Monetary Policy Indeterminacy Across the G7 and the Great Inflation

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Abstract

This paper estimates a New Keynesian model in order to assess the role played by monetary policy during the persistent worldwide inflation of the 1970's and 1980's. According to the model, passive monetary policy leads to equilibrium indeterminacy that is capable of generating high and volatile inflation. According to the estimates presented in this paper, monetary policy across the G7 was passive immediately preceding and during the Great Inflation, while policy was active for all G7 countries following the Great Inflation. The findings suggest that the dissolution of Bretton Woods was a necessary condition for the end of the Great Inflation; however, only Germany and Japan transitioned to low inflation immediately following the breakup of Bretton Woods.

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I. Introduction

The Great Inflation (hereafter GI) of the 1970s and 1980s was a period characterized by high and volatile inflation throughout much of the world. Following this period, the developed world has for the most part experienced both low and stable inflation coupled with relatively low output volatility (a period known as the Great Moderation). Many influential papers, such as Clarida et al. (2000), Stock and Watson (2002), Lubik and Schorfheide (2004), and Boivin and Giannoni (2006) suggest that one of the primary causes of the Great Moderation was an improvement in the way in which central banks conduct monetary policy. Specifically, a common theme among these papers is a theory that the monetary policy preceding the GI was destabilizing, while the policy that followed acted as a stabilizing force in the economy. Another common element in all of these works is that each focuses solely on the US economy.

The primary focus of this paper is to explore whether an improvement in monetary policy is capable of explaining the inflation dynamics across the developed world, or if this improved monetary policy was a feature exclusive to the US. This paper formulates and estimates a dynamic stochastic general equilibrium (DSGE) New Keynesian model, as in Lubik and Schorfheide, (2004, hereafter L&S) for each of the G7 countries. The workhorse model takes the common three equation form in which monetary policy follows a Taylor rule. The essential characteristic of the L&S New Keynesian DSGE model is that the L&S model uses a likelihood based approach to estimate the probability of indeterminacy in monetary policy rather than simply restricting estimation to the determinate region of the parameter space. This issue of indeterminacy is important as indeterminate or destabilizing monetary policy allows for the existence of multiple equilibria and the actions of the monetary authority do nothing to discourage the economy from settling into a high inflation steady state. The main empirical result of this paper is that for all G7 countries, monetary policy during the GI is consistent with indeterminate equilibria while post-GI policy leads to determinacy. These results lend support to the explanation of the GI as a period where monetary policy in G7 countries was not sufficiently aggressive in response to inflation.

One of the primary arguments offered in defense of looking solely at US monetary policy as a means of studying the global GI phenomena is the view that due to the preferential treatment of the US dollar in the Bretton Woods system, the US was able to single-handedly incite and perpetuate the worldwide inflation through rapid monetary expansion (commonly referred to as exporting inflation). This work does not disagree with the position that the Bretton Woods system was a catalyst for the GI; however, the idiosyncratic lag between the dissolution of the system and the transition to a lower inflation equilibrium for each of the G7 countries suggests that focusing solely on the policy actions of the US is somewhat myopic. This paper presents evidence that only for certain countries in the G7, specifically Japan and Germany, did the collapse of the Bretton Woods system usher in an era of hawkish monetary policy. Consequently, the perpetuation of the GI experience for each of the G7 countries beyond the collapse of the Bretton Woods system appears to be a result of the individual countries choices in conducting monetary policy.

The literature describing the worldwide inflationary episode of the 1970s and 1980s is quite extensive, although the bulk of it concentrates almost exclusively on the US inflationary experience (see Meltzer 2005 for a good overview). Only recently has there been a concerted effort to examine the effect that the Great Inflation had on the entirety of the developed world. One such work by Cecchetti et al. (2007) provides an excellent descriptive account of how the GI was manifested in each of the G7 countries. With the exception of Germany, each G7 country experienced a period of double-digit inflation during the GI.[1] Moreover, the United Kingdom, Italy, and Japan each experienced periods of inflation of at least 20%. Beyond the significant run-up of inflation in each of the G7 countries, the simultaneity with which this inflation was experienced across countries was remarkable.

Using an approach based on the variance of the inflation process, and alternatively trend inflation, Cecchetti et al. (2007) estimates that the beginning of the GI for the majority of the G7 countries was clustered around 1969 with the exception of Japan, which began experiencing high inflation significantly earlier. In addition to the contemporaneous start to the great inflation, peak inflation for each of the G7 countries was tightly clustered around the first quarter of 1975, with the exception of Germany (which had already emerged from its GI experience by this time). Table 1 contains information on the starting and ending date (as measured by trend inflation) as well as peak inflation for each of the G7 countries.[2] Despite the uniform start and peak of the GI for the G7 countries, the duration of the GI varied from a low of 5 years for Germany to over 17 years in a number of cases.

In order to make sense of macroeconomic phenomena in general, DSGE models have become widely used as of late. Frequently, in order to solve these models linear

[1] German peak inflation reached 8.3% in 1970 which although not double-digit was well above trend.

[2] I chose to use the Cecchetti et al. (2007) measure of trend inflation to date the GI across countries because it is not only a very intuitive measure, but the dates for the US correspond well to the dates used by L&S.

rational expectations are applied as a local approximation. Linear rational expectations models can, however, feature multiple equilibria under certain circumstances in which case the model is called indeterminate. Indeterminacy within the system can result in the non-unique propagation of shocks as well as allowing for self-fulfilling expectations to influence equilibrium allocations. In the workhorse New Keynesian monetary DSGE model (see Giannoni and Woodford 2003 for an example), indeterminacy can arise if the monetary authority pursues an interest rate rule that does not react aggressively enough to an increase in inflation. Although self-fulfilling expectations do not necessarily negatively affect societal welfare (see Christiano and Harrison 1999), if the monetary authority is concerned with avoiding the least favorable outcome then eliminating these self-fulfilling expectations and multiple equilibria is of great importance.

The landmark Clarida et al. (2000) paper was one of the first to suggest that US monetary policy was consistent with a passive Taylor rule in the post-war period prior to 1979. The model used in order to generate this result, however, suffered from a number of undesirable characteristics, chief among them being the univariate nature of the estimation. Since determinacy/indeterminacy is inherently a dynamic property, estimating a univariate Taylor rule, then inserting that rule into a model and analyzing the dynamics is not entirely coherent. Building on the result of their earlier paper (2003a), L&S constructed a multivariate model capable of estimating the additional parameters that characterize the system under indeterminacy. Moreover, the L&S model is a full information estimation as opposed to the instrumental variable approach used in the Clarida et al. paper. Full information techniques are able to avoid any potential weak instrument problems and additionally, in the context of DSGE models, Ruge-Murcia

(2002) provides evidence that full information estimators are typically more efficient than their single equation instrumental variable counterparts. Since the L&S model utilizes a Bayesian estimation technique, the resulting posterior density allows the researcher to construct probability weights for the determinacy and indeterminacy regions of the parameter space (conditional on the observed data) rather than simply testing as to whether the data is consistent with equilibrium determinacy.[3]

II. The New Keynesian Model

The empirical work presented in this paper uses the benchmark New Keynesian monetary model of Woodford (2003) as estimated by Lubik and Schorfheide (2004). The model can be summarized by the following three equations:

(1) $$x_t = \mathrm{E}_t\left(x_{t+1}\right) - \sigma^{-1}\left(R_t - \mathrm{E}_t\left(\pi_{t+1}\right)\right) + g_t \ ,$$

(2) $$\pi_t = \beta \mathrm{E}_t\left(\pi_{t+1}\right) + \kappa\left(x_t - z_t\right) \ ,$$

(3) $$R_t = \rho_R R_{t-1} + \left(1-\rho_R\right)\left(\psi_\pi \pi_t + \psi_x\left(x_t - z_t\right)\right) + \varepsilon_{R,t} \ ,$$

where x is output, π is inflation, and R is the nominal interest rate (all as the percentage deviation from the steady state or in the case of output from the trend path).

Equation (1) is an intertemporal Euler equation obtained from a linear approximation to households' optimal choice of both consumption and bond holdings. The parameter $0 < \beta < 1$ is the households' discount factor and $\sigma^{-1} > 0$ represents the

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[3] Beyer and Farmer (2007) point out that the L&S New Keynesian model is more sensitive than the baseline New Keynesian model to model misspecification. To address this, L&S compared the fit of their New Keynesian model to a richer model which includes habit formation and backward looking price-setters. The data favored the indeterminacy result proposed by the simpler model. For a discussion of broader criticisms of the benchmark New Keynesian DSGE approach and its use of a Taylor monetary policy rule see Tovar 2008.

intertemporal elasticity of substitution. The net effect of the exogenous shifts on the Euler equation is captured by the g_t process which is a linear combination of government spending, preference, and productivity shocks. Equation (2) is an expectational Phillips curve and describes the inflation dynamics of the economy. The equation comes from the pricing decisions made by a continuum of monopolistically competitive firms each of which faces a downward sloping demand curve. Prices are sticky due to quadratic adjustment costs in nominal prices or, alternatively, a Calvo-style ad hoc rigidity. The parameter κ is the slope of the Phillips curve, while the z_t process captures shifts in the marginal costs of production. Finally, equation (3) describes a nominal interest rate rule, similar in form to Taylor's (1993) rule that dictates the actions of the monetary authority. The $\varepsilon_{R,t}$ shock, with corresponding standard deviation σ_R, can be interpreted as unanticipated deviations from the policy rule or policy implementation error.

Both g_t and z_t are assumed to evolve according to the following AR(1) processes:

(4) $$g_t = \rho_g g_{t-1} + \varepsilon_{g,t}, \qquad z_t = \rho_z z_{t-1} + \varepsilon_{z,t} .$$

Additionally, the model allows for nonzero correlation ρ_{gz} between the innovations $\varepsilon_{g,t}$ and $\varepsilon_{z,t}$, which have standard deviations denoted by σ_g and σ_z respectively. The parameters of the loglinearized DSGE model are collected in the vector:

$$\boldsymbol{\theta} = \left[\psi_\pi, \psi_x, \rho_R, \beta, \kappa, \sigma^{-1}, \rho_g, \rho_z, \rho_{gz}, \sigma_R, \sigma_g, \sigma_z\right],$$

with domain Θ. The linear rational expectations model comprised by (1)-(4) can be written in the canonical form:

(5) $$\boldsymbol{\Gamma}_0(\boldsymbol{\theta})\boldsymbol{s}_t = \boldsymbol{\Gamma}_1(\boldsymbol{\theta})\boldsymbol{s}_{t-1} + \mathbf{G}(\boldsymbol{\theta})\boldsymbol{\varepsilon}_t + \mathbf{H}(\boldsymbol{\theta})\boldsymbol{\eta}_t ,$$

where

$$\boldsymbol{s}_t = \left[x_t, \pi_t, R_t, \mathrm{E}_t\left(x_{t+1}\right), \mathrm{E}_t\left(\pi_{t+1}\right), g_t, z_t \right]'$$

$$\boldsymbol{\varepsilon}_t = \left[\varepsilon_{R,t}, \varepsilon_{g,t}, \varepsilon_{z,t} \right]'$$

$$\boldsymbol{\eta}_t = \left[\left(x_t - \mathrm{E}_{t-1}\left(x_t\right)\right), \left(\pi_t - \mathrm{E}_{t-1}\left(\pi_t\right)\right) \right]' .$$

Agents are also assumed to observe an exogenous sunspot shock denoted ζ_t.

Since (5) is linear and the only sources of uncertainty are the shocks ε_t and ζ_t, the forecast errors for output and inflation can be expressed as:

(6) $$\boldsymbol{\eta}_t = \mathbf{A}_1 \varepsilon_t + \mathbf{A}_2 \zeta_t \ .$$

Solution algorithms are applied to subsequently construct a mapping from the shocks to the expectational errors as in Sims (2002) and Lubik and Schorfheide (2003a).

Loosely speaking, the monetary model described by equations (1) – (3) has a unique and stable solution if the central bank raises the interest rate more than one-to-one with changes in inflation ($\psi_\pi > 1$) and has multiple stable solutions otherwise. Constraining our attention to the subset of solutions for which $\boldsymbol{s}_t$ is non-explosive, we can distinguish between three cases. In the first case, it is possible that there will exist no solution to the model for which $\boldsymbol{s}_t$ is stable. In the second case, referred to as determinate, there is a unique and stable solution in which $\mathbf{A}_1$ is determined by the structural parameters $\boldsymbol{\theta}$ and $\mathbf{A}_2 = 0$. In the final case, referred to as indeterminate, there exists a continuum of stable solutions in which $\mathbf{A}_1$ is not uniquely determined by $\boldsymbol{\theta}$ and $\mathbf{A}_2$ can be nonzero. The case in which $\psi_\pi > 1$ will be referred to as "active" monetary policy while the alternative will be referred to as "passive" or "accommodating."

It is useful to consider a simplified version of the model to flesh out its testable implications by explicitly solving (5).[4] Suppose that the monetary authority is only interested in targeting current inflation ($\rho_R = \psi_x = 0$). Additionally, suppose that the exogenous processes g_t and z_t exhibit no serial correlation ($\rho_g = \rho_z = 0$). Define the conditional expectations $\xi_t^x = \mathrm{E}_t\left(x_{t+1}\right)$, $\xi_t^\pi = \mathrm{E}_t\left(\pi_{t+1}\right)$, and the vector $\boldsymbol{\xi}_t = \left[\xi_t^x, \xi_t^\pi\right]'$.

The vector $\boldsymbol{\xi}_t$ evolves according to:

(7)
$$\boldsymbol{\xi}_t = \underbrace{\begin{bmatrix} 1+\frac{\kappa\sigma^{-1}}{\beta} & \sigma^{-1}\left(\psi_1 - \frac{1}{\beta}\right) \\ -\frac{\kappa}{\beta} & \frac{1}{\beta} \end{bmatrix}}_{\mathbf{\Gamma}_1^*} \boldsymbol{\xi}_{t-1} + \underbrace{\begin{bmatrix} \sigma^{-1} & -1 & 0 \\ 0 & 0 & \kappa \end{bmatrix}}_{\mathbf{G}^*} \boldsymbol{\varepsilon}_t + \underbrace{\begin{bmatrix} 1+\frac{\kappa\sigma^{-1}}{\beta} & \sigma^{-1}\left(\psi_1 - \frac{1}{\beta}\right) \\ -\frac{\kappa}{\beta} & \frac{1}{\beta} \end{bmatrix}}_{\mathbf{H}^*} \boldsymbol{\eta}_t$$

The dynamics of the system depend on the eigenvalues of $\mathbf{\Gamma}_1^*$. Both eigenvalues are unstable if $\psi_\pi > 1$ (see Bullard and Mitra 2002), in which case the only stable solution is $\boldsymbol{\xi}_t = 0$ and the forecast errors are uniquely defined by $\boldsymbol{\eta}_t = -\mathbf{H}^{*-1}\mathbf{G}^*\boldsymbol{\varepsilon}_t$. This leads to the following law of motion for output, inflation, and interest rates:

(8)
$$\begin{bmatrix} x_t \\ \pi_t \\ R_t \end{bmatrix} = \frac{1}{1+\kappa\sigma^{-1}\psi_\pi} \begin{bmatrix} -\sigma^{-1} & 1 & \kappa\sigma^{-1}\psi_\pi \\ -\kappa\sigma^{-1} & \kappa & -\kappa \\ 1 & \kappa\psi_\pi & -\kappa\psi_\pi \end{bmatrix} \begin{bmatrix} \varepsilon_{R,t} \\ \varepsilon_{g,t} \\ \varepsilon_{z,t} \end{bmatrix}.$$

Note that the model exhibits no dynamics since the $\boldsymbol{\xi}_t = 0$ solution suppresses both roots of the autoregressive matrix $\mathbf{\Gamma}_1^*$.

If, alternatively, $\psi_\pi < 1$ then only one of the eigenvalues is unstable and the evolution of the endogenous variables takes the form of:

[4] The appendix outlines the solution technique to (5) for the simplified model in greater detail.

$$
(9) \qquad \begin{bmatrix} x_t \\ \pi_t \\ R_t \end{bmatrix} = \frac{1}{1+\kappa\sigma^{-1}\psi_\pi} \begin{bmatrix} -\sigma^{-1} & 1 & \kappa\sigma^{-1}\psi_\pi & \left(\lambda_2 - 1 - \kappa\sigma^{-1}\psi_\pi\right) \\ -\kappa\sigma^{-1} & \kappa & -\kappa & \kappa\lambda_2 \\ 1 & \kappa\psi_\pi & -\kappa\psi_\pi & \psi_\pi\kappa\lambda_2 \end{bmatrix} \begin{bmatrix} \varepsilon_{R,t} \\ \varepsilon_{g,t} \\ \varepsilon_{z,t} \\ \zeta_t \end{bmatrix} + \begin{bmatrix} \left(\beta\left(\lambda_2 - 1\right) - \sigma^{-1}\kappa\right)/\kappa \\ 1 \\ \psi_\pi \end{bmatrix} w_{1,t-1}
$$

with $w_{1,t}$ following the AR(1) process:

$$
w_{1,t} = \lambda_1\left(\boldsymbol{\theta}\right) w_{1,t-1} + \mu_1\left(\boldsymbol{\theta}\right)\left(\mathbf{M}\boldsymbol{\varepsilon}_t + \zeta_t\right) ,
$$

where λ_1 is the stable and λ_2 the unstable eigenvalues of $\boldsymbol{\Gamma}_1^*\left(\boldsymbol{\theta}\right)$; μ_1 is a function of the parameter vector $\boldsymbol{\theta}$, and **M** is a parameter vector, unrelated to $\boldsymbol{\theta}$, that arises because the effect of the fundamental shock $\boldsymbol{\varepsilon}_t$ is not determined. Consequently, the implication of restricting the **M** parameters to zero is that the structural shocks have no persistent effects on the endogenous variables. Therefore, if $\mathbf{M} \neq 0$ or $\sigma_\zeta > 0$ then output, inflation, and interest rates will be serially correlated.

As shown here, there are two pieces of information that can be used to distinguish between determinacy and indeterminacy; direct information about $\boldsymbol{\theta}$, and the autocovariance pattern of the observations. Under indeterminacy the number of stable eigenvalues is generally larger than under determinacy meaning that fewer of the $w_{i,t}$ terms, which L&S refer to as "latent states", are suppressed. As such, we could expect to find a richer autocovariance pattern that cannot be reproduced with parameters from the determinacy region. Moreover, (8) suggests that the covariance matrix of the endogenous variables can provide direct information about ψ_π.

After solving the LRE system (5), likelihood–based Bayesian techniques that exploit both of the aforementioned sources of information are employed to extend the estimation into the indeterminacy region. For a more complete discussion of the solution techniques applied to solve the L&S model, as well as the practical implementation thereof, I refer the reader to the original Lubik and Schorfheide (2004) paper.

III. Data

The empirical section of this paper utilizes quarterly data on GDP, prices, and interest rates for Canada, France, Germany, Japan, the United Kingdom, and the United States. I had initially intended to include all of the G7 countries in the empirical section; however, the lack of reliable data for Italy in the earlier part of the sample lead me to omit the country. Data on real GDP and prices came exclusively from the IMF's International Financial Statistics (IFS) database. In order to obtain the deviation of real GDP from potential/natural GDP, I used an HP filter to remove a smooth trend from the output series for each country. The data on prices were taken directly from the non-seasonally adjusted urban CPI series of each country.

Data on interest rates were obtained from a number of different sources. To measure French monetary policy I use the Bank of France's repurchase agreement rate available from the IFS database. This rate has been employed as a measure of French monetary policy during the GI era by works such as Apel (1998). The Japanese monetary policy instrument used in this paper is the overnight call money rate which is available from the IFS database. This measure of monetary policy has been employed in a number of previous studies including Jinushi et al. (2000) and McCallum (2003). Some more recent works like Nakashima (2008) contend that the call money rate is a bad tool for measuring Japanese monetary policy; however, the concerns are in the post-1995 period which is beyond the scope of this paper. For Canada and the UK, I use data on the official bank rates, which are available directly from the Bank of Canada and Bank of England respectively. For the United States, I use data on the federal funds rate which is available directly from the Federal Reserve.

The Bundesbank conducted monetary policy in a way that was very different from the rest of the G7. The German monetary authority maintained a pair of official interest rates, the discount rate and the Lombard rate, which they used to conduct monetary policy. The discount rate, unlike what we think of as a discount rate in the US, was set below the market rate and was subject to a quota. Since the rate of interest charged on this type of credit was intentionally kept below the market rate it was viewed as a kind of permanent liquidity inflow and banks regularly borrowed until they had met their quota. The interest rate charged on Lombard loans was always kept higher than the discount rate (usually by about one percentage point) and these loans had to be fully collateralized by the borrowing institution. Consequently, German monetary policy would logically be a function of the discount rate, the Lombard rate, the discount window quota, and potentially the spread between the discount and Lombard rates (as this spread increased during the GI). This type of interest rate specification is far too rich to be accommodated by the simple model used for empirical analysis by this paper.

Fortunately, this topic has been examined by Bernanke and Mihov (1997), who assert that of the official policy tools, the Lombard rate best characterized the Bundesbank's monetary intentions. Unfortunately, in response to the inflationary pressures of the GI, the Bundesbank suspended all Lombard borrowing, thereby invalidating the use of the Lombard rate as a policy indicator for the GI period. Bernanke and Mihov go on to say that the Bundesbank was able to "fine tune" movements in market rates, such as the overnight (or call rate) in a manner very similar to how the US Federal Reserve pegs the Federal Funds Rate. Consequently, historically the call rate can be viewed as an indicator of German monetary policy, albeit not the cleanest of measures. As such, the analysis of this paper utilizes the overnight rate as the interest rate indicator of Bundesbank monetary policy.

The data for each country were split into a GI period as well as a Post-GI period. The GI period for each country consisted of observations from the first quarter of 1965 up until 2 years before the end of the GI for that country, as shown in Table 1. The Post-GI period for each country consisted of the 10 years immediately following the GI end date. Using the United States as an example, the GI period was 1965:Q1 – 1980:Q4 while the Post-GI period was 1983:Q1 – 1992:Q4. The inclusion of the two year adjustment period between the GI period and Post-GI period was motivated by the belief that the switch to an active policy regime is not able to immediately transition an economy from a high-inflation to a low-inflation steady state. Looking at the results of the empirical section within L&S, if no adjustment period is allowed between the GI and Post-GI period for the US the probability of determinacy in the post-GI period is 60-70%, rather than the 99% predicted probability of determinacy if the 1980-1981 period is discarded. The core results of the empirical section are robust to the inclusion or exclusion of this adjustment period; however, the results are much cleaner if the two year adjustment period is used.

The motivation behind restricting my attention to the decade following the GI to define the Post-GI period was two-fold. First, the European monetary unification took place in 1998 and I wanted to avoid the effect that the required homogenization of monetary policy preceding this event would have on the parameter estimates for the European members of the G7. Secondly, the Japanese deflationary episode coupled with a zero interest rate policy by the Bank of Japan resulted in a number of problems for the estimation of the Post-GI period for Japan if data from the mid-90s were included in the estimation.

IV. Empirical Analysis

For the empirical analysis conducted in this paper I adopt the same prior distributions as L&S and apply it to each of the countries. Although this approach may not be ideal from a theoretical Bayesian point of view (in that a prior distribution is meant to contain the pre-estimation specific beliefs and knowledge of the researcher), the L&S priors were chosen such that they were fairly agnostic about the probability of determinacy rather than strictly reflecting the characteristics of the US economy. Moreover, the priors for the parameters that we would expect to differ across the G7 countries (steady state inflation and interest rate, the slope of the Phillips curve, etc…) are set with a high degree of uncertainty that should accommodate the differences in these parameters across countries. Although these countries do have significant differences, they are all large developed economies so in the context of this simple DSGE model they should be relatively similar. Consequently, as long as the prior distribution incorporates enough uncertainty about the point estimates of the model parameters, the data should be able to push the posterior estimate into an appropriate region of the parameter space.

Table 2 reports prior densities, means, standard deviations, and 90-percent probability intervals for the parameters θ, π^*, r^*, $\mathbf{M}$, and σ_ζ, where π^* and r^* represent the steady-state inflation and real interest rates, $\mathbf{M}$ is a collection of the additional model parameters that reflect the richer propagation of the fundamental shocks under the unrestricted ($\mathbf{M} \neq 0$) indeterminacy solution, and σ_ζ is the standard deviation of the sunspot shock.[5] The prior presented in the table is referred to as Prior 1; Prior 2 is identical with the exception that the $\mathbf{M}$ terms are restricted to zero.

A quick note on the interpretation of the $\mathbf{M} = \left[\mathrm{M}_{R\zeta}, \mathrm{M}_{g\zeta}, \mathrm{M}_{z\zeta}\right]'$ parameter vector; if $\mathbf{M} \neq 0$ then the propagation of the fundamental shocks in the model is given by a linear combination of the baseline impulse response functions (IRF) as well as an inflationary sunspot shock as in (9). As such, the **M** vector consists of a parameter corresponding to each of the equations (1)-(3) (indexed by the corresponding fundamental shock) that describes the effect that the richer autocovariance structure under the unrestricted indeterminacy solution has relative to the baseline $\mathbf{M} = 0$ indeterminacy case. The sign of the terms within the **M** vector indicate whether the effect of this richer form of indeterminacy is inflationary or deflationary relative to the baseline. Specifically, if a given $\mathrm{M}_{i\zeta}$ is negative (positive) than the propagation of fundamental shock *i* in the unrestricted indeterminacy case is more (less) inflationary than the baseline case. The higher the magnitude of a given $\mathrm{M}_{i\zeta}$, the larger the effect.

[5] Note: I replaced the discount factor by $\beta = \left(1 + r^* / 100\right)^{-1/4}$ as in the original L&S paper.

The DSGE model was estimated under both priors for both sample periods. To obtain the posterior probabilities of determinacy versus indeterminacy, L&S define the following marginal data density (MDD):

$$(10) \qquad p^s\left(\mathbf{Y}^T\right)=\int\left\{\boldsymbol{\theta}\in\boldsymbol{\Theta}^s\right\}L\left(\boldsymbol{\theta},\mathbf{M},\sigma_\zeta \mid \mathbf{Y}^T\right)\times p\left(\boldsymbol{\theta},\mathbf{M},\sigma_\zeta\right)d\boldsymbol{\theta}\cdot d\mathbf{M}\cdot d\sigma_\zeta \quad s\in\left\{D,I\right\} ,$$

In which likelihood function is integrated over the region s with respect to the parameters $\boldsymbol{\theta},\mathbf{M},\text{and}\,\sigma_\zeta$. Noting that $p^D\left(\mathbf{Y}^T\right)$ and $p^I\left(\mathbf{Y}^T\right)$ are both equivalent to a partial posterior distribution without a normalizing constant (which is common to both), it is fairly straightforward to show that the posterior probability of indeterminacy can be given by:

$$\pi_T\left(I\right)=\frac{p_I\left(\mathbf{Y}^T\right)}{p_I\left(\mathbf{Y}^T\right)+p_D\left(\mathbf{Y}^T\right)} .$$

Table 3 gives $\ln\left[p^s\left(\mathbf{Y}^T\right)\right]$ and $\pi_T\left(s\right)$ by prior and sample period.

Using this MDD comparison, the probability of determinacy implied by the prior distribution is 0.53. Consequently, as the posterior estimates of determinacy differ substantially from the prior probability of determinacy, the data appear informative about the determinate or indeterminate nature of monetary policy in both periods.[6] In all cases, the posterior places the majority of the probability mass within the indeterminacy region for the GI period, and in many cases the posterior probability of indeterminacy in the GI period is approaching 1. Additionally, the data densities from Table 3 can be used to compare the different specifications of the model. The MDDs suggest that the data seems to favor Prior 1 over Prior 2 for the majority of countries in the GI period (conditional on indeterminacy). The Post-GI period exhibits essentially the opposite

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[6] In Bayesian estimation, the prior information is only updated in the directions that the data are informative and is not updated in the directions for which the likelihood is flat (see Poirier 1998).

trend in that the large majority of the probability mass is concentrated in the determinacy region for almost all countries, with the exception being Japan under Prior 2.[7] Note that in all cases, conditional on determinacy, the additional parameters that characterize the solution under indeterminacy have no effect on the likelihood - which is why the marginal data density $p^D\left(\mathbf{Y}^T\right)$ is identical for under both Priors 1 and 2.

Tables 4 - 6 report the posterior estimates for the GI period under both Prior 1 and 2, as well as the posterior for the Post-GI period (which is invariant to the choice of prior) for each country. The posterior estimates for $\mathbf{M}$ and σ_ζ are omitted from the Post-GI sample as the posterior probabilities would simply be identical to the prior distribution over these variables. The average value for ψ_π across countries for the GI subsample is approximately 0.66 (Prior 1), well within the indeterminacy region for the model, while in the Post-GI period this value increases to 1.86 on average.

Moving to the estimates of the other model parameters we can see that monetary policy's response to the output gap (ψ_x) varied significantly from a low value of 0.15 (Japan) to a high of 0.43 (France) in the GI period. In the Post-GI period this spread tightened noticeably with the lowest estimated value being 0.22 (Germany and Japan) and the highest 0.32 (United States). Convergence of monetary policy is also observed in the Post-GI estimate of interest rate persistence/smoothing (ρ_R) which takes a value in the neighborhood of 0.8 for each country, which in the case of France is double the estimated value from the GI period. Moreover, the estimated values for π^* decreased for all countries between the GI and Post-GI period while the value of r^* increased for the

[7] Given the more rigid structure of Prior 2, it seems that for Post-GI Japan the data cannot distinguish between determinacy and indeterminacy and is simply returning the prior probability of determinacy.

same period (although both are estimated with a relatively high degree of uncertainty). Looking at the estimated slope of the Phillips curve (κ), the values seem to be on the high side but are estimated with a high degree of uncertainty. Additionally, the estimates of the **M** parameters suggest that overall under the unrestricted indeterminacy case (in which there is non-unique propagation of the fundamental shocks as well as self-fulfilling expectations arising from the sunspot shock ζ_t) the propagation of monetary policy shocks are more inflationary ($\mathrm{M}_{R\zeta} < 0$), demand shocks are less inflationary ($\mathrm{M}_{g\zeta} < 0$), and supply shocks are more inflationary ($\mathrm{M}_{z\zeta} < 0$) relative to the baseline indeterminacy solution (where the **M** parameters are restricted to zero). [8]

Finally, a quick note about robustness; the prior distributions were chosen with a large degree of uncertainty. Due to this, the results presented in the empirical section are mostly robust to changes in the point estimates of the priors. As long as these priors are not set with a high degree of certainty, and are centered such that the reasonable parameter range is assigned a positive probability mass, the estimated posterior distributions remain qualitatively unchanged from the values presented in Tables 4-6.[9]

V. Understanding the Effect of Bretton Woods

In the wake of WWII a new system of foreign exchange was negotiated by the world's major industrialized states in order to eliminate the competitive devaluations and wild exchange rate fluctuations that had characterized the previous decades. Moreover,

[8] The magnitude of the elements of the M vector as well as the remaining model parameters have a less intuitive interpretation and are best interpreted through IRFs. The qualitatively similar posterior estimates across countries result in IRFs that in general have a very similar shape to those of Figures 2 - 6 in the L&S paper. Consequently, in the interest of brevity in-depth IRF analysis is omitted from the paper.

[9] As should be expected, if the prior is chosen such that very little probability is assigned to either the determinacy or indeterminacy region, the estimated posterior distribution will mimic this.

the system was designed to allow European markets access to the pent up American demand, a mutually beneficial arrangement as concerns about demand-push inflation were growing within the US, while domestic demand in Europe was still reeling. The crux of the system was that all currencies would be convertible to US dollars at a fixed rate, while dollars would be convertible to gold at a rate of $35 per ounce. Although the size and range of international trade had rendered the previous gold standard (prevalent until the Great Depression of the 1920s and 1930s) cumbersome and unsustainable, Bretton Woods effectively established the dollar as the new, more flexible gold standard.

Initially the system worked as intended, however, as the size of the foreign exchange market expanded far more rapidly than the gold base, the ability to maintain the full convertibility of dollars to gold became untenable. Moreover, the United States chose to finance costly ventures such as the Vietnam War through monetary expansion rather than increased taxation. Since the dollar's value remained fixed, this was akin to the US exporting its domestic inflation to the rest of the participants in the Bretton Woods system. As a response to the strain placed on the United States' gold reserves, in 1971 the US "gold window" was closed and dollars were only convertible to gold on the open market. In late 1971, full convertibility to gold was re-established; however, the price was reset to $38 per ounce. Within a year, due to numerous devaluations of the US dollar, the official rate of exchange had eclipsed $70 per ounce and countries began abandoning the peg altogether. In February of 1973 the Bretton Woods currency exchange markets closed altogether and a general float was instituted in foreign exchange.

One of the primary arguments offered in defense of looking at only US monetary policy as a means of studying the global GI phenomena is the view that due to the preferential treatment of the US dollar in the Bretton Woods system, the US was able to single-handedly incite the worldwide inflation through monetary expansion. In order to investigate this, I re-estimated the model presented in Section III, however I set a common break date for all countries to correspond to the official end of the Bretton Woods system. Specifically, I estimated the model for each country for the period 1965:Q1 – 1972:Q4 and then again for 1975:Q1 – 1984:Q4 (referred to as the BW and Post-BW periods respectively) allowing for a two-year transitional period as in the previous estimations.[10]

The estimated coefficients of the BW period were quantitatively similar (although in some cases estimated with greater uncertainty due to the shorter time series for almost all countries) and qualitatively identical to those of the GI period in Tables 4-6. The Post-BW parameter estimates, however, differ noticeably from the Post-GI parameter estimates. Table 7 contains the probability of determinacy and corresponding parameter estimates for each country in the Post-BW period.[11] Looking at the Probability of determinacy, we can see that two countries, Japan and Germany, responded to the breakdown of Bretton Woods by aggressively fighting inflation, no doubt a result of their recent previous experiences with hyperinflation (Germany in the 1920s and Japan in the late 1940s and early 1950s). This observation is contrasted by the UK and France who practiced accommodating monetary policy in the decade following the dissolution of

[10] As with the previous estimations, the inclusion or exclusion of this transitional period does not qualitatively change the core results, however, the inclusion of the adjustment period makes the results much more clear-cut.

[11] Prior 1 was used for all estimations in this section.

Bretton Woods and consequently endured a much longer GI experience. Finally, the US and Canada appeared to have pursued monetary policy that was near the border of accommodating policy.

These findings are interesting in a number of ways. First, since the common indeterminacy result of the GI period is maintained in the BW period, I interpret this as strong suggestive evidence that the Bretton Woods system was likely the catalyst that triggered the global run up of inflation. That said, it is important to note that the disbanding of Bretton Woods wasn't in itself enough to cause a wholesale shift towards "good policy." Only the countries that had a relatively recent experience with runaway inflation took a very hawkish approach once their monetary policy was under their control. The other countries, which were possibly less wary of inflation, had to learn that in order to combat rising prices you must respond with interest rate increases in a greater than one-to-one fashion. It is reasonable, after all, to expect that many countries would adopt the monetary policy of the US following the breakup of Bretton Woods. It is interesting to note that Germany, a vocal critic of US monetary policy during the Bretton Woods years, was the first country identified by my estimation to act aggressively against inflation. Put another way, it appears that the end of the Bretton Woods system was a necessary but not sufficient condition for a given country to emerge from the GI. One can point to Bretton Woods as a potential cause of the GI, but the Bretton Woods system cannot explain the length of the continuous inflation experienced by some of the G7.

VI. Conclusion

Using a Bayesian DSGE framework pioneered by Lubik and Schorfheide (2004), I have estimated a monetary business-cycle model for the G7 economies. This approach is novel in the sense that it is able to estimate the benchmark New Keynesian DSGE model without restricting the parameters to the determinacy region. The estimation of this model shows that the pattern of passive US monetary policy during the Great Inflation and active policy in the following decades observed by the original L&S paper as well as Clarida et al. (2000) is present throughout the developed world as a whole. Although the benchmark DSGE model is highly stylized, this result provides at least suggestive evidence in favor of the “good policy” explanation of the Great Moderation.

Additional support for this idea stems from the fact that monetary policy across the G7 was accommodating before the breakup of the Bretton Woods system; but immediately following the system’s dissolution the more inflation hawkish countries were able to staunch inflation in short order. Consequently, my story of the Great Inflation would be one of dovish monetary policy being spread across the world by the US through the Bretton Woods system, followed by a period of learning how to implement sound monetary policy after the demise of Bretton Woods (where the speed of learning/adoption was influenced by a country’s recent inflation history).

An avenue for further research would be to take into consideration the manner in which the monetary policy decisions of the G7 countries may have depended on one another. Since the Bretton Woods system was in place until the early 1970s, the case could be made that the rest of the world was simply importing US monetary policy to a large degree. Following the breakdown of the Bretton Woods system, countries were able to exercise more freedom in conducting monetary policy and may have begun to set monetary policy independently or possibly followed a different monetary policy leader such as the Bundesbank. Lubik and Schorfheide (2005) have shown that the joint estimation of monetary policy rules across countries can have an affect on the estimated parameters and model fit, suggesting that a rigorous modeling of the dependence of monetary policy across countries may at the very least improve the fit of the model and possibly yield some fruitful insights.

Appendix

The following solution outline borrows heavily from Lubik and Schorfheide's unpublished technical appendix (2003b). The simplified version of the DSGE model discussed in the latter part of Section III can be expressed in terms of $\boldsymbol{\xi}_t = \left[\xi_t^x, \xi_t^\pi\right]'$ as:

$$\text{(A1)}\quad \underbrace{\begin{bmatrix} 1 & \sigma^{-1} \\ 0 & \beta \end{bmatrix}}_{\Gamma_0} \boldsymbol{\xi}_t = \underbrace{\begin{bmatrix} 1 & \sigma^{-1}\psi_\pi \\ -\kappa & 1 \end{bmatrix}}_{\Gamma_1} \boldsymbol{\xi}_{t-1} + \underbrace{\begin{bmatrix} \sigma^{-1} & -1 & 0 \\ 0 & 0 & \kappa \end{bmatrix}}_{\mathbf{G}} \boldsymbol{\varepsilon}_t + \underbrace{\begin{bmatrix} 1 & \sigma^{-1}\psi_\pi \\ -\kappa & 1 \end{bmatrix}}_{\mathbf{H}} \boldsymbol{\eta}_t \ .$$

Premultiplying the system by Γ_0^{-1} we obtain:

$$\text{(A2)}\quad \boldsymbol{\xi}_t = \underbrace{\begin{bmatrix} 1+\dfrac{\kappa\sigma^{-1}}{\beta} & \sigma^{-1}\left(\psi_\pi - \dfrac{1}{\beta}\right) \\ -\dfrac{\kappa}{\beta} & \dfrac{1}{\beta} \end{bmatrix}}_{\Gamma_1^*} \boldsymbol{\xi}_{t-1} + \underbrace{\begin{bmatrix} \sigma^{-1} & -1 & -\dfrac{\kappa\sigma^{-1}}{\beta} \\ 0 & 0 & \dfrac{\kappa}{\beta} \end{bmatrix}}_{\mathbf{G}^*} \boldsymbol{\varepsilon}_t + \underbrace{\begin{bmatrix} 1+\dfrac{\kappa\sigma^{-1}}{\beta} & \sigma^{-1}\left(\psi_\pi - \dfrac{1}{\beta}\right) \\ -\dfrac{\kappa}{\beta} & \dfrac{1}{\beta} \end{bmatrix}}_{\mathbf{H}^*} \boldsymbol{\eta}_t$$

The eigenvalues of Γ_1^* solve the equation:

$$\text{(A3)}\quad 0 = \det\begin{bmatrix} \left(1+\kappa\sigma^{-1}/\beta\right)-\lambda & \sigma^{-1}\left(\psi_\pi - 1/\beta\right) \\ -\kappa/\beta & \left(1/\beta\right)-\lambda \end{bmatrix},$$

which we can rewrite as

$$\text{(A4)}\quad 0 = \lambda^2 - \lambda\left[1+\frac{1}{\beta}\left(1+\kappa\sigma^{-1}\right)\right] + \frac{1}{\beta}\left(1+\kappa\sigma^{-1}\psi_\pi\right) \ .$$

The solution of this quadratic equation is:

$$\text{(A5)}\quad \lambda_1, \lambda_2 = \underbrace{\frac{1}{2}\left(1+\frac{\kappa\sigma^{-1}+1}{\beta}\right)}_{l_1} \pm \underbrace{\frac{1}{2}\sqrt{\left(\frac{\kappa\sigma^{-1}+1}{\beta}-1\right)^2 + \frac{4\kappa\sigma^{-1}}{\beta}\left(1-\psi_\pi\right)}}_{l_2} \ .$$

The eigenvectors must satisfy the relationship:

(A6) $\begin{bmatrix} 1+\kappa\sigma^{-1}/\beta & \sigma^{-1}\left(\psi_\pi - 1/\beta\right) \\ -\kappa/\beta & 1/\beta \end{bmatrix}\begin{bmatrix} x \\ 1 \end{bmatrix} = l_1 \begin{bmatrix} x \\ 1 \end{bmatrix} \pm l_2 \begin{bmatrix} x \\ 1 \end{bmatrix}$,

which implies that

(A7) $x = \frac{1}{\kappa}\left(1-\beta l_1 \pm \beta l_2\right)$.

We can use x to obtain the following Jordan Decomposition of Γ_1^*:

(A8) $\Gamma_1^* = J\Lambda J^{-1}$,

where

$$J = \begin{bmatrix} \frac{1}{\kappa}\left(1-\beta l_1 + \beta l_2\right) & \frac{1}{\kappa}\left(1-\beta l_1 - \beta l_2\right) \\ 1 & 1 \end{bmatrix},$$

$$\Lambda = \begin{bmatrix} l_1 - l_2 & 0 \\ 0 & l_1 + l_2 \end{bmatrix},$$

$$J^{-1} = \begin{bmatrix} \frac{1}{2\beta l_2} & \kappa & -1+\beta l_1 + \beta l_2 \\ & -\kappa & 1-\beta l_1 + \beta l_2 \end{bmatrix}.$$

Let $\boldsymbol{w}_t = J^{-1}\boldsymbol{\xi}_t = \left[w_{1,t}, w_{2,t}\right]'$. We can now write the LRE system in terms of the transformed variables:

(A9) $\boldsymbol{w}_t = \Lambda \boldsymbol{w}_{t-1} + J^{-1}\mathbf{G}^*\boldsymbol{\varepsilon}_t + J^{-1}\mathbf{H}^*\boldsymbol{\eta}_t$.

Looking at (A9), the nature of the eigenvalues λ_1 and λ_2 (alternatively $l_1 \pm l_2$) determines how many of these $w_{i,t}$ "latent states" we must suppress with predetermined values in order to make the system non-explosive. For each root $i, i \in \{1,2\}$ outside the unit circle (unstable) we need to impose that the corresponding $w_{i,t} = 0$, thereby suppressing it. Consequently, if both eigenvalues are unstable then the unique solution to equation (A9) is given by:

(A10) $0 = J^{-1}\mathbf{G}^{*}\boldsymbol{\varepsilon}_t + J^{-1}\mathbf{H}^{*}\boldsymbol{\eta}_t$,

which after a bit of algebra and substitution yields (8) from Section III.

For roots that lies within the unit circle (stable) we do not require that the corresponding $w_{i,t} = 0$ in order to keep the system non-explosive.[12] Define $\mathbf{G}_x^J$ and $\mathbf{H}_x^J$ to be the evaluation of the row of $J^{-1}\mathbf{G}^{*}$ and $J^{-1}\mathbf{H}^{*}$ respectively that corresponds to the unstable eigenvalue. Since the stable root need not be suppressed, the stability condition becomes:

(A11) $0 = \mathbf{G}_x^J\boldsymbol{\varepsilon}_t + \mathbf{H}_x^J\boldsymbol{\eta}_t$.

This condition leaves state $w_{j,t}$, $j \neq i$ unsuppressed and therefore free to affect the law of motion for output, inflation, and interest rates as in (9) from Section III. Consequently, these stable roots allow for both the non-unique propagation of fundamental shocks as well as self-fulfilling sunspot shocks to affect equilibrium allocations.

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[12] Note that based on the assumption that $0 < \beta < 1$ and $\kappa, \sigma^{-1} > 0$, at least one of the eigenvalues must be unstable, implying that the degree of indeterminacy in the system is at most one.

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Table 1 - Descriptive Statistics of the Great Inflation for the G7

	Start, End, and Duration of GI			Peak Inflation		Secondary Peak	
	Trend > 4%	Trend < 4%	Duration (Q)	Level	Date	Level	Date
Canada	1966:Q2	1983:Q4	70	12.8	1974:Q4	10.5	1981:Q1
France	1968:Q4	1986:Q2	71	13.9	1975:Q1	12.3	1982:Q2
Germany	1969:Q4	1974:Q2	19	8.3	1970:Q1	7.9	1974:Q4
Italy	1970:Q1	1986:Q3	67	20	1974:Q4	19.8	1981:Q3
Japan	1960:Q1	1977:Q3	71	20	1974:Q2	9	1961:Q4
UK	1970:Q1	1982:Q2	50	25	1975:Q2	20.3	1980:Q2
US	1968:Q1	1983:Q1	61	10.4	1975:Q1	9.7	1981:Q1

Notes: Source Cecchetti et al. (2007). The duration of the GI for each country is given in quarters. Trend inflation for France briefly exceeded 4% in 1963 but this short episode is omitted above.

Table 2 - Prior Distributions

Name	Range	Density	Mean	Std Dev	PI Low	PI High
ψ_π	$\mathbf{R}^+$	Gamma	1.10	0.50	0.33	1.85
ψ_x	$\mathbf{R}^+$	Gamma	0.25	0.15	0.06	0.43
ρ_R	[0, 1)	Beta	0.50	0.20	0.18	0.83
π^*	$\mathbf{R}^+$	Gamma	4.00	2.00	0.90	6.91
r^*	$\mathbf{R}^+$	Gamma	2.00	1.00	0.49	3.47
κ	$\mathbf{R}^+$	Gamma	0.50	0.20	0.18	0.81
σ	$\mathbf{R}^+$	Gamma	2.00	0.50	1.16	2.77
ρ_g	[0, 1)	Beta	0.70	0.10	0.54	0.86
ρ_z	[0, 1)	Beta	0.70	0.10	0.54	0.86
ρ_{gz}	[-1, 1]	Truncated Normal	0.00	0.40	-0.65	0.65
$M_{R\zeta}$	$\mathbf{R}$	Normal	0.00	1.00	-1.64	1.64
$M_{g\zeta}$	$\mathbf{R}$	Normal	0.00	1.00	-1.64	1.64
$M_{z\zeta}$	$\mathbf{R}$	Normal	0.00	1.00	-1.64	1.64
σ_R	$\mathbf{R}^+$	Inverse Gamma	0.31	0.16	0.13	0.50
σ_g	$\mathbf{R}^+$	Inverse Gamma	0.38	0.20	0.16	0.60
σ_z	$\mathbf{R}^+$	Inverse Gamma	1.00	0.52	0.42	1.57
σ_ζ	$\mathbf{R}^+$	Inverse Gamma	0.25	0.13	0.11	0.40

Notes: Source Lubik and Schorfheide (2004). The above prior is referred to a Prior 1. Prior 2 imposes $M_{R\zeta} = M_{g\zeta} = M_{z\zeta} = 0$.

Table 3 - Posterior Probability of Determinacy versus Indeterminacy

Canada

Sample	Prior	MDD (Det)	MDD (Indet)	Prob (Det)	Prob (Indet)
GI	1	-366.907	-362.450	0.000	1.000
	2	-366.907	-363.243	0.000	1.000
Post-GI	1	-207.071	-209.128	0.998	0.003
	2	-207.071	-211.786	0.998	0.002

France

Sample	Prior	MDD (Det)	MDD (Indet)	Prob (Det)	Prob (Indet)
GI	1	-261.604	-261.227	0.263	0.737
	2	-261.604	-260.572	0.020	0.980
Post-GI	1	-141.538	-146.157	0.958	0.042
	2	-141.538	-149.198	1.000	0.000

Germany

Sample	Prior	MDD (Det)	MDD (Indet)	Prob (Det)	Prob (Indet)
GI	1	-290.413	-287.574	0.140	0.860
	2	-290.413	-287.151	0.063	0.937
Post-GI	1	-214.008	-218.639	0.959	0.042
	2	-214.008	-218.615	0.998	0.002

Japan

Sample	Prior	MDD (Det)	MDD (Indet)	Prob (Det)	Prob (Indet)
GI	1	-374.981	-367.382	0.000	1.000
	2	-374.981	-370.925	0.184	0.816
Post-GI	1	-281.138	-283.589	0.829	0.171
	2	-281.138	-281.467	0.524	0.476

United Kingdom

Sample	Prior	MDD (Det)	MDD (Indet)	Prob (Det)	Prob (Indet)
GI	1	-428.195	-417.723	0.000	1.000
	2	-428.195	-421.779	0.000	1.000
Post-GI	1	-234.738	-232.976	1.000	0.000
	2	-234.738	-236.367	1.000	0.000

United States

Sample	Prior	MDD (Det)	MDD (Indet)	Prob (Det)	Prob (Indet)
GI	1	-345.785	-338.676	0.000	1.000
	2	-345.785	-340.254	0.001	0.999
Post-GI	1	-170.905	-176.242	0.997	0.003
	2	-170.905	-174.697	0.975	0.025

Notes: This table reports posterior marginal data densities and the probability of determinacy for each prior and subsample. Prior probability of determinacy is 0.527. Conditional on determinacy, the marginal data density under either prior is identical.

Table 4 - Parameter Estimation Results

Canada

	GI (Prior 1)			GI (Prior 2)			Post-GI		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_π	0.84	0.67	1.00	0.93	0.85	1.00	1.91	1.22	2.56
ψ_x	0.31	0.08	0.53	0.31	0.07	0.54	0.23	0.05	0.39
ρ_R	0.79	0.71	0.87	0.72	0.65	0.80	0.71	0.60	0.83
π^*	4.70	1.62	7.77	4.70	1.65	7.50	3.39	2.34	4.52
r^*	1.83	0.87	2.72	1.87	1.05	2.64	4.46	3.03	5.82
κ	0.54	0.21	0.86	0.46	0.23	0.69	0.77	0.40	1.14
σ	2.59	1.72	3.42	2.80	1.89	3.68	1.90	1.16	2.63
ρ_g	0.71	0.60	0.82	0.71	0.63	0.80	0.84	0.78	0.91
ρ_z	0.71	0.59	0.84	0.65	0.52	0.77	0.72	0.60	0.83
ρ_{gz}	0.38	-0.03	0.82	0.68	0.41	0.91	0.66	0.39	0.92
$M_{R\zeta}$	-1.03	-2.01	-0.05	0			--		
$M_{g\zeta}$	1.07	0.05	2.25	0			--		
$M_{z\zeta}$	-0.20	-0.78	0.30	0			--		
σ_R	0.32	0.27	0.37	0.34	0.28	0.40	0.34	0.26	0.43
σ_g	0.33	0.21	0.44	0.29	0.20	0.38	0.21	0.15	0.27
σ_z	1.06	0.80	1.36	1.08	0.82	1.32	1.03	0.79	1.27
σ_ζ	0.25	0.11	0.39	0.26	0.15	0.38	--		

France

	GI (Prior 1)			GI (Prior 2)			Post-GI		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_π	0.61	0.30	0.92	0.83	0.63	1.00	2.62	1.70	3.61
ψ_x	0.43	0.14	0.71	0.35	0.09	0.59	0.27	0.06	0.46
ρ_R	0.37	0.20	0.55	0.43	0.29	0.57	0.78	0.70	0.86
π^*	5.93	2.66	9.31	6.40	3.16	10.00	2.46	1.98	2.91
r^*	1.17	0.32	1.99	0.90	0.26	1.51	4.22	3.40	5.07
κ	0.39	0.15	0.61	0.38	0.19	0.57	0.64	0.26	1.01
σ	2.91	2.04	3.76	2.98	2.08	3.86	1.85	1.05	2.65
ρ_g	0.69	0.59	0.80	0.67	0.57	0.76	0.80	0.73	0.88
ρ_z	0.74	0.61	0.87	0.71	0.58	0.84	0.69	0.58	0.81
ρ_{gz}	0.06	-0.39	0.52	0.41	0.08	0.76	0.56	0.27	0.85
$M_{R\zeta}$	0.00	-0.53	0.44	0			--		
$M_{g\zeta}$	1.10	-0.07	2.33	0			--		
$M_{z\zeta}$	-0.18	-0.81	0.46	0			--		
σ_R	0.72	0.57	0.88	0.78	0.62	0.93	0.19	0.14	0.24
σ_g	0.36	0.21	0.50	0.31	0.20	0.41	0.18	0.13	0.22
σ_z	0.94	0.57	1.29	0.85	0.60	1.10	0.65	0.50	0.80
σ_ζ	0.25	0.11	0.41	0.26	0.12	0.39	--		

Notes: This table reports posterior means and 90% probability intervals. GI posteriors are conditional on indeterminacy, while Post-GI posteriors are conditional on determinacy.

Table 5 - Parameter Estimation Results (cont.)

Germany

	GI (Prior 1)			GI (Prior 2)			Post-GI		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_{π}	0.50	0.21	0.78	0.54	0.27	0.81	1.78	1.18	2.39
ψ_{x}	0.17	0.04	0.30	0.16	0.03	0.28	0.22	0.05	0.38
ρ_{R}	0.79	0.71	0.87	0.73	0.65	0.81	0.76	0.68	0.85
π^*	2.97	1.71	4.15	2.90	1.98	3.79	2.56	1.64	3.49
r^*	1.41	0.70	2.08	1.45	0.71	2.17	1.85	0.89	2.73
κ	0.70	0.36	1.02	0.66	0.32	0.98	0.85	0.45	1.24
σ	1.98	1.22	2.70	2.14	1.35	2.89	1.77	1.06	2.47
ρ_{g}	0.75	0.67	0.84	0.75	0.67	0.83	0.83	0.76	0.90
ρ_{z}	0.59	0.47	0.71	0.56	0.45	0.68	0.67	0.57	0.76
ρ_{gz}	0.87	0.64	0.99	0.94	0.88	0.99	0.80	0.66	0.94
$M_{R\zeta}$	-0.98	-1.87	-0.08	0			--		
$M_{g\zeta}$	0.45	-0.97	1.78	0			--		
$M_{z\zeta}$	-0.02	-0.36	0.32	0			--		
σ_{R}	0.25	0.20	0.30	0.27	0.22	0.32	0.31	0.23	0.38
σ_{g}	0.39	0.25	0.52	0.38	0.26	0.50	0.27	0.19	0.35
σ_{z}	2.18	1.71	2.63	2.25	1.76	2.78	1.20	0.96	1.44
σ_{ζ}	0.21	0.11	0.31	0.22	0.11	0.32	--		

Japan

	GI (Prior 1)			GI (Prior 2)			Post-GI		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_{π}	0.71	0.49	0.96	0.72	0.47	1.00	1.34	1.00	1.74
ψ_{x}	0.15	0.04	0.26	0.17	0.04	0.29	0.22	0.06	0.38
ρ_{R}	0.86	0.81	0.91	0.88	0.84	0.92	0.83	0.77	0.90
π^*	4.90	1.77	7.79	5.72	2.82	8.32	3.21	2.16	4.21
r^*	1.29	0.36	2.16	1.29	0.40	2.14	2.66	1.62	3.76
κ	0.60	0.29	0.90	0.48	0.23	0.72	0.51	0.22	0.80
σ	1.46	0.79	2.10	1.81	1.01	2.62	1.73	1.00	2.46
ρ_{g}	0.79	0.65	0.92	0.77	0.65	0.92	0.68	0.56	0.80
ρ_{z}	0.78	0.66	0.90	0.69	0.57	0.82	0.68	0.56	0.82
ρ_{gz}	0.40	-0.15	0.94	0.95	0.91	0.99	0.81	0.66	0.96
$M_{R\zeta}$	0.46	-1.21	2.10	0			--		
$M_{g\zeta}$	0.34	-1.48	1.95	0			--		
$M_{z\zeta}$	-0.60	-0.87	-0.33	0			--		
σ_{R}	0.18	0.15	0.22	0.18	0.14	0.21	0.25	0.20	0.30
σ_{g}	0.95	0.18	2.32	2.26	0.81	3.42	1.00	0.67	1.34
σ_{z}	3.45	0.73	5.98	3.70	1.60	5.77	3.23	2.63	3.82
σ_{ζ}	0.27	0.11	0.44	0.48	0.10	1.03	--		

Notes: This table reports posterior means and 90% probability intervals. GI posteriors are conditional on indeterminacy, while Post-GI posteriors are conditional on determinacy.

Table 6 - Parameter Estimation Results (cont.)

United Kingdom

	GI (Prior 1)			GI (Prior 2)			Post-GI		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_π	0.55	0.26	0.86	0.53	0.27	0.82	1.38	1.00	1.81
ψ_x	0.17	0.03	0.30	0.17	0.03	0.30	0.23	0.05	0.40
ρ_R	0.83	0.77	0.90	0.78	0.72	0.85	0.80	0.72	0.88
π^*	5.96	2.93	8.96	6.64	4.11	9.19	5.61	4.01	7.18
r^*	1.37	0.36	2.30	1.33	0.39	2.22	4.67	3.29	6.06
κ	0.93	0.48	1.38	0.77	0.40	1.11	1.14	0.67	1.59
σ	2.32	1.46	3.15	2.59	1.70	3.43	2.16	1.38	2.96
ρ_g	0.70	0.59	0.82	0.73	0.61	0.84	0.78	0.71	0.86
ρ_z	0.69	0.57	0.81	0.67	0.54	0.79	0.71	0.59	0.85
ρ_{gz}	0.22	-0.14	0.91	0.79	0.60	1.00	0.35	0.06	0.66
$M_{R\zeta}$	-1.53	-2.77	-0.28	0			--		
$M_{g\zeta}$	1.82	0.31	3.22	0			--		
$M_{z\zeta}$	-0.31	-0.73	0.07	0			--		
σ_R	0.35	0.29	0.41	0.37	0.30	0.44	0.35	0.27	0.43
σ_g	0.51	0.22	0.79	0.29	0.19	0.40	0.25	0.16	0.32
σ_z	1.91	1.44	2.35	1.92	1.42	2.40	0.89	0.65	1.13
σ_ζ	0.41	0.10	0.98	0.91	0.52	1.30	--		

United States

	GI (Prior 1)			GI (Prior 2)			Post-GI		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_π	0.77	0.58	0.98	0.71	0.44	1.00	2.12	1.19	3.01
ψ_x	0.25	0.06	0.43	0.33	0.08	0.56	0.32	0.08	0.55
ρ_R	0.59	0.41	0.77	0.50	0.37	0.63	0.84	0.78	0.90
π^*	4.77	2.12	7.24	4.92	2.51	7.17	3.83	3.11	4.55
r^*	1.24	0.63	1.83	1.23	0.65	1.81	3.01	2.02	4.01
κ	0.58	0.23	0.93	0.29	0.11	0.51	0.54	0.25	0.83
σ	1.86	1.13	2.59	2.28	1.43	3.09	2.07	1.22	2.88
ρ_g	0.72	0.61	0.83	0.75	0.67	0.83	0.78	0.70	0.86
ρ_z	0.80	0.71	0.90	0.78	0.67	0.91	0.81	0.71	0.91
ρ_{gz}	0.34	-0.11	0.81	0.60	0.20	0.98	0.28	-0.06	0.64
$M_{R\zeta}$	-0.81	-1.65	0.10	0			--		
$M_{g\zeta}$	1.17	0.27	2.11	0			--		
$M_{z\zeta}$	-0.53	-0.94	-0.15	0			--		
σ_R	0.32	0.27	0.37	0.31	0.26	0.37	0.19	0.14	0.23
σ_g	0.28	0.18	0.38	0.30	0.19	0.40	0.24	0.16	0.31
σ_z	1.13	0.92	1.33	1.04	0.79	1.28	0.70	0.53	0.87
σ_ζ	0.23	0.11	0.36	0.30	0.15	0.43	--		

Notes: This table reports posterior means and 90% probability intervals. GI posteriors are conditional on indeterminacy, while Post-GI posteriors are conditional on determinacy.

Table 7 - Post Bretton Woods Probability of Determinacy & Parameter Estimates

Probability of Determinacy Post-Bretton Woods

Canada	0.421	Germany	0.959	United Kingdom	0.000
France	0.188	Japan	1.000	United States	0.596

Parameter Estimates Post-Bretton Woods

	Canada			France			Germany		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_π	0.65	0.36	0.98	0.55	0.25	0.86	1.79	(1.0996	2.407)
ψ_x	0.38	0.09	0.64	0.61	0.27	0.94	0.22	0.05	0.39
ρ_R	0.62	0.47	0.78	0.33	0.15	0.51	0.81	0.74	0.88
π^*	6.27	3.14	9.50	5.64	2.52	8.76	4.20	3.25	5.12
r^*	2.77	1.50	3.99	1.44	0.46	2.38	1.87	0.99	2.77
κ	0.42	0.12	0.69	0.33	0.16	0.50	0.70	0.31	1.10
σ	2.52	1.65	3.35	2.89	2.00	3.74	1.82	1.08	2.52
ρ_g	0.72	0.60	0.83	0.71	0.62	0.81	0.82	0.76	0.90
ρ_z	0.82	0.72	0.92	0.79	0.68	0.90	0.69	0.58	0.81
ρ_{gz}	0.19	-0.26	0.66	-0.09	-0.48	0.28	0.69	0.45	0.92
$M_{R\zeta}$	-0.14	-1.01	0.66	0.00	-0.46	0.44	--		
$M_{g\zeta}$	0.78	-0.39	1.99	1.47	0.54	2.41	--		
$M_{z\zeta}$	-0.32	-0.97	0.38	0.07	-0.36	0.50	--		
σ_R	0.43	0.32	0.54	0.68	0.53	0.83	0.24	0.19	0.29
σ_g	0.34	0.19	0.48	0.36	0.22	0.48	0.27	0.19	0.35
σ_z	0.99	0.64	1.31	0.79	0.51	1.06	1.27	1.00	1.54
σ_ζ	0.25	0.11	0.41	0.23	0.11	0.35	0.00	0.00	0.00

	Japan			United Kingdom			United States		
	Mean	PI Low	PI High	Mean	PI Low	PI High	Mean	PI Low	PI High
ψ_π	1.29	1.00	1.65	0.46	0.15	0.76	1.46	1.00	1.89
ψ_x	0.20	0.05	0.37	0.19	0.04	0.32	0.26	0.06	0.45
ρ_R	0.84	0.77	0.91	0.81	0.73	0.89	0.76	0.68	0.84
π^*	5.16	3.67	6.84	6.82	3.83	10.00	6.31	4.58	8.01
r^*	1.77	0.65	2.83	1.66	0.50	2.76	2.05	0.86	3.22
κ	0.50	0.18	0.81	0.77	0.38	1.13	0.42	0.19	0.64
σ	1.62	0.85	2.34	2.59	1.73	3.42	2.42	1.57	3.23
ρ_g	0.76	0.63	0.91	0.72	0.60	0.85	0.80	0.73	0.88
ρ_z	0.78	0.67	0.89	0.71	0.58	0.85	0.79	0.69	0.89
ρ_{gz}	0.89	0.78	0.98	0.03	-0.46	0.40	0.45	0.13	0.78
$M_{R\zeta}$	--			-1.28	-2.59	0.05	--		
$M_{g\zeta}$	--			1.79	0.45	3.21	--		
$M_{z\zeta}$	--			-0.18	-0.69	0.23	--		
σ_R	0.31	0.24	0.38	0.39	0.31	0.47	0.43	0.34	0.52
σ_g	1.13	0.50	1.62	0.48	0.21	0.73	0.34	0.22	0.46
σ_z	5.07	3.87	6.60	2.16	1.47	2.82	1.11	0.83	1.37
σ_ζ	0.00	0.00	0.00	0.33	0.10	0.64	0.00	0.00	0.00