Monetary Policy and the Great Inflation: A Multi-Country Time-Varying Analysis Using the Taylor Rule

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Abstract

This paper is motivated by the observation that the Great Inflation, i.e., the high and volatile inflation that developed in the mid 1960s and lasted for almost twenty years, was an international phenomenon. For the US, the argument criticizing monetary policy has it that the Federal Reserve followed an accommodative policy during the 1970s, although it later changed its policy, fought inflation and managed to lower it to moderate levels. We examine how the weights in a forward looking Taylor rule change over time, and we study the above argument for the G7 countries. More interestingly, we explore whether the G7 countries implemented similar changes to their policies during the period of the Great Inflation. To do this, we develop a generalized Bayesian time-varying parameter model to jointly estimate the G7 monetary authorities' response to inflation. We allow these responses to be correlated across countries, capturing common information, ideas or communication across them. We find that monetary authorities in the G7 countries accommodated inflation until almost the mid 1980s, after which they systematically fought it. Furthermore, we find that the correlation of the policy changes in response to inflation across countries is positive. This commonality among otherwise different economies may be responsible for the common inflation patterns observed during the Great Inflation era.

1 Introduction

From the mid-1960s until the mid-1980's United States experienced high and volatile inflation. As figure 1 shows, after 1965 the CPI inflation started increasing, reaching 6% in 1969 and peaking at 13% in 1980. In the literature, there have been presented many explanations why this phenomenon took place and lasted for almost twenty years. However, figure 2 depicts the fact that Great Inflation was an international phenomenon, affecting all the $G7$ countries. We explore the Great Inflation era as an international phenomenon and we attempt to gather information from the international experience in order to contribute towards identifying its cause. Some of the important explanations studied earlier in the literature, mostly concerning the US Great Inflation, are presented bellow.

Sargent (1999), Cogley and Sargent (2005) and Sargent, Williams and Zha (2006) argue that the Great Inflation was promoted by the monetary authorities changing views about the natural rate hypothesis. After Samuelson and Solow's (1960) observation that the US data exhibit a Philips curve similar to that of the UK, policy makers attempted to exploit the relationship between inflation and unemployment, allowing inflation to increase. Later, monetary authorities learned that the Philips curve is not an exploitable relationship and that unemployment cannot be permanently reduced by allowing inflation to increase. They followed tighter policies and reduced inflation to moderate levels. As Nelson (2005) notes, this argument would imply that in a Taylor type of monetary rule only the inflation target changes. While Ireland (2005) finds that inflation target indeed rose dramatically during the Great Inflation era in the US, Nelson argues that this is not the entire story and that the response to inflation changed too and this information should be taken into account when a Taylor type of rule is estimated.

Meltzer (2005) bases his explanation of the Great Inflation era on the Fed's coordination with the Treasury. He argues that while the monetary authorities knew that inflation should not be as high and were ready to take action to reduce it, they did not do so because of the political pressure the Fed was subject to. Meltzer points out the role of even keel policy and deficit financing by reserves that the Fed was providing at that period. He argues that the Great Inflation started when the Fed's coordination was becoming necessary for the government, and ended when the Fed became independent. However, Romer's (2005) analysis of Greenbook forecast errors for inflation indicate that monetary authorities were underestimating future inflation or they were overestimating the effects of the policies they were following to reduce inflation for the Great Inflation period. Therefore, she claims that an argument based merely on the political pressure the FED was experiencing is not adequate for justifying the Great Inflation era. In addition she claims that the international experience, captured by figure 2, suggests that there is some common behavior in the inflation pattern of the G7 countries, implying common monetary policy behavior. And the narrative evidence does not indicate that all central banks' independence from the governments happened at the same time. Romer suggests that common bad ideas gave rise to bad monetary policy in all developed countries during the seventies, while improved ideas contributed towards better policy during the eighties.

Clarida, Galí and Gertler (2000) use a forward-looking Taylor-type rule to show that self- fulfilling expectations may arise when the Fed reacts less than one-to-one to an increase in inflation expectations. In this case, people expect high inflation because they believe that the Fed will follow accommodating policy. This creates a bubble in inflation expectations, which leads to increases in actual inflation. Clarida et al. (2000) split the US data sample and estimate a Taylor-type of rule, before and after 1979. Their findings suggest that during the pre-Volker era the monetary authorities were reacting less than to one to inflation, creating possible expectations trap and increasing inflation, an effect of the 1973 oil-sunspot shock. The analysis of the post-Volker sample shows that policy makers were responding more than one -to-one to inflation, shutting down the expectations bubble channel and managing to reduce inflation to moderate levels.

Orphanides (2004) emphasizes the effects that the potential output mismeasurement have in Taylor rule estimations. According to his hypothesis, policy makers were responding correctly to a mistakenly overestimated potential output. Oprhanides supports his argument using real time data for his estimations. He argues that policy makers were following expansionary policy in response to a far bellow potential perceived output gap and not as response to inflation. His estimation strategy suggests that policy makers were responding by more than one-to-one to inflation, before and after Volker took office.

However, Nelson (2005) argues that this is not the case. Policy makers at that period were not associating high output gap with low inflation, but they were attributing inflation to other, non monetary sources like cost push factors. He supports his claim using both the narrative approach and empirics. He proposes another explanation, the "monetary neglect hypothesis", according to which there are various planks one can identify in the pre-Volker monetary policy. For example there is narrative evidence that inflation was believed to be a cost-push and not a monetary phenomenon and also that monetary authorities were unable to influence monetary variables that affect the real economy. Using various sources he identifies these bad ideas in other countries too. This argument has been also supported by Romer's (2005).

We consider the Great Inflation as an international phenomenon and attempt a joint multi-country estimation of forward looking Taylor rules. We allow monetary authorities to change their policy over time employing a time varying parameter framework. As there might be reasons for monetary authorities across developed countries to follow similar policies, we allow the changes in monetary policy to be correlated across countries. Such specification allows us to be consistent with aforementioned explanation for Great Inflation and conduct of monetary policy. For example, our framework is compatible with Sargent (1999), Romer (2005) and Nelson (2005) as it captures the case where misleading ideas were prevailing among monetary economic researchers at the beginning of the Great Inflation era. Ideas spread around the developed countries driving their monetary authorities to follow accommodating inflation policies. At the beginning of the 80's new ideas became influential and in combination with the urgent necessity to reduce inflation, monetary authorities changed their policies in a similar way and managed to reduce inflation in temperate levels. In general, our framework accounts for common information, ideas, communication or any other reason for common monetary policy reaction, besides economic shocks affecting inflation and output gap.

We proceed by estimating the monetary authorities' response to inflation, using Kim and Nelson (2006) time varying parameter framework. We depart from them in that we are applying Bayesian methods and that we jointly estimate Taylor-type of rules in various developed countries. We allow the shocks the monetary authorities realize in their learning process to be correlated with these realized by their fellow policy makers in other developed countries. These correlations capture the effect of common information, ideas or maybe communication across monetary authorities in the G7 countries, which might have been important for the central banks' policy decisions. This approach allows us to compare the response to inflation the various countries were having over time and also to estimate how these responses are correlated across countries.

We find that the G7 countries have not only similar inflation patterns but also similar monetary policy patterns. We find low response to inflation during the seventies and higher response during the nineties. Moreover, we find this result to be robust for the G7 countries which were changing their policy in a similar to each other way. Until the beginning of the 80's monetary authorities were reluctant to increase money market rates in response to high inflation, something that later changed and higher response to inflation for many developed countries is realized. In addition, it seems that monetary authorities in the G7 countries have positive correlation in their inflation responses, indicating that there is a common component in policy around the developed world.

2 The Model

Our model is based on Kim and Nelson(1989, 2006) time-varying parameters model, extended to jointly estimate Taylor type of rules for more than one country and to calculate the covariance of the responses between countries. In addition the estimation is done using Gibbs-Sampling instead of maximum likelihood.

2.1 One Country Model

This version is based on Kim and Nelson (2006), allowing for interest rate smoothing which creates non-linearity in estimated coefficients. We account for endogeneity in the regressors and implement instrumental variables estimation and also allow for heteroscedasticity, by assuming a break in the variance-covariance matrix. This allows to account for Sims and Zha (2006) critique.

We consider a forward-looking Taylor-type rule where the target money market rate $r^*_{i,t}$ and the actual money market rate $r_{i,t}$ for country i are specified as follows:

$$r^*_{i,t} = \beta^*_{0,i,t} + \beta_{1,i,t}(E_t(\pi_{i,t,J}) - \pi^*_{i,t}) + \beta_{2,i,t}E_t(y_{i,t,J}), \tag{1}$$

and

$$r_{i,t} = (1 - \theta_{i,t})r^*_{i,t} + \theta_{i,t}r_{i,t-1} + m_{i,t}, \quad 0 < \theta_t < 1, \tag{2}$$

where for country i, $\pi^*_{i,t}$ is the target inflation rate, $\pi_{i,t,J}$ is the inflation rate from period t to period $t + J$, $y_{i,t,J}$ is the average output gap from period t to period $t + J$ and $\beta^*_{0,i,t}$ is the target money market rate when both inflation and output gap are equal to their target values. By $\theta_{i,t}$ we denote the smoothing parameter, which is also time varying and $m_{i,t}$ is a random disturbance term.

From (1) and (2) we obtain the measurement equation of our state-space model:

$$r_{i,t} = (1-\theta_{i,t})(\beta_{0,i,t}+\beta_{1,i,t}\pi_{i,t}+\beta_{2,i,t}y_{i,t})+\theta_{i,t}r_{i,t-1}+e_{i,t}, \quad e_{i,t} \sim i.i.d.N(0, \sigma^2_{e_i}), \tag{3}$$

where we assume that $J = 1$. For country i, $\pi_{i,t}$ denotes the current inflation rate and $y_{i,t}$ the average output gap at the current period. Also:

$$\beta_{0,i,t} = \beta^*_{0,i,t} - \beta_{1,i,t}\pi^*_{i,t} \tag{4}$$

and

$$e_{i,t} = (1 - \theta_{i,t})[\beta_{1,i,t}(\pi_{i,t} - E_t(\pi_{i,t,1})) + \beta_{2,i,t}(y_{i,t} - E_t(y_{i,t,1}))] + m_{i,t} \quad (5)$$

The state space model consists of the measurement equation (3) and the transition equation specified bellow. The time varying coefficients follow random walk dynamics, so a central bank has the same behavior as the previous period, allowing for the effect of a possible random shock,

$$\beta_{k,i,t} = \beta_{k,i,t-1} + \epsilon_{k,i,t}, \quad \epsilon_{k,i,t} \sim i.i.d.N(0, \sigma^2_{\epsilon,k,i}), \quad i = 0, 1, 2, 3. \quad (6)$$

In addition, the smoothing parameter θ is constrained to take values between 0 and 1, as follows:

$$\theta_{i,t} = \frac{1}{1 + exp(-\beta_{3,i,t})}, \quad (7)$$

2.1.1 Heteroscedastic Disturbances

Sims and Zha (2006) argue that the most important factor in the US interest rate instability is the time varying disturbances' variance and not the time varying parameters in the monetary policy reaction equation. Then, whenever the changing variance for the error term is not taken into account, spurious variation is picked by the time varying parameters. To account for these effects, we include a break at the variance of the Taylor's rule disturbance term ($\epsilon_{k,i,t}$), assumed to occurred at the third quarter of 1979. This is when Paul Volcker become chairman and changed the US inflation policy. We do assume that the break occurs at the same time for all the G7 countries. Possible extension of the model includes estimation of break dates for each country separately. Then, for the estimation, we replace equation (6) by equation (8) bellow:

$$r_{i,t} = (1-\theta_{i,t})(\beta_{0,i,t}+\beta_{1,i,t}\pi_{i,t}+\beta_{2,i,t}y_{i,t})+\theta_{i,t}r_{i,t-1}+e_{i,t}, \quad e_{i,t} \sim i.i.d.N(0, \sigma^2_{e_{i,t}}), \quad (8)$$

where for $t \leq 1979:3$

$$\sigma^2_{e_{i,t}} = \sigma^2_{e_{i,A}}$$

and for $t > 1979:4$

$$\sigma^2_{e_{i,t}} = \sigma^2_{e_{i,B}}$$

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2.1.2 Regressors' Endogeneity

In equation (3) the regressors are correlated with the error term $e_{i,t}$, as given by equation (5). To manage the endogeneity issue we use an instrumental variable application, specified bellow:

Let $z_{i,t}$ be a vector of instruments. We specifically use four lags of inflation, output gap, M2 and interest rate spread. Then:

$$\pi_{i,t} = z'_{i,t}\delta_{1,i} + v_{1,i,t}, \quad v_{1,i,t} \sim i.i.d.N(0, \sigma^2_{v,1,i}) \tag{9}$$

and

$$y_{i,t} = z'_{i,t}\delta_{2,i} + v_{2,t}, \quad v_{2,t} \sim i.i.d.N(0, \sigma^2_{v,2,i}). \tag{10}$$

Equations (9) and (10) can be decomposed in two pieces: The predicted part and the prediction error:

$$\begin{bmatrix} \pi_{i,t} \\ y_{i,t} \end{bmatrix} = E(\begin{bmatrix} \pi_{i,t}|t-1 \\ y_{i,t}|t-1 \end{bmatrix}) + \begin{bmatrix} v_{1,i,t|t-1} \\ v_{2,i,t|t-1} \end{bmatrix},$$

where

$$\begin{bmatrix} v_{1,i,t|t-1} \\ v_{2,i,t|t-1} \end{bmatrix} = \Omega^{1/2} \begin{bmatrix} v^*_{1,i,t} \\ v^*_{2,i,t} \end{bmatrix}, \tag{11}$$

$$\begin{bmatrix} v^*_{1,i,t} \\ v^*_{2,i,t} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\right)$$

Ω denotes the variance covariance matrix of the prediction errors' vector, $v_{i,t|t-1} = \begin{bmatrix} v_{1,i,t|t-1} \\ v_{2,i,t|t-1} \end{bmatrix}$.

With no loss of generality we assume, as Kim (2006) that the relationship of the measurement equation's error term, $e_{i,t}$ and the standardized prediction error $v^*_{i,t} = \begin{bmatrix} v^*_{1,i,t} \\ v^*_{2,i,t} \end{bmatrix}$ is given as:

$$\begin{bmatrix} v^*_{i,t} \\ e_{i,t} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} I_2 & \rho_{i,t}\sigma_{\epsilon,i,t} \\ \rho'_{i,t}\sigma_{\epsilon,i,t} & \sigma^2_{\epsilon,i,t} \end{bmatrix}\right)$$

where $\rho'_{i,t} = [\rho_{1,i,t} \quad \rho_{2,i,t}]$.

The Cholesky decomposition of the variance covariance matrix above results in:

$$\begin{bmatrix} v_{i,t}^* \\ e_{i,t} \end{bmatrix} = \begin{bmatrix} I_2 & 0_2 \\ \rho_{i,t}'\sigma_{\epsilon,i,t} & \sqrt{(1-\rho_{i,t}'\rho_{i,t})}\sigma_{\epsilon,i,t} \end{bmatrix} \begin{bmatrix} \epsilon_{i,t} \\ \omega_{i,t} \end{bmatrix},$$

$$\begin{bmatrix} \epsilon_{i,t} \\ \omega_{i,t} \end{bmatrix} \sim N\left(\begin{pmatrix} 0_2 \\ 0 \end{pmatrix}, \begin{pmatrix} I_2 & 0_2 \\ 0_2' & 1 \end{pmatrix} \right)$$

Then $e_{i,t}$ can be re-written as the sum of components correlated with the endogenous regressors and an exogenous part $\omega_{i,t}$:

$$e_{i,t} = \alpha_{1,i,t}\hat{v_{1,i,t}^*} + \alpha_{2,i,t}\hat{v_{2,i,t}^*} + \omega_{i,t} \tag{12}$$

where $\alpha_{j,i,t} = \rho_{j,i,t}'\sigma_{\epsilon,i,t}$ for $j = 1, 2$.

In practice, we estimate equations (9) and (10) for each country considered and find the vector $\hat{v_{i,t}}$. Then we can calculate the standardized prediction errors $\hat{v_{i,t}^*}$ through equation (11). Finally, we estimate:

$$r_{i,t} = (1-\theta_{i,t})(\beta_{0,i,t}+\beta_{1,i,t}\pi_{i,t}+\beta_{2,i,t}y_{i,t})+\theta_{i,t}r_{i,t-1}+\alpha_{1,i,t}\hat{v_{1,i,t}^*}+\alpha_{2,i,t}\hat{v_{2,i,t}^*}+\omega_{i,t} \tag{13}$$

where $\omega_{i,t} \sim i.i.d.N(0, \sigma_{\omega,i,t}^2)$ is uncorrelated with the regressors.

Letting $l = 1, 2$, the break implies that for $t < 1979:3$

$$\alpha_{l,i,t} = \alpha_{l,i,A}, \quad \sigma_{\omega,i,t}^2 = \sigma_{\omega,i,A}^2,$$

and for $t < 1979:3$

$$\alpha_{l,i,t} = \alpha_{l,i,B}, \quad \sigma_{\omega,i,t}^2 = \sigma_{\omega,i,B}^2.$$

2.1.3 Non-linear Estimation

Equation (13) is non-linear in the coefficients we are interested in estimating. The model needs to be linearized. For that purpose we re-write equation (13) as:

$$r_{i,t} = f(x_{i,t};\beta_{i,t}) + \alpha_{1,i,t}\hat{v_{1,i,t}^*} + \alpha_{2,i,t}\hat{v_{2,i,t}^*} + \omega_{i,t} \tag{14}$$

$$\beta_{i,t} = \beta_{i,t-1} + \epsilon_{i,t}, \quad \epsilon_{i,t} \sim i.i.d.N(0, Q_i), \tag{15}$$

$$Q_i = \begin{bmatrix} \sigma_{\epsilon,0,i}^2 & 0 & 0 & 0 \\ 0 & \sigma_{\epsilon,1,i}^2 & 0 & 0 \\ 0 & 0 & \sigma_{\epsilon,2,i}^2 & 0 \\ 0 & 0 & 0 & \sigma_{\epsilon,3,i}^2 \end{bmatrix} \tag{16}$$

where $\beta_{i,t} = [\beta_{0,i,t} \quad \beta_{1,i,t} \quad \beta_{2,i,t} \quad \beta_{3,i,t}]'$ and $x_t = [1 \ \ \pi_{i,t} \ \ y_{i,t} \ \ r_{i,t-1}]'$.

We use first order Taylor expansion of the function $f(x_{i,t}; \beta_{i,t})$ around $\beta_{i,t} = \beta_{i,t|t-1} = E(\beta_{i,t}|\psi_{t-1})$, where ψ_{t-1} denotes the information available at time $t-1$.
Therefore,

$$f(x_{i,t}; \beta_{i,t}) \simeq f(x_{i,t}; \beta_{i,t-1|t-1}) + \frac{\partial f(x_{i,t}; \beta_{i,t|t-1})}{\partial \beta_{i,t}} (\beta_{i,t} - \beta_{i,t|t-1}).$$

and the liberalization of equation (12) yields

$$Y_{i,t} = X'_{i,t}\beta_{i,t} + \alpha_{1,i,t}\hat{v^*_{1,i,t}} + \alpha_{2,i,t}\hat{v^*_{2,i,t}} + \omega_{i,t} \tag{17}$$

where

$$Y_{i,t} = r_{i,t} - \frac{r_{i,t-1}}{1 + exp(-\beta_{3,i,t|t-1})} +$$

$$+ \frac{(r_{i,t-1} - \beta_{0,i,t|t-1} - \beta_{1,i,t|t-1}y_{i,t} - \beta_{2,i,t|t-1}\pi i, t)exp(-\beta_{3,i,t|t-1})\beta_{3,i,t|t-1}}{(1 + exp(\beta_{3,i,t|t-1}))^2},$$

$$X_{i,t} = \begin{bmatrix} 1 - \frac{1}{1+exp(-\beta_{3,i,t|t-1})} \\ \pi_{i,t} - \frac{\pi_{i,t}}{1+exp(-\beta_{3,i,t|t-1})} \\ y_{i,t} - \frac{y_{i,t}}{1+exp(-\beta_{3,i,t|t-1})} \\ \frac{(r_{i,t-1} - \beta_{0,i,t|t-1} - \beta_{1,i,t|t-1}y_{i,t} - \beta_{2,i,t|t-1}\pi i, t)exp(-\beta_{3,i,t|t-1})}{(1+exp(\beta_{3,i,t|t-1}))^2} \end{bmatrix} = \begin{bmatrix} f(c_{i,t}) \\ f(\pi_{i,t}) \\ f(y_{i,t}) \\ f(r_{i,t-1}) \end{bmatrix} \tag{18}$$

2.2 Multi Country Model: G7

We now extend the above model to take into account information shared among countries, in the following way. The measurement equation is

$$Y_t = X_t\beta_t + \Lambda'_t\hat{v}^*_t + \omega_t \quad \omega_t \sim i.i.d.N(0, R_t), \tag{19}$$

$$R_t = \begin{cases} R_A & \text{for } t \leq 1979:3 \\ R_B & \text{for } t > 1979:4 \end{cases}, \tag{20}$$

and the transition equation is

$$\beta_t = \beta_{t-1} + \epsilon_t, \quad \epsilon_t \sim i.i.d.N(0, Q), \tag{21}$$

We illustrate the case of 2 countries: $\omega_t = [\omega_{1,t} \quad \omega_{2,t}]'$ and R_t is a diagonal matrix with $\{\sigma_{\omega,A}\}^2_i$ for $t \leq 1979:3$ and $\{\sigma_{\omega,B}\}^2_i$ for $t > 1979:4$. The remaining variables are defined as

$$Y_t = \begin{bmatrix} Y_{1,t} & 0 \\ 0 & Y_{2,t} \end{bmatrix}, \quad \Lambda_t = \begin{bmatrix} \alpha_{1,t} \\ \alpha_{2,t} \end{bmatrix}, \quad \hat{v}^*_t = \begin{bmatrix} \hat{v}^*_{1,t} \\ \hat{v}^*_{2,t} \end{bmatrix},$$

where

$$\hat{v}^*_{1,t} = \begin{bmatrix} \hat{v}^*_{1,1,t} & 0 \\ 0 & \hat{v}^*_{1,2,t} \end{bmatrix}, \qquad \hat{v}^*_{2,t} = \begin{bmatrix} \hat{v}^*_{2,1,t} & 0 \\ 0 & \hat{v}^*_{2,2,t} \end{bmatrix}.$$

Also

$$\alpha_{1,t} = \begin{bmatrix} \alpha_{1,1,t} \\ \alpha_{1,2,t} \end{bmatrix}, \qquad \alpha_{2,t} = \begin{bmatrix} \alpha_{2,1,t} \\ \alpha_{2,2,t} \end{bmatrix}$$

To take into account possible covariances in the responses across countries, we use a modification of the model which implies that

$$X_t = \begin{bmatrix} f(c_{1,t}) & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & f(c_{2,t}) & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & f(\pi_{1,t}) & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & f(\pi_{2,t}) & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & f(y_{1,t}) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & f(y_{2,t}) & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & f(r_{1,t-1}) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & f(r_{2,t-1}) \end{bmatrix} \tag{22}$$

and

$$\beta_{i,t} = \begin{bmatrix} \beta_{0,1,t} \\ \beta_{0,2,t} \\ \beta_{1,1,t} \\ \beta_{1,2,t} \\ \beta_{2,1,t} \\ \beta_{2,2,t} \\ \beta_{3,1,t} \\ \beta_{3,2,t} \end{bmatrix}$$

Since variance-covariance matrix, Q, in transition equation is 28×28 for 7 countries, we assume a particular structure of covariances to facilitate estimation. We allow for cross–country correlations in changing a response to target interest rate, inflation, gap, and degree of smoothing but exclude possible within-country correlation of this innovations. We can then express the variance-covariance matrix Q as a four blocks matrix

$$Q = \begin{bmatrix} Q_0 & 0 & 0 & 0 \\ 0 & Q_1 & 0 & 0 \\ 0 & 0 & Q_2 & 0 \\ 0 & 0 & 0 & Q_3 \end{bmatrix} \tag{23}$$

For our two–country example, each block Q_i is a 2×2 matrix with the variance and the covariance of the monetary policy's responses. In this way we allow for correlation of the responses across countries and we estimate this correlation.

3 Estimation

We employ Baysian estimations techniques to estimate the state space model given by equations (18) and (19). Following Kim and Nelson (1999), we assume arbitrary starting values for the models' hyperparameters and repeat the following two steps:

- Using instrumental variables equation, generate $\hat{v}^*$.
- Conditional on the hyperparameters, Q, R, Λ, and on the data, Y, generate series of states, $\tilde{\beta_T} = \{\beta_1, \ldots, \beta_T\}$.
- Conditional on $\tilde{\beta_T}$, Λ, and the data, generate the hyperparameters, Q, R.
- Conditional on β, Q, R, and the data, estimate Λ.

Bellow, we explain these two steps in more detail.

3.1 Generating $\tilde{\beta_T}$ with Kalman filter

We use the multi-move Gibbs-sampling suggested by Carter and Kohn (1994), were the vector of $\tilde{\beta_T} = \{\beta_1, \ldots, \beta_T\}$ can be generated from

$$p(\tilde{\beta_T}|\tilde{Y}_T, Q, R) = p(\beta_T|\tilde{Y}_T, Q, R)p(\beta_t|\beta_{t+1}, \tilde{Y}_t, Q, R)$$

So, to generate $\tilde{\beta_T}$, we first sample β_T from the posterior distribution $p(\beta_T|\tilde{Y}_T, Q, R)$ and then recursively, we can generate β_t from $p(\beta_t|\beta_{t+1}, \tilde{Y}_t, Q, R)$. Because of the normality assumptions accompanying our state-space model, it follows that:

$$\begin{aligned} \beta_T|\tilde{Y}_T, Q, R &\sim \mathcal{N}(\beta_{T|T}, P_{T|T}), \\ \beta_t|\beta_{t+1}, \tilde{Y}_t, Q, R &\sim \mathcal{N}(\beta_{t|t,\beta_{t+1}}, P_{t|t,\beta_{t+1}}), \end{aligned}$$

where $\beta_{T|T}, P_{T|T}, \beta_{t|t,\beta_{t+1}}, P_{t|t,\beta_{t+1}}$ can be obtain running Kalman filter. The updating procedure taking into account old and new information is as usually:

$$\begin{aligned} \beta_{t|t} &= \beta_{t|t-1} + P_{t|t-1}X_t' f_{t|t-1}^{-1}\eta_{t|t-1}, \\ P_{t|t} &= P_{t|t-1} - P_{t|t-1}X_t' f_{t|t-1}^{-1}P_{t|t-1}, \end{aligned}$$

with

$$\begin{aligned}
\beta_{t|t-1} &= \beta_{t-1|t-1}, \\
P_{t|t-1} &= P_{t|t} + Q, \\
\eta_{t|t-1} &= Y_t - Y_{t|t-1} = Y_t - X_t\beta_{t|t-1}, \\
f_{t|t-1} &= X_t P_{t|t-1} X_t' + R,
\end{aligned}$$

Finally, as we are using forward recursion, we should also take into account the information contained in β_{t+1}:

$$\begin{aligned}
\beta_{t|t,\beta_{t+1}} &= \beta_{t|t} - P_{t|t}(P_{t|t} + Q)^{-1}(\beta_{t+1} - \phi_{t|t}), \\
P_{t|t,\beta_{t+1}} &= P_{t|t} - P_{t|t}(P_{t|t} + Q)^{-1}P_{t|t}.
\end{aligned}$$

In this way we obtain the $\tilde{\beta_T}$ vector given the observed data and the models hyperparameters. We now can condition on $\tilde{\beta_T}$ to estimate the hyperparameters.

3.2 Sampling Λ and hyperparameters, Q and R

Denote $\tilde{\beta_T} = \beta$. We adopt standard conjugate priors for the variance-covariance matrix R. Specifically,

$$R^{-1} \sim W(\rho_0, Z_0).$$

The prior for each Q_i is also Wishart,

$$Q_i^{-1} \sim W_7(\nu_{0,i}, S_{0,i})$$

where Q_i^{-1}, $i = 0, 1, 2, 3$ is a 7×7 matrix.

The above estimation procedure, allows the variance covariance matrix to be blocked in four pieces, one for each of the time varying intercept, reaction to inflation, reaction to output gap and interest rate smoothing. For each of these blocks the covariances across countries can be estimated, i.e. covariances of changes in reaction to inflation across countries, or to output gap, or changes in the interest rate smoothing.

We assume Gaussian prior for Λ,

$$\Lambda \sim N(\lambda_0, L_0)$$

The posterior distributions of R^{-1}, Q^{-1}, and Λ are

$$\begin{aligned}
R^{-1}|Y, \beta, Q, \Lambda &\sim W(\rho_1, Z_1) \\
Q_i^{-1}|Y, \beta, R, \Lambda &\sim W_7(\nu_{1,i}, S_{1,i}) \\
\Lambda|Y, \beta, Q, R &\sim N(\lambda_1, L_1)
\end{aligned}$$

where

$$
\begin{aligned}
\rho_1 &= \rho_0 + T \\
Z_1 &= [Z_0^{-1} + (y - X\beta - \Lambda'\tilde{v}^*)(y - X\beta - \Lambda'\tilde{v}^*)']^{-1} \\
\nu_{1,i} &= \nu_{0,i} + T \\
S_{1,i} &= [S_{0,i}^{-1} + \sum_{t=1}^{T}(\beta_t - \beta_{t-1})(\beta_t - \beta_{t-1})']^{-1}
\end{aligned}
$$

4 Conclusions

We explore the Great Inflation era as an international phenomenon. We employ a time-varying, multi-country model of the most popular monetary policy reaction function, i.e. a version of the forward looking Taylor-rule, to explore the monetary authorities' behavior in the G7, during and after the Great Inflation era. We allow monetary authorities' responses to inflation and output gap to be correlated across countries, capturing common information, communication or shared ideas. We find that there is a common component in the way monetary policy is conducted across countries, captured by similar changes in the reaction the G7 were having towards inflation. Specifically, we find that monetary authorities were similarly accommodating inflation during the Great Inflation era and were similarly fighting inflation after the mid-eighties, possibly explaining why we observe such a similarity in inflation patterns.

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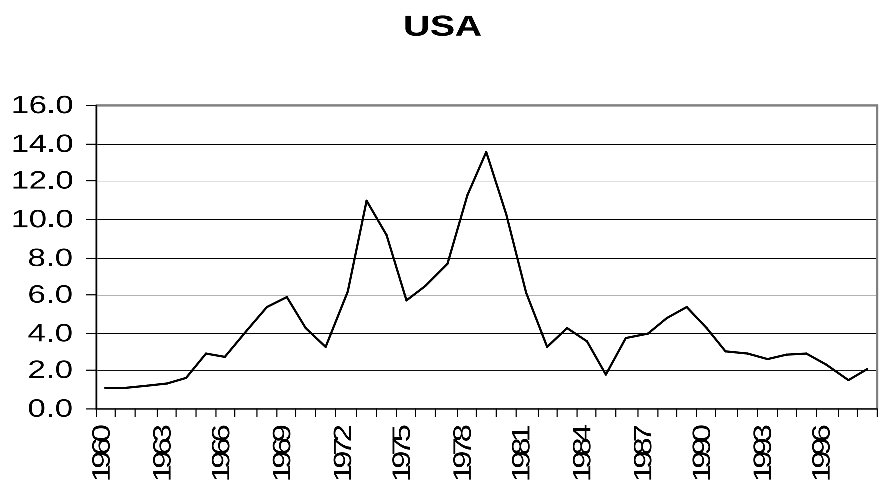
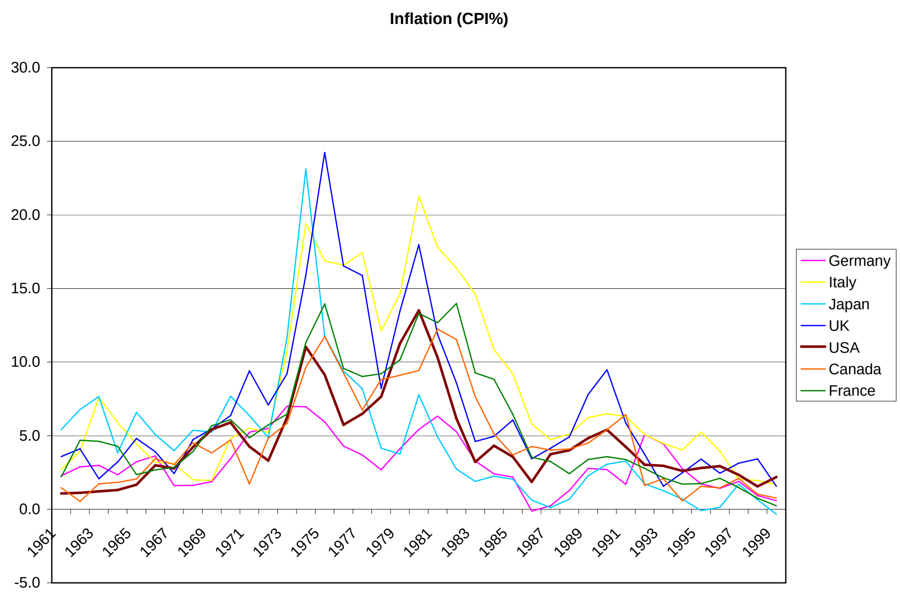
5 Appendix



USA
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996



Inflation (CPI%)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
Germany
Italy
Japan
UK
USA
Canada
France