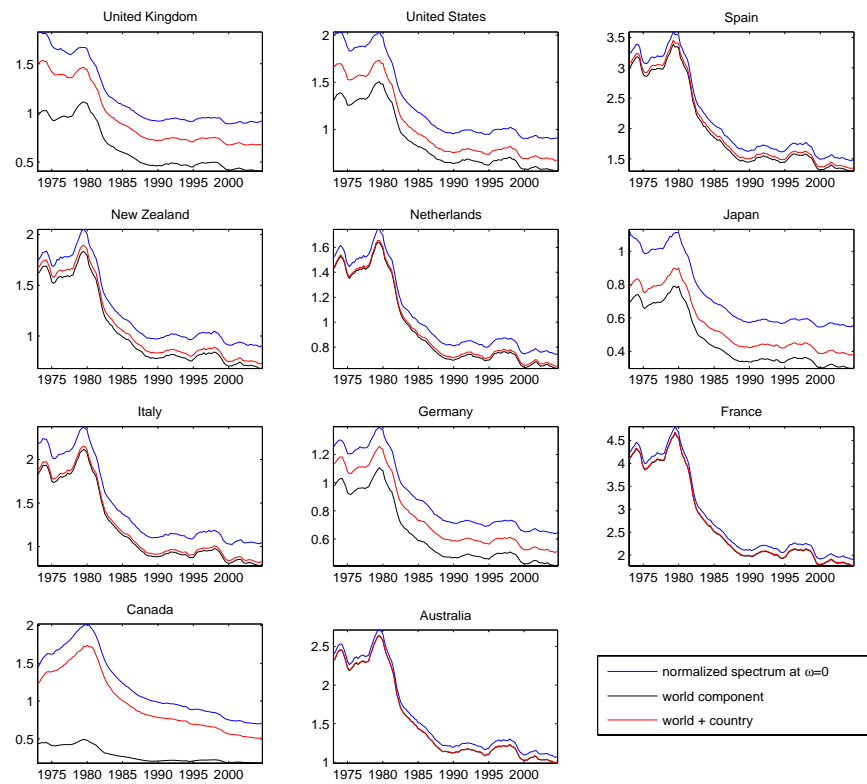


Figure 4: Inflation persistence: world and country specific components

gether with the world contribution (in black) and the sum of the world and domestic components (in red). The gap between the dark and red lines reflects the country-specific component. The time *evolution* of the gap between the two lines reflects the evolution of inflation persistence attributable to the national factors.

The main results are as follows. First, the international common component accounts for the bulk of the decline in inflation persistence for all countries but Canada, where the gap between the red and the black lines is not negligible. Second, the contribution of the national factor is sizable for UK, US, Japan, Germany and Canada. Third, the domestic components are stable over time for most countries with the exception of Canada, and possibly the U.S., though the decline here is significantly smaller than the decline of the world component.

In summary, the decline in the persistence of national inflation rates, which earlier contributions have documented for single countries, appears in fact an international common feature of the 1980s. In Appendix C, we report the 68th central posterior bands of the distribution of inflation persistence.

3.3 Stochastic volatility

The decline in the level and persistence of inflation is a common international feature. Inflation fluctuations, however, may still be country specific. Figure 5 plots the stochastic volatility of world and country factors.

Domestic characteristics are associated with far larger volatilities than the international common feature, especially during the 1970s and the beginning of the 1980s. The decline is particularly pronounced for the U.K., U.S., Japan and Italy. The dynamics for Germany, Canada and Australia are fairly stable.

The stochastic volatility of the world factor, in contrast, is characterized by small magnitudes and little time variation. Until the mid-1980s national conditions appear quantitatively more important than the world factor for the variance of inflation. During the last two decades, the volatilities of both

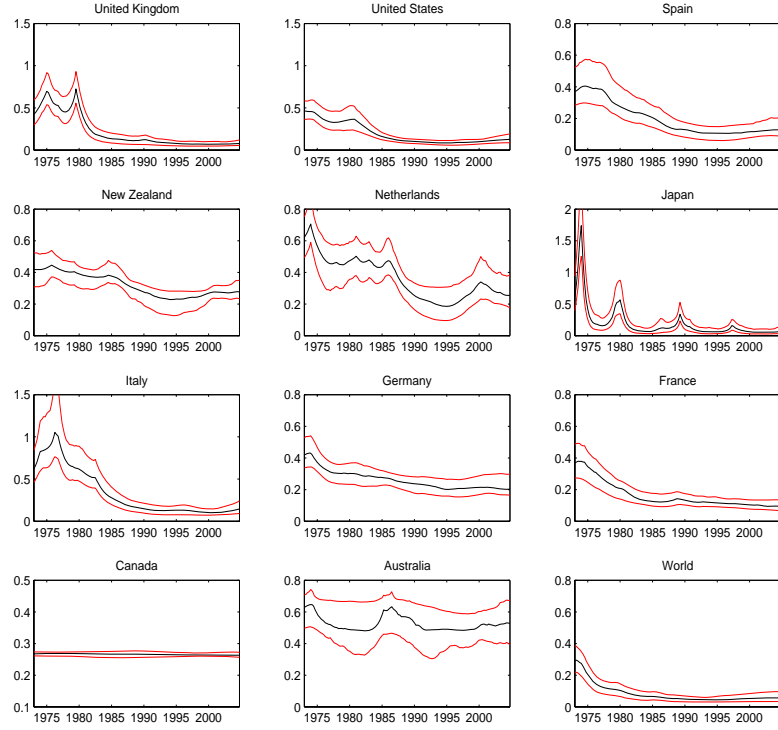


Figure 5: Standard deviations of factor innovations

national and international factors have declined in most countries.

4 Variance decomposition and predictability

In this section, we compute two measures of the relative contributions of world and country factors to the variance of inflation. The first measure represents the fraction of variance that, at each point time, can be explained individually by *each* factor. The second measure represents the fraction of variance that, at each point in time, can be explained jointly by *both* factors, and thus corresponds to the R^2 statistics.

4.1 Variance decomposition

To take both time-varying coefficients and stochastic volatility into account, at each point in time we compute the integrated spectral density of national and international common features using the parametric estimate of the population spectrum (see Hamilton, 1994, Section 6.1). Figure 6 plots the fraction of inflation variance explained by the domestic factor in each country.

Remarkable declines in the relative importance of the country specific factors are apparent for the U.K., the U.S., Japan, and to a lesser extent Spain and Italy. Country specific conditions were the dominant sources of inflation fluctuations in the U.K. during the 1970s and at the beginning of the 1990s. The fraction of variance explained by domestic conditions moved from median values around 60% between 1975 and 1980 to values around 15% in the period 1981-1992. The average contribution over the last decade is far smaller, just below 4%.

In the U.S., domestic factors accounted for a sizable portion of variation in inflation during the 1970s and at early 1980s. The largest fall occurred in 1983 and coincided with the end of Volcker's experiment of non-borrowed reserve targeting (see Goodfriend, 1993). The contribution of national features declined from an average of 22% before 1983 to 3% after.

In Spain and Italy, small variations characterized the pattern of variance decomposition with the highest national contributions associated with the income policies of the 1970s and mid-1980s. A similar picture emerges for New Zealand and the Netherlands where the most notable decline occurred around the end of the 1980s.

The dating of domestic contributions for Japan accords with conventional wisdom: 1980 was an important year for the liberalization of financial markets; 1990 was associated with the bursting of the asset price bubble. The Russian default in 1997 and the Bank of Japan independence granted in 1998 do not seem to have affected the variance of inflation.

The picture for Germany contrasts with those for the other countries

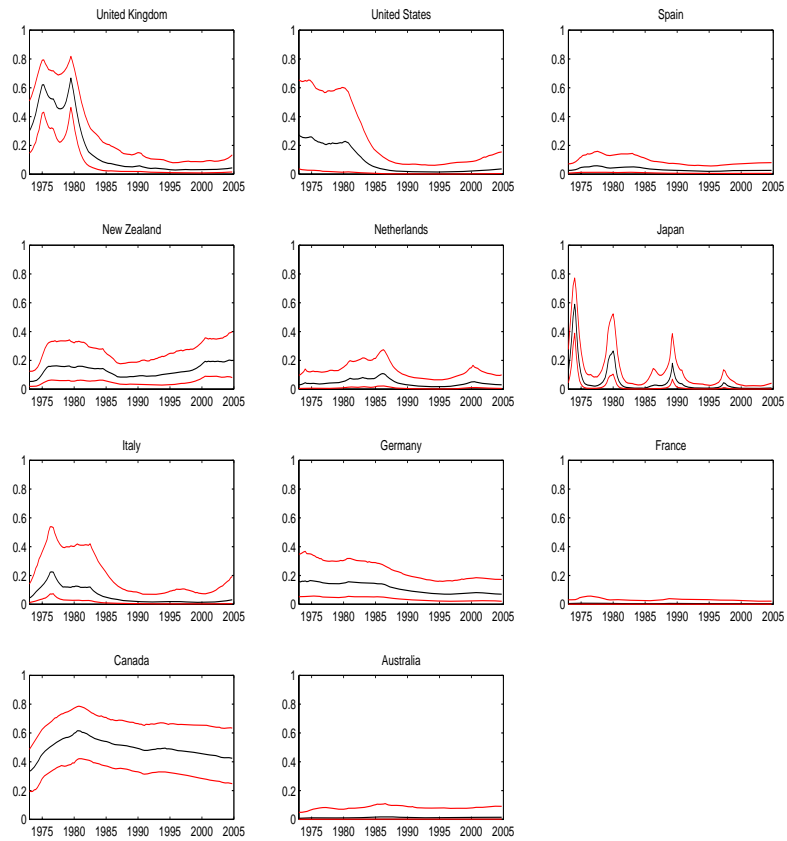


Figure 6: Variance decomposition: contribution of the country factors

in that it reveals a remarkable stability in the domestic contribution to inflation over the entire sample, a sample characterized by rigorous national policies. The results for Canada display no obvious tendency over time, and the national factor explains, on average, around 50% of fluctuations. In Australia and France, domestic conditions seem to have little impact on the variance of inflation.

The decline in the fraction of variance accounted for by the country factors coincide with the decline in inflation volatility documented by earlier contributions. It is worth noting that while the reductions in volatility are broadly concentrated around the middle of the sample, they are not synchronized across nations, suggesting that the source of change is truly country specific.

Domestic shocks, differences in the transmission mechanism of a common shock as implied, for instance, by differences in nominal and/or real rigidities, and national economic policies are consistent with the different timings in the decline of volatility. A common international shock that affects national economies at similar paces, in contrast, is inconsistent with events.

In Figure 7, we show the relative contributions of the world factor to the volatility of national inflation rates. In most countries, the variance share accounted for by an international common feature has declined significantly over time, with the largest falls associated with countries most open to trade: New Zealand, the Netherlands, France and Australia. The largest international contributions, around 50%, occurred during the oil price increase of 1974.

The second half of the 1970s was a period of significant decline in the volatility due to international conditions. For most countries, the fall of explained variance at the beginning of the 1980s was less pronounced than the fall in the previous decade. Since the end of the 1980s, the fraction accounted for by the world component is at the lowest historical levels, around 5%, across the industrialized world.

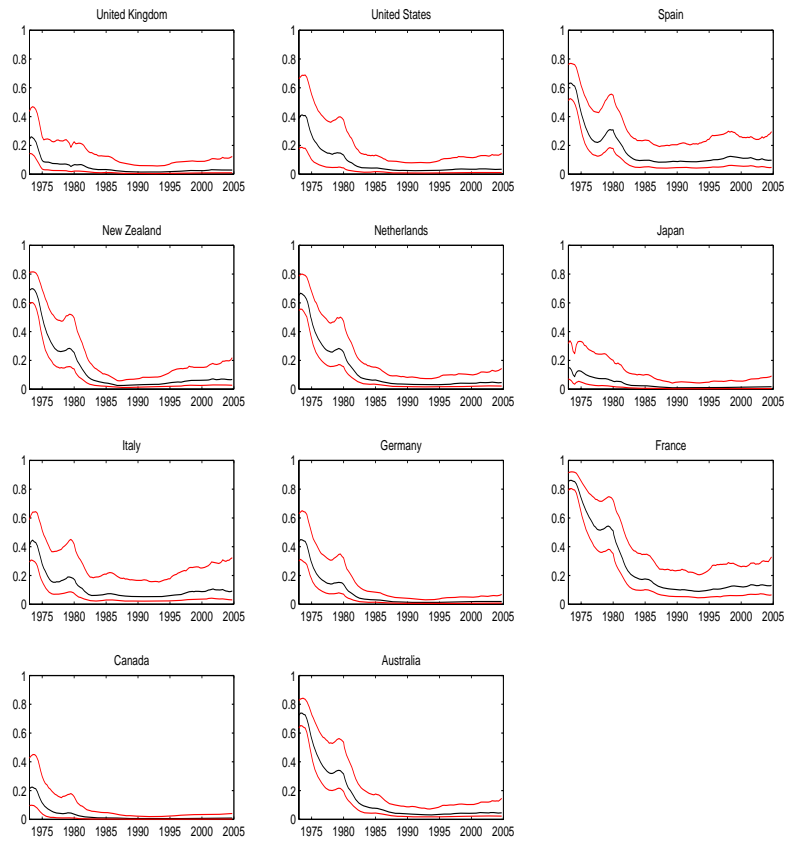


Figure 7: Variance decomposition: contribution of the world factor

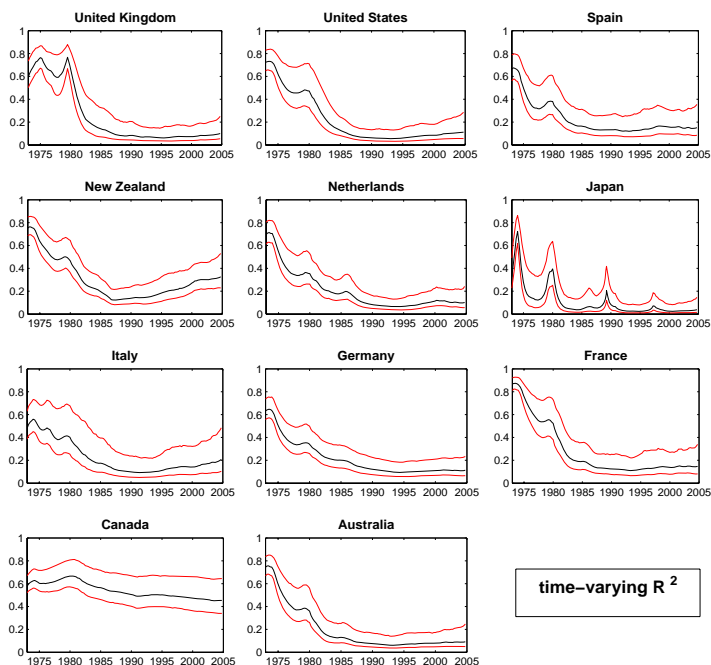


Figure 8: Evolving inflation predictability

4.2 Predictability

The variance decomposition analysis revealed that neither national factors nor international features provide a satisfactory account for the inflation fluctuations of the most recent past. A possible explanation for this finding is that inflation has become less predictable over time.

To formalize the hypothesis of a fall in inflation predictability, in Figure 8 we plot a time-varying version of the R^2 statistics, computed as the ratio of the conditional variance to the unconditional variance of inflation.⁷

⁷The unconditional variance is the integrated spectrum of inflation based on our estimated model. The conditional variance is the difference between the unconditional variance and the variance of the idiosyncratic component.

The first two panels in the top row corroborate the evidence of declining predictability in Benati (2007) for the U.K., and Cogley and Sargent (2006), D’Agostino, Giannone and Surico (2006), Benati and Mumtaz (2007), and Stock and Watson (2007) for the U.S.. The novel finding is that the fall is not specific to these economies, rather it is shared by all other countries but Canada. Inflation predictability has been steadily declining during the 1980s, and today it is far smaller than it was during the 1970s.

5 Conclusions

We have proposed a dynamic factor model with time-varying parameters and stochastic volatility to study national and international common features in a panel of 164 series for the most industrialized economies in the world. A common international factor tracks the *level* and *persistence* of national inflation rates reasonably well. Country conditions capture the evolution of the *volatility* of inflation.

The national factors account for a large share of variance in the second half of the 1970s and early 1980s. The rise and fall of national contributions are not synchronized across economies and their timing confirms conventional wisdom on the conduct of national policies: income policies and accommodative monetary policies are associated with periods of volatile inflation in the U.K., the U.S., Spain, Italy, New Zealand and Japan. Furthermore, the German experience of stable and small country specific contributions over the entire sample is consistent with the notion that effective domestic policies generate only small variations in inflation.

In the most recent period of inflation stability, the contribution of national and international features to the variance of inflation has fallen in most countries. We find that the decline in inflation predictability, which earlier contributions have documented for the U.K. and U.S. since the mid-1980s, is in fact an international common feature of the industrialized world.

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Appendix A: priors and estimation

Consider the time varying factor model in (1) and (2).

Prior distributions and starting values

Factors and factor loadings

Following Bernanke, Boivin and Elias (2005), we center our prior on the factors (and obtain starting values) by using a Principal Component (PC) estimator applied to the inflation series for each country. The covariance of the states ($P_{0/0}$) is set equal $I_{0.01}$ where I_n denotes an identity matrix with n on the main diagonal.

Starting values for the factor loadings are also obtained from the PC estimator. The prior on the diagonal elements of R is assumed to be inverse gamma:

$$R_{ii} \sim IG(3, 0.001)$$

In choosing a diffuse prior, we closely follow Bernanke, Boivin and Elias (2005).

AR coefficients

Following Del Negro and Otrok (2005) we treat the initial conditions for the AR coefficients Φ_0 and ρ_0 as an additional parameter and add a step in the Gibbs sampling procedure to estimate them.

Elements of Σ_t

The prior for the diagonal elements of the covariance matrix (see equation 4 and 5) is as follows:

$$\begin{aligned} \ln \Sigma_0 &\sim N(\ln \mu_0, I) \\ \ln R_0 &\sim N(\ln R_0, I) \end{aligned}$$

where μ_0 and R_0 are set equal to 0.1.

Hyperparameters

The prior on Q and q is assumed to be inverse Wishart

$$\begin{aligned} Q_0 &\sim IW(\bar{Q}_0, T_0) \\ q_0 &\sim IW(\bar{q}_0, T_0) \end{aligned}$$

where \bar{Q}_0 and \bar{q}_0 is assumed to be $I_{1 \times 10^{-3}}$ and T_0 is the length of the sample used to obtain starting values for the algorithm.

In line with Cogley and Sargent (2002), we postulate an inverse-Gamma distribution for the elements of G and g (denoted as $\sigma_{G,j}^2$ and $\sigma_{g,i}^2$),

$$\begin{aligned} \sigma_{G,j}^2 &\sim IG\left(\frac{10^{-4}}{2}, \frac{1}{2}\right) \\ \sigma_{g,i}^2 &\sim IG\left(\frac{10^{-4}}{2}, \frac{1}{2}\right) \end{aligned}$$

Simulating the posterior distributions

Factors and factor loadings

This closely follows Bernanke, Boivin and Elias (2005). Details can also be found in Kim and Nelson (2000).

Factors The distribution of the factors F_t is linear and Gaussian:

$$\begin{aligned} F_{T \setminus X_{i,t}, R_t, \Xi} &\sim N(F_{T \setminus T}, P_{T \setminus T}) \\ F_t \setminus F_{t+1}, X_{i,t}, R_t, \Xi &\sim N(F_{t \setminus t+1, F_{t+1}}, P_{t \setminus t+1, F_{t+1}}) \end{aligned}$$

where $t = T - 1, \dots, 1$, Ξ denotes a vector that holds all the other parameters and:

$$\begin{aligned} F_{T \setminus T} &= E(F_{T \setminus X_{i,t}, R_t, \Xi}) \\ P_{T \setminus T} &= Cov(F_{T \setminus X_{i,t}, R_t, \Xi}) \\ F_{t \setminus t+1, F_{t+1}} &= E(F_t \setminus X_{i,t}, R_t, \Xi, F_{t+1}) \\ P_{t \setminus t+1, F_{t+1}} &= Cov(F_t \setminus X_{i,t}, R_t, \Xi, F_{t+1}) \end{aligned}$$

As shown by Carter and Kohn (2004), the simulation proceeds as follows. First we use the Kalman filter to draw $F_{T\setminus T}$ and $P_{T\setminus T}$ and then proceed backwards in time using:

$$F_{t|t+1} = F_{t|t} + P_{t|t}P_{t+1|t}^{-1} (F_{t+1} - F_t)$$

$$P_{t|t+1} = P_{t|t} - P_{t|t}P_{t+1|t}^{-1}P_{t|t}$$

If more than one lag of the factors appears in the transition equation, this procedure has to be modified to take account of the fact that the covariance matrix of the shocks to the transition equation (used in the filtering procedure described above) is singular. For details see Kim and Nelson (2000).

Elements of R As in Bernanke, Boivin and Elias (2005), R is a diagonal matrix. The diagonal elements R_{ii} are drawn from the following inverse gamma distribution:

$$R_{ii} \sim IG(\bar{R}_{ii}, T + 0.001)$$

where

$$\bar{R}_{ii} = 3 + \hat{e}'_i \hat{e}_i + \beta'_i \left[\bar{M}_0^{-1} + (F'_{i,t} F_{i,t})^{-1} \right]^{-1} \beta_i$$

and $M_0 = I$.

Elements of β The factor loadings are sampled from

$$\beta_i \sim N(\bar{\beta}_i, R_{ii} \bar{M}_i^{-1})$$

where $\bar{\beta}_i = \bar{M}_i^{-1} (F'_{i,t} F_{i,t}) \hat{\beta}_i$, $\bar{M}_i = \bar{M}_0 + (F'_{i,t} F_{i,t})$ and $\hat{\beta}_i$ represents an OLS estimate.

Time varying AR

Given an estimate for the factors, the model becomes an AR model with drifting coefficients and covariances. This model has become fairly standard in the literature and details on the posterior distributions can be found in a number of papers including Cogley and Sargent (2005), Primiceri (2005) and Benati and Mumtaz (2007). Here, we describe the algorithm briefly.

AR coefficients Φ_t As in the case of the unobserved factors, the time varying AR coefficients are drawn using the methods described in Carter and Kohn (2004). Following Del Negro and Otrok (2005) we add an additional step in the sampler to estimate the initial condition Φ_0 and ρ_0 . Starting from a prior for $\Phi_0 \sim N(\bar{\Phi}_0, \bar{V}_0)$ and $\rho_0 \sim N(\bar{\rho}_0, \bar{v}_0)$ obtained via OLS regressions on the pre-sample 1961Q1-1972Q4, we obtain the posterior estimate of Φ_0 and ρ_0 by updating the mean and variance $\bar{\Phi}_0, \bar{V}_0$ and $\bar{\rho}_0, \bar{v}_0$ using the methods described in Carter and Kohn (2004).

Note that we require the roots of the AR process to be inside the unit circle for each t .

Elements of Σ_t and R_t Following Cogley and Sargent (2005) and Benati and Muntaz (2007), the diagonal elements of the AR covariance matrix are sampled using the methods described in Jacquier, Polson and Rossi (2004).

Hyperparameters Conditional on $F_t, \Phi_{j,t}$ and Σ_t , the innovations to $\Phi_{j,t}$ and Σ_t are observable, which allows us to draw the hyperparameters—the elements of Q, G and q and g —from their respective distributions.

Appendix B: data

Description of Variables

No.	Description	Country
1	CPI	UK
2	PPI / WPI	UK
3	RPI Total Food	UK
4	RPI Total Non-Food	UK
5	RPI Total All items other than seasonal Food	UK
6	GDP Deflator	UK
7	QMA Data	UK
8	Total Wages and Salaries	UK
9	METALS	UK
10	AGR. RAW MATERIALS	UK
11	BEVERAGES	UK
12	FOOD	UK
13	Petroleum Average Crude Pounds Per barrel	UK
14	CPI	US
15	US CAPITAL EQUIPMENT	US
16	US CPI - ALL ITEMS LESS FOOD	US
17	US CPI - ALL ITEMS LESS ENERGY	US
18	US CPI - ALL ITEMS LESS FOOD and ENERGY	US
19	US CPI - DURABLES	US
20	US CPI - NEW VEHICLES	US
21	US CPI - SERVICES	US
22	US EXPORT PRICES	US
23	US GDP DEFLATOR VOLN	US
24	US IMPLICIT PRICE DEFLATOR - GNP	US
25	US IMPORT PRICES	US
26	US PPI - COMMERCIAL ELECTRIC POWER	US
27	US PPI - COAL	US
28	US PPI - CRUDE FUEL	US
29	US PPI - ELECTRICAL MACHINERY and EQUIPMENT	US
30	US PPI - IRON and STEEL	US
31	SD CPI - FOOD	SW
32	SD CPI - HOUSING, FUEL and ELECTRICITY	SW
33	ES CPI	SP
34	ES EXPORT UNIT VALUE	SP
35	ES CPI - RENT	SP
36	ES IMPORT UNIT VALUE	SP
37	ES PPI	SP
38	ES PPI - MANUFACTURING ALL ITEMS	SP
39	ES PPI WPI	SP
40	NZ CPI	NZ
41	NZ CPI - ENERGY	NZ
42	NZ CPI - HOUSING	NZ
43	NZ CPI: FOOD (QUARTERLY)	NZ
44	NZ EXPORT PRICE - BUTTER	NZ
45	NZ EXPORT PRICE INDEX	NZ
46	NZ EXPORT PRICE INDEX: DAIRY PRODUCTS	NZ
47	NZ EXPORT PRICE INDEX: MEAT	NZ
48	NZ EXPORT PRICE INDEX: MEAT, WOOL and BY-PRODUCTS	NZ
49	NZ EXPORT PRICE INDEX: PASTORAL and DAIRY PRODUCTS	NZ
50	NZ INFLATION RATE	NZ
51	NZ MARKET PRICE - LAMB, NEW ZEALAND (LONDON)	NZ
52	NZ PPI	NZ
53	NZ PPI - MANUFACTURING	NZ
54	NZ PPI WPI	NZ
55	NL CPI	NL
56	NL CPI - ENERGY	NL
57	NL CPI - EXCLUDING FOOD and ENERGY	NL
58	NL CPI - FOOD	NL
59	NL CPI: RENT INCLUDING IMPUTED RENT	NL
60	NL PPI	NL
61	NL PPI - OUTPUT	NL
62	NL EXPORT UNIT VALUE	NL
63	NL IMPORT UNIT VALUE	NL
64	NL PPI WPI	NL
65	JP CPI	JP
66	JP CPI - ENERGY	JP
67	JP DOMESTIC CORP.GOODS PRICE INDEX-CHEMICALS and RELATED PRODS.	JP
68	JP DOMESTIC CORP.GOODS PRICE INDEX-ELECTRICITY, GASand WATER	JP
69	JP DOMESTIC CORP.GOODS PRICE INDEX-GENERAL MACHINERY and EQUIP.	JP
70	JP DOMESTIC CORP. GOODS PRICE INDEX - METAL PRODUCTS	JP
71	JP DOMESTIC CORP.GOODS PRICE INDEX-PULP,PAPER and RELATED PRDS.	JP
72	JP DOMESTIC CORP.GOODS PRICE INDEX-PETROLEUM and COALPRODS.	JP

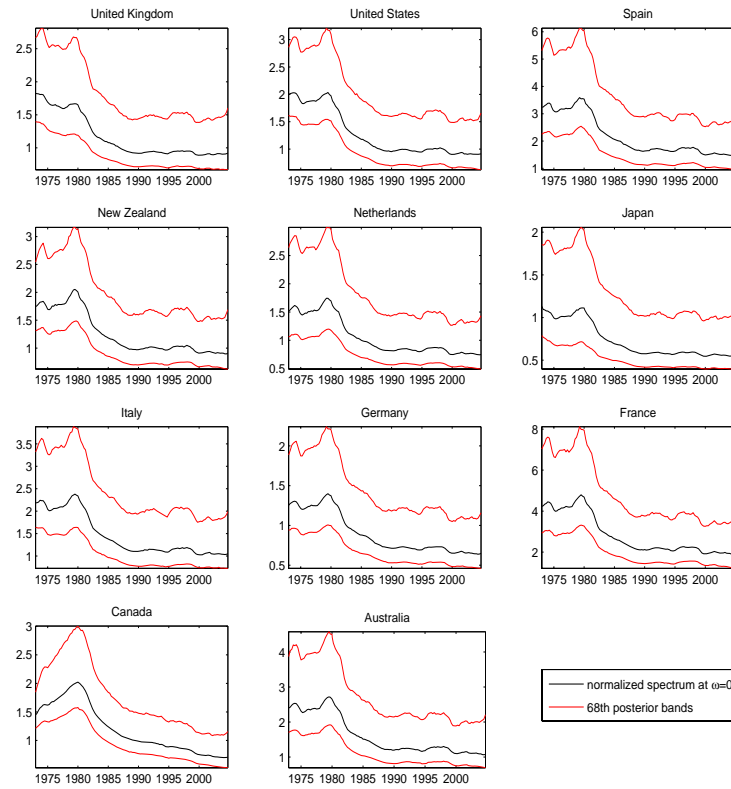
Description of Variables (continued...)

No.	Description	Country
73	JP IMPORT UNIT VALUE	JP
74	JP MONTHLY EARNINGS - MANUFACTURING	JP
75	JP PPI - IRON and STEEL	JP
76	JP PPI - CHEMICALS and CHEMICAL PRODS	JP
77	JP PPI - MANUFACTURING	JP
78	JP UNIT LABOUR COST - MANUFACTURING	JP
79	JP WAGE INDEX: CASH EARN. - MANUFACTURING (SEE JPWAMFROE)	JP
80	IT CPI	IT
81	IT CPI - ENERGY	IT
82	IT CPI - EXCLUDING FOOD and ENERGY	IT
83	IT CPI - FOOD	IT
84	IT CPI - HOUSING	IT
85	IT CPI - SERVICES LESS HOUSING	IT
86	IT CPI EXCLUDING TOBACCO (FOI)	IT
87	IT CPI INCLUDING TOBACCO (NIC)	IT
88	IT HOURLY WAGE RATE : INDUSTRY	IT
89	BD CPI	GER
90	BD CPI - FOOD AND ALCOHOL-FREE DRINKS (EXCL. REST)	GER
91	BD EXPORT PRICES	GER
92	BD HOURLY EARNINGS: MANUFACTURING	GER
93	BD IMPORT UNIT VALUE	GER
94	BD PERSONAL SAVINGS RATIO (PAN BD Q0191)	GER
95	BD PPI	GER
96	BD WAGE and SALARY RATES: MONTHLY-OVERALL ECONOMY(PANBD M0191)	GER
97	BD WHOLESALE OUTPUT PRICE INDEX REBASED TO 1975=100	GER
98	BD WPI	GER
99	FR CPI	FR
100	FR CONSTRUCTION COST INDEX - RESIDENTIAL PROPERTY	FR
101	FR CPI - ENERGY	FR
102	FR CPI - EXCLUDING FOOD and ENERGY	FR
103	FR CPI - FOOD	FR
104	FR CPI - SERVICES EXCLUDING RENT	FR
105	FR EXPORTS (IN US\$)	FR
106	FR HOURLY WAGE RATE: INDUSTRY	FR
107	FR HOURLY WAGE RATES ALL ACTIVITIES	FR
108	FR IMPORT PRICE - GRADE A SETTLEMENT LEATHER (LONDON)	FR
109	FR IMPORT PRICE - GRAIN (CHICAGO)-PRICE PER 60 POUND BUSHEL	FR
110	FR IMPORT PRICE - SETTLEMENT LEAD (LONDON)	FR
111	FR IMPORT PRICE - SETTLEMENT ZINC (LONDON)	FR
112	FR IMPORTS CIF (IN US\$)	FR
113	FR PPI - AGRICULTURAL GOODS	FR
114	FR PPI - METAL PRODUCTS	FR
115	FR PPI - MANUFACTURED PRODUCTS	FR
116	FR PPI - INTERMEDIATE GOODS EXCLUDING ENERGY	FR
117	FR PPI- IMPORTED RAW MATERIALS	FR
118	FR WAGE RATE : HOURLY - MANUAL WORKERS	FR
119	FN CPI	FI
120	FN CPI - ENERGY	FI
121	FN CPI - EXCLUDING FOOD and ENERGY	FI
122	FN CPI - FOOD	FI
123	FN CPI - HOUSING	FI
124	FN EXPORT UNIT VALUE	FI
125	FN EXPORTS (IN US\$)	FI
126	FN HOURLY EARNINGS - MANUFACTURING	FI
127	FN IMPORTS CIF (IN US\$)	FI
128	FN PPI	FI
129	CN CPI	CN
130	CN CPI - EXCLUDING FOOD and ENERGY	CN
131	CN CPI - SERVICES EXCLUDING RENT	CN
132	CN CPI ENERGY	CN
133	CN CPI: ALCOHOLIC BEVERAGES and TOBACCO PRODUCTS	CN
134	CN CPI: ALL ITEMS EXCLUDING FOOD	CN
135	CN CPI: ALL ITEMS EXCLUDING FOOD and ENERGY	CN
136	CN CPI: DURABLE GOODS	CN
137	CN CPI: FOOD	CN
138	CN CPI: GASOLINE	CN
139	CN CPI: GOODS	CN
140	CN CPI: HOUSING	CN
141	CN CPI: NONDURABLE GOODS	CN
142	CN EXPORTS (IN US\$)	CN
143	CN GDP (IMPLICIT PRICE DEFLATOR)	CN
144	CN HOURLY EARNINGS - MANUFACTURING	CN
145	CN IMPORTS CIF (IN US\$)	CN
146	CN INDUSTRIAL PRICE INDEX: ALL COMMODITIES	CN
147	CN INDUSTRIAL PRICE INDEX:BLEACHED SULPHATE WOODPULP	CN
148	CN INDUSTRIAL PRICE INDEX:LINER BOARD	CN

Description of Variables (continued...)

No.	Description	Country
149	CN INDUSTRIAL PRICE INDEX:LUMBER and TIES, SOFTWOOD	CN
150	CN INDUSTRIAL PRICE INDEX:NEWSPRINT PAPER	CN
151	CN MARKET PRICE - ALUMINUM, CANADA (UK)	CN
152	CN MARKET PRICE - NICKEL, LONDON METALS EXCHANGE, SPOT, CIF	CN
153	CN MARKET PRICE-POTASH,FOB CANADA(VANCOUVER)(AVG OF DAILIES)	CN
154	CN PPI	CN
155	AU CPI	AUS
156	AU EXPORT PRICES	AUS
157	AU GDP DEFLATOR VOLN	AUS
158	AU GFCF:PRIVATE - DWELLINGS (IPD)	AUS
159	AU GDP (IMPLICIT PRICE DEFLATOR)	AUS
160	AU IMPORT PRICES	AUS
161	AU MARKET PRICE - BEEF, ALL ORIGINS (US PORTS)	AUS
162	AU GFCF:PRIVATE - MACHINERY (IPD)	AUS
163	AU GFCF:PUBLIC (IPD)	AUS
164	AU PPI	AUS

Appendix C: inflation persistence



Evolving inflation persistence: 68th central posterior bands