What's so Great about the Great Moderation? A Multi-Country Investigation of Time-Varying Volatilities of Output Growth and Inflation ♦

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Abstract: Changes in volatility of output growth and inflation are examined for eight countries with at least 140 years of uninterrupted data. Time-varying parameter vector autoregressions are used to estimate standard deviations of each variable. Both volatilities rise quickly with World War I and its aftermath, stay relatively high until the end of World War II, and then drop rapidly until the mid- to late 1960s. This Postwar Moderation typically yields the largest decline in output growth volatilities. For all countries, volatilities of both output growth and inflation fall more during this Postwar Moderation than during the Great Moderation, and often the difference is huge. Both volatilities typically reach their lowest levels following the Great Moderation. The Great Moderation often counteracts an increase in volatility that took place in the 1970s, particularly for inflation. In nearly all the countries in our sample, the recent financial crisis has eliminated the stability gains associated with the Great Moderation, and sometimes it has even eroded gains made during the Postwar Moderation. Periods in which a fixed exchange rate system was widespread are associated with relatively low volatilities for both variables. Based on our structural VAR identification, permanent shocks to output account for nearly all of the fluctuations in the volatility of output growth while shocks that have only a temporary effect on output explain most of the fluctuations in inflation volatility. These last two findings suggest that changes in the volatility for each variable are primarily driven by a fundamentally different type of disturbance.

JEL Classification: *E30, E31, E65*

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1. Introduction

A considerable amount of evidence reveals that economic activity is not well-characterized by constant volatility. Empirical research has found a substantial decline in the volatility of macroeconomic aggregates beginning perhaps as early as the late 1970s. This period is identified as the Great Moderation, and a large literature has developed to understand this event.[1] Many empirical studies have focused exclusively on the United States.[2] Most investigations consider only the post-World War II experience. This paper investigates a number of important questions about the volatilities of output growth and inflation for eight countries that have 140 years or more of uninterrupted annual source data.

Our first question is: how have these volatilities behaved over time? Given the finding that both variables experience substantial fluctuation in volatility, with particularly large movements in inflation volatility, we next ask: do these patterns of variation share any similarities across different economies? A remarkable number of patterns are found to be robust across countries. These robust tendencies raise the question: are observed movements in volatility associated with changes in policy or with non-policy events?

To address these questions, we use recently developed techniques for vector autoregression (VAR) modeling that allow for time-varying parameters. Our specification permits the coefficients to potentially change at each point in time, and it also provides for possible stochastic volatility in the errors. We use this model to estimate volatilities for real output growth and inflation for each country found to have relatively lengthy time series.[3]

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[1] See McConnell and Perez-Quiros (2000), Blanchard and Simon (2001), Stock and Watson (2002), Davis and Khan (2008), and Inoue and Rossi (2011) among many.

[2] Exceptions include Summers (2005), who examines the G7 countries, and Cecchetti et al. (2005), who conclude that a Great Moderation in the mid-1980s can be found in many OECD countries.

[3] It seems particularly reasonable to allow shock variances and coefficients in the model to change when studying an economy over a long period of time.

Our study is motivated, in part, by the common wisdom that the Great Moderation is an unprecedented event. In contrast to that view, we present evidence of other periods in which even greater moderations have occurred. Following World War II, the volatilities of output growth and inflation in all of the countries we consider fell more than they did during the Great Moderation—and in most cases the difference is substantial. This period has been labeled the Postwar Moderation.[4] Our evidence suggests that the Postwar Moderation is not merely a return to normal pre-World War II volatilities, but the beginning of a period in which volatilities are persistently lower than before. In a number of cases, much of the improvement associated with the Great Moderation is a reversal of the rise in volatility that occurred during the 1970s, particularly for inflation. We also find that volatilities of output growth and inflation are relatively low during the Classical Gold Standard period (1880-1914). Excluding this period, volatilities are almost always lower after the Postwar Moderation than in the sample period before World War II. This evidence of other moderations provides a better understanding of the scale and the significance of the so-called Great Moderation.

Another more immediate concern is whether the recent financial crisis has cut into stability gains achieved during the two preceding moderations. In most cases, volatilities are now higher than the lowest levels reached during the Postwar Moderation. Hence, the stability gains from the Great Moderation have been completely eroded for most of the countries in this study. While this finding does not mean policymakers are incapable of bringing the economy back to a relative stable state, our evidence suggests many countries now face a long road to achieving the low volatilities found previously.

[4] While different authors have used the term "Postwar Moderation" to mean various things, Keating and Valcarcel (2012) use that term to refer specifically to the period from shortly after World War II until the mid-1960s.

It would be of particular interest to determine what structural factors are behind these robust cross-country patterns in volatilities. One approach is to identify structural shocks from the reduced-form and use these shocks to interpret the data. Clearly this road is subject to a host of well-known difficulties.[5] While there is no generally accepted framework for performing investigations of this nature, perhaps the most widely used identification scheme in the literature comes from Blanchard and Quah (1989) — henceforth BQ— who decompose output into permanent and transitory shocks. If their identifying assumptions are structurally valid, the permanent shock to output is an aggregate supply (real) shock and the transitory shock is an aggregate demand (nominal) shock.[6]

In contrast to BQ, and most of the literature that builds on their work, we identify the permanent and transitory shocks using a time-varying VAR model. We find that changes in volatility for output growth are primarily associated with the permanent shocks to output and that most changes in inflation volatility are associated with shocks that have only a temporary effect on output.

While most volatility studies have omitted data from earlier periods, we are not the first to examine changes in volatility from a historical perspective.[7] Previous research has examined the evidence from long time series by assuming volatilities were constant over arbitrary subsamples. An important distinguishing feature of our paper, relative to the previous literature, is that we econometrically estimate when and how volatilities have changed. We do

[5] See Kilian (2012) for a useful overview of many crucial issues in the context of the literature.
[6] While popular, the Blanchard and Quah (1989) approach is subject to a number of potential concerns one should be aware of. Faust and Leeper (1997) point out that each identified shock should be viewed as an aggregate of multiple underlying shocks. They argue that the Blanchard and Quah (1989) scheme is only valid if the macroeconomic variables in question respond to each type of a particular structural shock in the same way qualitatively. In other words, all types of disturbance to aggregate supply must affect output growth and the unemployment rate in qualitatively the same way, and all types of disturbance to aggregate demand must affect the two variables in qualitatively the same way. In other work, Erceg, Guerrieri and Gust (2005) study how well the Blanchard and Quah decomposition identifies technology shocks by performing a Monte Carlo investigation of calibrated structural models. They find that this decomposition performs well but does so under conditions even more restrictive than are implied by the identification assumptions.
[7] For example, Romer (1999), and more recently, Nason and Smith (2008) have considered evidence from subsamples including periods prior to World War I.

not presuppose dates of change in volatilities but instead allow the data to speak for itself on this issue. Another advantage of our model, when compared with a more traditional fixed-parameter approach, is that it allows us to determine whether a period of moderation takes place gradually or rapidly.

The paper is organized as follows: Section 2 constructs the time-varying parameter model, specifies the identification strategy, and describes the analysis of second moments. Section 3 discusses data sources and methods. Section 4 describes our results on time-variation in the volatilities of output growth and inflation. Section 5 examines the role of permanent and transitory shocks to output in explaining movements in volatilities over time. We conclude by discussing our main empirical findings and by examining the implications of these results for the sources of variation in volatilities of output growth and inflation.

2. The Time-Varying VAR and the Decomposition of Permanent and Transitory Shocks

We model the time series using a VAR that allows for time variation in the autoregressive coefficients and shock covariance matrix. This framework does not require any *a priori* assumptions about timing, frequency, or magnitude of possible changes in parameters. An important advantage of this approach is that it allows us to estimate a model that combines data from periods in which an economy behaved quite differently. At one time it was common for economists to estimate fixed parameter models using sample periods that excluded interesting, but potentially extreme, events such as World War I, the Great Depression, and World War II. Many believed the economy operated in a fundamentally different way during periods of global warfare or world-wide depression and, thus, the parameters were assumed to take on different values. A time-varying parameter model allows us to include these unusual periods of time in the estimation and to formally address the hypothesis that the parameters are different.

Our approach is similar to those of Cogley and Sargent (2001, 2005), Primiceri (2005), and Galí and Gambetti (2009). Consider an l *-th* order VAR process

$$\theta_t(L)x_t = e_t \tag{2.1}$$

where x_t is an n-vector of endogenous variables determined at time t, each θ_{jt} in

$\theta_t(L) = I - \theta_{1t}L - \ldots - \theta_{lt}L^l$ is a matrix of time-varying coefficients, and e_t is an n-vector of mean-zero VAR innovations with the time-varying covariance matrix R_t. The coefficients in (2.1) evolve according to[8]

$$\theta_t = \theta_{t-1} + u_t \tag{2.2}$$

where the vector θ_t stacks all parameters in $\theta_t(L)$, and u_t is Gaussian white noise with zero mean and constant covariance matrix *Q*, independent of e_t at all leads and lags.[9] The model reduces to a VAR with fixed coefficients and stochastic volatility if $u_t = 0$ for all *t*. For convenience, we omit means from this exposition, but for estimation we allow the means to be time-varying following a process analogous to the autoregressive parameters in (2.2). We use a variant of the Jaquier et al. (1994) stochastic volatility framework that decomposes the covariance matrix of the reduced-form VAR as follows:

$$E(e_t e') \equiv R_t = F_t H_t F' \text{ where } F \text{ is given by } F_t = \begin{pmatrix} 1 & 0 & \ldots & 0 \\ f_{2,1,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ f_{n,1,t} & \cdots & f_{n,n-1,t} & 1 \end{pmatrix} \text{ and } H_t = \begin{pmatrix} h_{1,t} & 0 & \ldots & 0 \\ 0 & h_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \ldots\ldots & 0 & h_{n,t} \end{pmatrix}.$$

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[8] This is a parameterization of a more general law of motion $p\left(\theta_t \mid \theta_{t-1}, Q\right) \propto I\left(\theta_t\right) f\left(\theta_t \mid \theta_{t-1}, Q\right)$ for the posterior densities of the states where $I\left(\theta_t\right)$ is an indicator function that carries out the rejection sampling mechanism necessary to rule out explosive paths of x.

[9] According to Primiceri (2005), this assumption is not necessary, but it allows for more efficient computations.

The diagonal elements of H_t are independent univariate stochastic processes that evolve according to the following:

$$\ln h_{j,t} = \ln h_{j,t-1} + \xi_t \qquad j = 1,2,\dots n \tag{2.3}$$

where $\xi_t \sim iid(0,\Xi)$. This random walk specification allows us to focus on permanent shifts in the innovation variance—such as those emphasized in the US economic stabilization literature (Cogley and Sargent 2005)—while reducing the dimensionality of the estimation procedure (Primiceri 2005).[10]

We stack all the off-diagonal elements of F_t^{-1} into a vector γ_t and, following Primiceri (2005), we assume that this vector evolves according to the following drift-less random walk

$$\gamma_t = \gamma_{t-1} + \zeta_t \tag{2.4}$$

where $\zeta_t \sim iid(0,\Psi)$. All innovations are assumed to be jointly normally distributed, and our bivariate application assumes the following covariance matrix of the system:

$$\text{var}\left(\begin{bmatrix}\varepsilon_t \\ u_t \\ \xi_t \\ \zeta_t\end{bmatrix}\right) = \begin{bmatrix} I & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & \Xi & 0 \\ 0 & 0 & 0 & \Psi \end{bmatrix}$$

where each vector of shocks $(\varepsilon_t, u_t, \xi_t, \zeta_t)$ consists of two elements; ε_t is a vector of uncorrelated structural shocks with unit variance; Q, Ξ, and Ψ are positive definite 2x2 matrices; I is a 2x2 identity matrix; and 0 is a 2x2 matrix of zeros. None of the off-diagonal zero restrictions are required for estimation.[11] However, allowing for an entirely unrestricted correlation structure among the different sources of uncertainty would negate any structural interpretation of the innovations.

[10] This presents an alternative to ARCH models where the variances are generated by an unobserved components (UC) approach.
[11] Primiceri (2005) outlines a minor modification to the estimation scheme to allow for non-zero off-diagonal blocks.

Following Galí and Gambetti (2009), we assume that the innovations, e_t, of reduced–form system (2.1) are a time-varying transformation of the ε_t structural shocks satisfying $E(\varepsilon_t \varepsilon_t') = I$. Thus, we have the following:

$$e_t = \varphi_t \varepsilon_t \qquad \forall t \tag{2.5}$$

where φ_t is a nonsingular matrix that satisfies $\varphi_t \varphi_t' = R_t$. Given this normalization scheme, changes in the contributions of different structural shocks to the volatility in innovations to the variables are captured by changes in φ_t.

The identification of shocks has nothing to do with the unconditional volatilities, which will be a major focus of the discussion that follows. These volatilities can be derived directly from the reduced form and do not depend on the identification of permanent and transitory shocks to the level of output. Conditional volatilities are the only ones that depend on these shocks.

Let the companion form of (2.1) be given by

$$x_t = \Theta_t x_{t-1} + D e_t \tag{2.6}$$

where $x_t = (x_t', x_{t-1}', \dots, x_{t-\ell+1}')'$, $D = (I, 0, \dots, 0)'$, both of these matrices have the same dimensions, and Θ_t is the companion-form matrix derived from the autoregressive coefficients in (2.1). A standard local projection of (2.6) yields

$$\frac{\partial x_{t+k}}{\partial e_t} = s_{2,2}(\Theta_t^k) \qquad \forall t, \quad k = 0, 1, 2, \dots \tag{2.7}$$

where $s_{2,2}(\bullet)$ is the appropriate selector function.[12] Application of the chain rule yields the following impulse responses at an arbitrary *k-th* horizon:

[12] Technically, the selector function is given by $s_{2,2}(\Theta_t^k) = D'\Theta_t^k D$ which selects the upper left 2x2 matrix from the larger matrix.

$$\frac{\partial x_{t+k}}{\partial \varepsilon_t} = \frac{\partial x_{t+k}}{\partial e_t}\frac{\partial e_t}{\partial \varepsilon_t} = s_{2,2}(\Theta_t^k)\varphi_t \qquad \forall t, \quad k = 0,1,2,... \tag{2.8}$$

Our model is based on y_t, the logarithm of real output, and p_t, the logarithm of the price level, and both variables are first differenced: $x_t = \left(\Delta y_t \ \Delta p_t\right)'$. For purposes of identifying shocks in the BQ decomposition, effects on the long-run level of y are of interest. This requires cumulative impulse responses that are obtained as follows. First, we define $\bar{\Theta}_t^k = \sum_{j=0}^{k} \Theta_t^j$. The level response of each variable to each shock after k periods is the accumulated response of the differenced series from period zero to period *k*. Following equation (2.8), the accumulated responses to each variable are given by $M_{t,k} \equiv \sum_{j=0}^{k} s_{2,2}(\Theta_t^j)\varphi_t$. Finally, from the properties of the selector function, we obtain $M_{t,k} = s_{2,2}(\bar{\Theta}_t^k)\varphi_t$. Furthermore, letting $k \to \infty$ allows us to define $M_t \equiv s_{2,2}(\bar{\Theta}_t^\infty)\varphi_t$ as a time-varying matrix of cumulative multipliers that measure the long-run effect of each shock on output and the price level.

The underlying structural shocks, $\varepsilon_t = \left(\varepsilon_t^P \varepsilon_t^T\right)'$, are identified by assuming a transitory shock does not affect the output level in the long run, in addition to the prior assumption that permanent shocks are uncorrelated with transitory shocks. This implies that our matrix of cumulative long-run multipliers is of a lower triangular form. Thus, from the definition of M_t

$$M_t M_t' = s_{2,2}(\bar{\Theta}_t^\infty) R_t [s_{2,2}(\bar{\Theta}_t^\infty)]' \tag{2.9}$$

M_t is obtained as the Cholesky factor of the right-hand side of (2.9). Given M_t, we can solve for φ_t as a function of the parameters in the VAR and obtain the structural impulse responses of each shock occurring at time t:

$$\frac{\partial x_{t+k}}{\partial \varepsilon_t} = s_{2,2}(\Theta_t^k)\Big[s_{2,2}(\overline{\Theta}_t^{\infty})\Big]^{-1} M_t \quad \forall t, \quad k = 0,1,2\ldots$$

With the exception of the long-run output response to a transitory output shock, every response of each variable to each disturbance may evolve over time.

Note that M_t is calculated in essentially the same way as BQ, except for two important differences: We allow for time variation in the coefficients and the covariance matrix of residuals, and we use the inflation rate as the second variable in the model, in contrast to BQ, who used the unemployment rate.

Recursive substitution on (2.6) allows each variable to be written as a function of current and past values of the permanent and transitory shocks to output. And letting x_{it} represent each variable, this time-varying moving average representation is given by:

$$x_{it} = \sum_{k=0}^{\infty} [\tilde{N}_{t,k}]_{i,P}\, \varepsilon_{t-k}^{P} + \sum_{k=0}^{\infty} [\tilde{N}_{t,k}]_{i,T}\, \varepsilon_{t-k}^{T} \qquad for\ i = \Delta y_t, \Delta p_t \tag{2.10}$$

where $\tilde{N}_{t,k} \equiv s_{2,2}(\Theta_t^k)\varphi_t$. From (2.11) we determine how the time-varying unconditional variance of x_{it} is decomposed into the contribution from each shock:

$$\mathrm{var}_t(x_{it}) = \sum_{k=0}^{\infty} [s_{2,2}(\Theta_t^k)\varphi_t]_{i,P}^2 + \sum_{k=0}^{\infty} [s_{2,2}(\Theta_t^k)\varphi_t]_{i,T}^2 \qquad for\ i = \Delta y_t, \Delta p_t \tag{2.11}$$

It is important to reemphasize that while this permanent-transitory shock decomposition serves as a means of identifying orthogonal shocks that may have structural interpretations, this decomposition has no effect on the unconditional standard deviations.

3. Data and Sources

We selected countries with uninterrupted annual time series of real output growth and inflation going back well into the 19th century.[13] In almost all cases, these series were computed on the basis of aggregate output measured in nominal and real terms. Canada's 1870 to 1960 period is the only exception, where we construct real output from nominal GDP and the GDP deflator.

A primary advantage of using a relatively long data sample is that it allows us to examine how economies have evolved under extremely different conditions. Volatilities are unlikely to remain constant as countries transition through the 19th century, the Great Depression, and the post-World War II period with intervening episodes of world-wide warfare. But, importantly, we do not constrain volatilities to be constant for arbitrary subsamples. The requirement of long uninterrupted annual time series does, however, limit our study to eight countries - the United States, the United Kingdom, Sweden, Italy, Finland, Denmark, Canada, and Australia. Most of the other countries in the world do not provide reliable series of comparable length. Some countries have data of similar quality and length but have breaks in the series, typically around a world war (e.g., France, Germany, and Japan).

Table 1 describes in detail the data used in our analysis. In all cases, we spliced output growth and inflation rates obtained from different sources. The table contains details on the various measures (GNP or GDP; chain-weighted or fixed base year measures of real output), data sources, splice dates, and base years (for calculating either a fixed weight measure of real output or the level of real output from chained growth rates). It is important to point out that despite various differences in data, our major results are robust across all, or nearly all, eight countries.

[13] Backus and Kehoe (1992) used many of the same countries and frequently the same sources for historical output series in their multi-country investigation of how business cycle properties have changed over time.

We estimate the model for the United States using Romer's (1989) data. However, strikingly similar results for the United States have been obtained by Keating and Valcarcel (2012) using data from Mitchell (2003b) and by Keating and Valcarcel (2011) using Balke and Gordon (1989) data.[14] One advantage of studying the United States is that alternative sets of data are available with which to compare estimates. A second advantage is that the Romer (1989) and Balke and Gordon (1989) series improve upon the original US time series for pre-1930 period. Unfortunately, little progress has been made on similar data improvements for other countries.

Another advantage of US data is that we have higher quality NIPA series going back to 1929, whereas for the other countries we have higher quality World Bank data that only goes back to around 1960. This raises a concern that the relatively limited span of high-quality data may play some role in generating results for the other seven countries. Obviously, we cannot directly address this concern because of data limitations. But we can determine if the US results are somehow affected if we perform our analysis with Mitchell's US data from 1822 to 1960 spliced to NIPA data from 1960 to 2009. The idea is to treat the US like the other countries by splicing its historical series of lower quality (Mitchell 2003b) to its modern series at roughly the same time as we spliced for those other countries. This procedure yields results that are virtually indistinguishable from the United States results reported here and in Keating and Valcarcel (2011, 2012).[15] Thus, our experiments show that the use of various sources of pre-1930

[14] It has been suggested by Romer (1986) and others that the volatility reduction in output growth during the 1940s could be due to measurement error. In a related paper, Romer (1989) constructs a GNP series from pre-1909 data on commodity output. She finds that the interwar period stands out as a time of "immoderation" flanked by periods of similar volatility in output growth. On the contrary, Balke and Gordon (1989) do not obtain this same result with their data. Also, Sheffrin (1988) finds that data from five of the six European countries in his study (Sweden being the exception) support Romer's claim that real output volatilities are essentially the same for the period before World War I and the period after World War II. But his approach is similar to previous researchers in that he calculated volatilities using preselected fixed sample periods, again in contrast to our approach.

[15] Furthermore, we estimated the model for the US based on Mitchell data from 1822 to 1993 (which is the last observation in the 2003 edition of Mitchell) spliced with NIPA data from 1993 to 2009. Our results from this experiment were quantitatively robust to all other US estimates. All of these efforts employ annual data, and, in the face of such robustness, some might still argue that this preponderance of similar estimates could be an artifice of the frequency of observation in the time series. Data limitations make it

data and the use of different sample periods have no effect on US results. These experiments support the view that findings for the other seven countries would not change appreciably if better historical measures of real output and price levels were available.[16] We conclude that the robustness of results to different samples of historical United States series and to series from seven other countries is inconsistent with the hypothesis that our results stem from noisy data.

Each series for each country is plotted in the Appendix. Henceforth, all references to output pertain to the real measure of output unless stated otherwise.

4. Evidence on Time-Varying Volatilities

Figure 1 reports time-varying standard deviations of output growth and inflation for the United States, while Figures 2 through 8 report both standard deviations for the United Kingdom, Sweden, Italy, Finland, Denmark, Canada, and Australia, respectively. Solid lines represent volatilities of output growth, while dashed lines denote inflation volatilities.

4.1 Output Growth Volatilities

We initially focus on the United States because the literature has paid a great deal of attention to US volatilities.[17] We then turn to results for the other seven countries to determine whether US findings are exceptional or generally the same. Output volatility for the United States starts out relatively low prior to World War I. However, it is virtually always higher from the beginning of World War I to shortly after the Korean War than in any other period in the

impossible to address this concern for every one of our results. But, based on monthly US data, graphs in Ahmadi (2009) show sizable reductions in volatility for industrial production and particularly for inflation taking place from the end of World War II until the mid-1960s. Thus the Postwar Moderation would seem robust, at least for the US, to higher frequency data. Note that the Postwar Moderation is not discussed in Ahmadi's paper and that he uses a different econometric model for other ends to those of this paper.

[16] Also, the well-known problems with historical US data may be less important for the European countries in our study. Sheffrin (1988) explains how "methods used to construct data in the United Kingdom, Denmark, Sweden and Italy do(es) not reveal the type of fundamental change in methods that afflict United States' estimates." He also argues that there is "generally better source material in the European countries" compared to the United States.

[17] It helps clarify our main findings by first focusing attention on a single country, and the US is the largest economy for most of the period covered in this study.

sample. Then, we observe the Postwar Moderation as output volatility begins to fall dramatically from shortly after World War II until the mid-1960s.

Table 2 provides a useful summary of some of the main results in this paper. It reports posterior standard deviation estimates at key points in time. Most importantly, this table facilitates a direct comparison of volatilities from the Postwar Moderation with those from the Great Moderation. Table 2 also shows the maximum and minimum values of each variable's volatility in the sample, along with the year in which each of those occurred. The Postwar Moderation is measured by the percentage decline in standard deviation from 1947 to 1965. Volatilities in 1983 and 1995 are used to measure the extent of the Great Moderation. During this Postwar Moderation, the standard deviation of US output growth fell by almost 60%. Volatility stabilized for some time, and then, in the early 1980s, it began falling again, reaching its global minimum in 1997. This most recent decline is known as the Great Moderation, during which output growth volatility fell by 36%. This decline in volatility pales in comparison to that which occurred during the Postwar Moderation.[18] At the end of the sample period, output growth volatility rises back to the level it had shortly before the Great Moderation.

When considering the other seven countries, Figures 2-8 indicate that, in general, output growth volatility declines rapidly almost immediately after World War II. In all cases, the decline in volatilities during this Postwar Moderation exceeds that of the Great Moderation, whether measured in terms of change in volatility or in percentage change. In fact, as illustrated by the figures, the Postwar Moderation clearly yields the largest decline in volatility in output volatility for six of the eight countries in our study. As indicated in Table 2, these reductions in volatility from 1947 and 1965 range from 85% in Italy to 49% in Denmark. For the remaining

[18] Our estimate of the reduction in US output growth volatility during Great Moderation is in the ballpark of Stock and Watson's (2002) estimate.

two countries, Finland and Sweden, the largest decline in output growth volatility occurs after World War I. However, the second largest reduction in output growth volatility for these countries begins shortly after World War II.[19]

Output growth volatility tends to be persistently lower following the Postwar Moderation. It is always lower for the United States, Australia, and Canada and nearly always lower for the United Kingdom. Over most of the sample, output volatilities for Sweden, Italy, and Finland are lower in the post-World War II period than in the period before that war. Denmark is the exception, with unusually low output growth volatility for most of our pre-World War I sample.

The moderations in output volatility that follow World War II are impressive for two reasons. One is that this period typically yields the most substantial decline in volatility for a country, and, if not largest, the Postwar Moderation is second largest. Regardless, the Postwar Moderation is in all cases more substantial than the Great Moderation. Second, the output growth volatility achieved by the end of this moderation is relatively low for the period up to that point in a sample.

While output growth volatility tends to be lower following the Postwar Moderation than in the period which precedes it, this is not always the case. The primary exception is the Classical Gold Standard period. Output growth volatility is unusually low for Italy, Sweden, and Denmark during that period. But, if we exclude the Classical Gold Standard period for each country, output growth volatility is almost always lower following the rapid post-World War II decline than for any time before the Postwar Moderation.

[19] Output volatility in Finland and Sweden reached an all-time peak (0.1 and 0.055, respectively) in 1918. Both countries experienced a reduction of 58% and 52% in output volatility after World War I that surpassed their Postwar Moderations—of 50% and 17%, respectively. These are the only two countries in our sample for which the Postwar Moderation was not the largest reduction in output growth volatility, but in both cases the Postwar Moderation was second largest.

Output growth volatility almost always reaches its lowest level following the Great Moderation. There are, however, a few episodes after the Postwar Moderation has ended when output growth volatility increases. One example of this is the experience of most countries during the 1970s or early 1980s. This is particularly noteworthy for the United Kingdom where output growth volatility sometimes exceeds levels typical of the pre-World War II period.

Another example of relatively high postwar volatilities comes from Finland and Sweden, which both experienced sizable increases in output growth volatility in the early 1990s. That period coincides with the Scandinavian financial crisis that primarily affected these two countries along with Norway. This crisis was associated with a boom in lending, which apparently caused a bubble in real estate and other asset markets. To make matters worse, the decline in asset prices was accompanied by a currency crisis. This crisis explains why output growth volatilities for these two countries were increasing while the other six countries in our study experienced a moderation in the late 1980s and early 1990s (see Table 2).

One of the most interesting findings is that output growth volatility for most countries is rising and relatively high at the end of our sample period. In all but one of them, output growth volatility has risen to a level not witnessed since the Great Moderation began. And for Sweden, Finland, and Denmark, volatility has reached levels not observed since much earlier in the postwar period. Australia is unique in that output growth volatility is not rising at the end of the sample period. This finding suggests the Australian economy has been mildly affected by the recent world-wide financial crisis, compared with the other seven countries.

4.2 Inflation Volatilities

Inflation volatilities are also reported in Figures 1 through 8 and in Table 2. First, we observe that US inflation volatility starts at a low level in the early 1900s that will not be reached again until after World War II. Volatility increases somewhat about the time of the Panic of 1907, but then rises much faster during World War I. It reaches the highest in-sample level in 1922, a few years after the war ends. Following a smaller post-World War II spike, inflation volatility falls more in percentage terms than in any other period. The steepest decline in inflation volatility occurs shortly after the 1951 Accord between the Treasury and the Federal Reserve, which terminated the Fed's obligation to peg the long-term nominal bond rate at a low level.[20] By the mid-1960s inflation volatility falls by roughly 80% and, thus, experiences a Postwar Moderation that coincides with that of output growth volatility. But, subsequently, inflation volatility starts to rise, slowly at first, and more rapidly as it spikes in the mid-1970s. Volatility stays relatively high until the early 1980s, and then it begins to fall until the 1990s when it reaches its lowest in-sample level.[21] Since then, it has increased a small amount and lies in the narrow range between the all-time low from the 1990s and the relatively low level reached in the mid-1960s. Thus, inflation volatility does not rise at the end of the sample, in contrast to output growth volatility.

Adding the other seven countries to our discussion of inflation volatility yields a number of robust results, many of which are strikingly similar to those for output growth volatility. For example, the lowest inflation volatility prior to the end of World War II occurs during the Classical Gold Standard period. Immediately after World War II, inflation volatility rises for a period of time, and sometimes the increase is quite substantial; but eventually it begins to fall rapidly. Each country experiences a substantial moderation in inflation volatility after World War II, which takes place for a decade or more. The US, UK, Sweden, Italy, Finland, Denmark, Canada, and Australia experience a reduction in volatility of 80%, 68%, 49%, 89%,

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[20] The finding from the rational expectations literature that an arbitrary peg of the nominal interest rate gives rise to indeterminacy of the price level, details of which are carefully explained in Woodford (2003), is consistent with our result that inflation volatility comes down rapidly when the peg is lifted.

[21] US inflation volatility reduces by 66% between 1983 and 1995 to an eventual all-time low of 0.0070 by 1997.

76%, 51%, 77%, and 35%, respectively, from 1947 to 1965.[22] During this Postwar Moderation, the largest single-year decline for a country occurs somewhere between 1952 and 1955, not long after the Fed-Treasury accord of 1951. By the 1960s, inflation volatility reaches its lowest level up to that point in the sample period for all but one of the countries.[23] Table 2 shows that inflation volatility falls during the Great Moderation, but by less than the Postwar Moderation—often by much less.

Inflation volatility has a strong tendency to be lower in the postwar period. But there are a few notable exceptions. For example, during the 1970s, inflation volatility for the UK, Sweden, Italy, Finland, Canada, and Australia often exceeds levels reached prior to the Postwar Moderation. It is during this period that the postwar highs for inflation volatility sometimes exceed the prewar lows experienced during the Classical Gold Standard period. Another exception to low postwar inflation volatility is the increase at the end of our sample. This occurs for every country—except, once again, in Australia—and is concurrent with the recent global financial crisis. The end-of-sample rise in inflation volatility is particularly pronounced for the UK, Denmark, and Canada.

In general, inflation volatility rises to a local, if not a global, maximum around the time of major wars. It spikes for all countries near the end of World War I, often reaching the highest level for a country.[24] Inflation volatility also tends to elevate during and after World War II, most notably in Italy and Denmark, each of which experiences an all-time peak during that period.

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[22] The inflation volatility for the US, UK, Italy, and Denmark begins this postwar decline in 1946 or 1947, while it does not fall for Sweden, Finland, Canada, and Australia until the early 1950s. For each of the latter four countries, the percentage decline for inflation volatility in the Postwar Moderation would be larger if measured from the early 1950s peak in inflation volatility.

[23] Finland, which had particularly low inflation volatility during the Classical Gold Standard period, is the exception.

[24] The maximum US inflation volatility in this paper occurs shortly after World War I. In contrast, Keating and Valcarcel (2012) find that this peak in inflation volatility is second to an all-time US peak that occurs during the Civil War. They used data from Mitchell (2003b) that provides much longer time series than the Romer (1989) data used in this paper.

We find that a large and rapid reduction in inflation volatility typically follows the upward spike that almost always accompanies a major war. Often the largest decline occurs in the early 1920s. This seems to be an opposite reaction to the enormous rise in inflation volatility associated with World War I and its aftermath. And, while inflation volatility declines rapidly at that point, it does not reach the low levels typical of the postwar period or the Classical Gold Standard period.

5. Accounting for Changes in Volatility of Output Growth and Inflation

Equation (2.11) is used to decompose the standard errors into components attributable to permanent and transitory shocks following a BQ-type identification scheme. That construct may provide a structural interpretation of the sources of changes in volatilities. If BQ's assumptions characterize the actual structure, their model associates permanent output shocks with aggregate supply and temporary output shocks with aggregate demand. This accounting for volatilities yields highly robust results across the eight countries.

Figure 9 illustrates how output growth volatility is decomposed into components associated with these shocks to output at each point in time for each country. The contribution from temporary shocks to the volatility of output growth never exceeds, and almost never comes close to, the contribution made by permanent shocks. We observe only a few cases (around World War I, World War II, and the mid-1970s to the early 1980s) when temporary shocks make a notable contribution to output growth volatility. Overall, the most striking feature in these graphs is how movements in output volatility are closely mirrored by changes in the contribution from permanent shocks. Most of the time, permanent shocks account for nearly all of the volatility of output growth. These results, interpreted in the context of BQ's model, imply that fluctuations in the contribution from aggregate supply are the primary factor explaining changes in output growth volatility.

Figure 10 displays each country's inflation volatility at each point in time along with the contribution from each shock. For all countries, we see that the fluctuations in inflation volatility are usually closely tracked by the contribution made by temporary shocks to output. However, there are periods for some of the countries in which the permanent shock accounts for nearly as much inflation volatility as the temporary shock, and sometimes for even more, though this is rare. These exceptions occur primarily during world wars, the period from the mid-1970s to early 1980s, and the latter part of the sample. However, for most years, the temporary shock accounts for nearly all of the inflation volatility. The BQ model implies that aggregate demand is the major force behind changes in inflation volatility, although there are some periods when aggregate supply was also important.

Ignoring the 1970s and the Classical Gold Standard period, inflation volatility strongly tends to be lower after the Postwar Moderation than during the preceding period. The BQ model suggests that this relatively lower inflation volatility stems largely from a reduction in the contribution from aggregate demand.

6. Conclusion

Many patterns of change in the volatilities of output growth and inflation are remarkably robust to all, or nearly all, the countries in our study. We find that volatilities rise quickly with World War I, stay relatively high until after World War II, and drop rapidly until the mid-to late 1960s. Volatilities show a very strong tendency to be lower following the Postwar Moderation compared with the whole period that precedes World War II. This finding suggests the greater emphasis on stabilization policy in the postwar period has yielded some success. For example, at the Bretton Woods meetings in July of 1944, a world-wide system of fixed exchange rates was established,[25] and policy was oriented more towards stabilizing economic fluctuations. Subsequently, the United States passed the Employment Act of 1946, which occurs just before US volatilities of output growth and inflation began rapid descents. That timing suggests the intent of the US Federal government "to promote maximum employment, production and purchasing power" (15 USC, §1021) led to policies that made important contributions to the Postwar Moderation.

The lowest volatilities at the end of the Postwar Moderation are typically larger than the lows achieved following the Great Moderation, though they are sometimes very close in magnitude. But the absolute reduction and the percentage decline for both volatilities during the Postwar Moderation exceeds that of the Great Moderation, and often does so by a huge margin.

Table 2 highlights a number of important points, in addition to the finding that the decline of both volatilities during the Postwar Moderation is uniformly greater than the Great Moderation. First, not every country experiences a Great Moderation. Sweden and Finland experienced an increase in volatilities between the mid-1980s and mid-1990s because of the Scandinavian financial crisis. Among the remaining countries, Denmark experienced the most modest Great Moderation, likely because of spillover effects from the neighboring countries hit hardest by the Scandinavian crisis. Second, output growth volatility in most countries peaked around World War I. The lowest levels in output volatility are reached following the Great Moderation for every country except Sweden. Third, except for Canada, each country's inflation volatility reaches its lowest level in the 1990s or 2000s, and most peaked shortly after

[25] For example, Australia and Sweden opted for a fixed exchange rate system after 1945. Italy, Denmark, and Finland pegged their currencies directly to the US dollar as well. This was not always the case. For example, after a couple of costly currency devaluations immediately following World War II, Canada opted for a floating exchange rate system in 1950.

World War I, with the exception of Italy, which experienced a post-World War II hyperinflation, and Australia which peaked in 1952.

The Classical Gold Standard typically yields the lowest volatilities for output growth and inflation in the period before 1945. For countries with long enough time series to allow us to estimate standard errors over a period encompassing the Classical Gold Standard, we find that volatilities fall at the beginning of the Classical Gold Standard period and rise near the end of that period.[26] Inflation volatility for each country is lower during the Classical Gold Standard period than it will be for a long time afterwards.

The Classical Gold Standard may serve as a natural experiment to test a fixed exchange rate system's ability to stabilize economic fluctuations. We also observe that the most dramatic declines in postwar output growth and inflation volatilities occur during the Postwar Moderation, which coincides with the Bretton Woods exchange rate regime. The timing of these two periods of reduced volatility suggests that a fixed exchange rate system is conducive to economic stability.[27]

Our estimates show that fixed exchange rate systems are associated with some of the largest reductions in volatility. However, a fixed exchange rate system is not necessary to achieve low volatilities. Standard errors of output growth and inflation over the last 20 years have been at or near historic lows, a time without any world-wide fixed exchange rate regime.[28]

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[26] The United Kingdom and Denmark are the only countries in this paper with volatility estimates extending back to a period before the Classical Gold Standard. For both countries, output volatility is lower during the Classical Gold Standard period compared with the years before or for a long time afterwards. In contrast, using the long series found in Mitchell (2003b), Keating and Valcarcel (2012) find that US output growth volatility trends upward during the Classical Gold Standard period. One possible explanation for this positive trend in output growth volatility is that the US may have become particularly adept at taking advantage of innovations that came about during that period when the US was becoming the world's largest economy. If creative destruction happened on a larger scale in the US compared with most other countries, then a rise in US output growth volatility may be associated with a period of rapid technological change. This conjecture suggests a potentially interesting line of future research.

[27] A lengthy literature that investigates whether a fixed exchange rate system is stabilizing, relative to flexible rates, has developed over the years. In general, fixed exchange rates may stabilize fluctuations in output growth and inflation depending on certain conditions that pertain to the variances of structural shocks and the values of structural parameters.

[28] However, during much of the Great Moderation period, exchange rates were not fully flexible for some of these countries. Starting in 1979, Denmark, Finland, Italy, Sweden, and the UK tied their currencies together with other European Union members through the European Exchange Rate Mechanism (EERM). In 1992, after a speculative attack on the British Pound, the UK exited the

Inflation volatility usually reaches its highest post-World War II level in the 1970s or early 1980s. In some cases, it greatly exceeds levels witnessed before that war. Output growth volatility also rises somewhat around that period. Thus, a sizable part of the Great Moderation constitutes a return to volatility levels achieved during the Postwar Moderation—a reclamation of stability gains surrendered during the 1970s. This response is particularly pronounced for the US, the UK, Italy, and Canada. One likely explanation for the rise in volatilities during the 1970s is that the variance of oil supply shocks was higher. Another possible explanation could be that monetary policy was not functioning properly. Specifically, central banks may not have obeyed the Taylor Principle. Such behavior often yields an indeterminate equilibrium in theoretical models.[29] Greater uncertainty and rising volatilities would be a natural outcome of indeterminacy.

Both volatilities increase at the end of the sample for every country except Australia. In nearly all cases, volatilities rise to levels not seen since the 1980s and sometimes even earlier. This evidence suggests the Great Moderation has ended for nearly all the countries in our sample.[30] Furthermore, recent volatilities now exceed lows reached during the Postwar Moderation for the UK, Sweden, Denmark, Finland, and Canada. This evidence suggests that most of the countries in our sample may be in jeopardy of losing some of the gains made during the Postwar Moderation.

We also find that permanent shocks to output account for nearly all of the fluctuations in the volatility of output growth, while shocks that have only a temporary effect on output account for most of the fluctuations in the volatility of inflation. The structural interpretation of

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EERM, with Italy following shortly after. In July 1993, the remaining EERM countries agreed to deviations from exchange rate targets up to 15%—a move closer to a fully floating exchange rate regime.

[29] See Clarida, Gali and Gertler (2000) on this point. However, Ascari and Ropele (2009) show that the determinacy region may shrink with steady state inflation. They argue that indeterminacy may still have obtained during the Volker-Greenspan period even if the policy rule satisfied the Taylor Principle.

[30] Using different methods, others have questioned whether the Great Moderation is over. See Clark (2009) for examples.

the BQ model suggests that fluctuations in output growth volatility are primarily attributable to aggregate supply and that fluctuations in inflation volatility are largely due to aggregate demand.[31] Of course, one may doubt that interpretation given that there are a number of different economic models for which aggregate demand may have a permanent effect on output. [32] But even if the BQ decomposition fails to provide an accurate description of the economic structure, it still serves as a statistical model that provides an interesting empirical regularity—permanent output shocks are the primary source of changes in output growth volatility. This finding might be used to evaluate different economic theories.[33]

Our study has established evidence of substantial movements in volatility of output growth and inflation. Frequently, these movements in volatility are associated with changes in policy such as to a wide-spread system of fixed exchange rates, to greater emphasis on economic stabilization in the post-World War II period, or to a possible failure of central banks to follow the Taylor Principle in the 1970s and early 1980s. We also observe large movements in volatilities around the time of major macroeconomic shocks such as World War I, World War II, and the oil price shocks of the 1970s. A better understanding of the fundamental causes of major movements in volatility is an important step towards the ultimate goal of crafting welfare-improving policies.

[31] Changes in each variable's volatility that are primarily driven by a different type of structural disturbance seem to contradict the "good luck" hypothesis. For "good luck" to explain our results, changes in volatilities of the two different structural shocks would need to be coordinated. But the different structural shocks in our model are uncorrelated. Instead, policy changes or structural changes induced by major events seem to be more plausible explanations, particularly since these can be observed at times when major changes in estimated volatilities occur.

[32] Keating (2010) shows how one may infer qualitative information about the underlying structure from impulse responses and variance decompositions for permanent and transitory shocks even if demand shocks permanently affect the level of output.

[33] The use of DSGE models to discriminate between different economic theories on the basis of the factors that influence volatility is a potentially useful research area. This framework could be used to quantify how much of the volatility of each variable is attributable to different types of structural shocks. To be consistent with our results, shocks that cause permanent movements in output in a theoretical model should be a primary source of fluctuations in output growth volatility.

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TABLE 1: Data Sources

	Current Output	Real Output or Deflator
United States	GNP 1869-1929 *(USD)* **Source: Romer (1989)** GNP 1929-2009 *(USD)* **Source: NIPA**	GNP 1869-1929 *(1982 USD)* **Source: Romer (1989)** GNP 1929-2009 *(chain-weighted 2005 USD)* **Source: NIPA**
United Kingdom	GDP 1830-1960 *(GBP)* **Source: Mitchell (2003a)** GDP 1960-2009 *(GBP)* **Source: WDI**	GDP 1830-1912 *(1900 GBP)* GDP 1912-1948 *(1938 GBP)* GDP 1948-1960 *(1958 GBP)* **Source: Mitchell (2003a)** GDP 1960-2009 *(2000 GBP)* **Source: WDI**
Sweden	GDP 1861-1960 *(SEK)* **Source: Mitchell (2003a)** GDP 1960-2009 *(SEK)* **Source: WDI**	GDP 1861-1950 *(1908 SEK)* GDP 1950-1960 *(1970 SEK)* **Source: Mitchell (2003a)** GDP 1960-2009 *(chain-weighted 2000 SEK)* **Source: WDI**
Italy	GNP 1861-1960 *(Lira)* **Source: Mitchell (2003a)** GDP 1960-2009 *(Euro)* **Source: WDI**	GNP 1861-1951 *(1938 Lira)* GNP 1951-1960 *(1963 Lira)* **Source: Mitchell (2003a)** GDP 1960-2009 *(chain-weighted 2000 Euro)* **Source: WDI**
Finland	GDP 1860-1960 *(Markaa)* **Source: Mitchell (2003a)** GDP 1960-2009 *(Euro)* **Source: WDI**	GDP 1860-1960 *(1985 Markaa)* **Source: Mitchell (2003a)** GDP 1960-2009 *(2000 Euro)* **Source: WDI**
Denmark	GDP 1818-1960 *(DKK)* **Source: Mitchell (2003a)** GDP 1960-2009 *(DKK)* **Source: WDI**	GDP 1818-1960 *(1929 DKK)* **Source: Mitchell (2003a)** GDP 1960-2009 *(2000 DKK)* **Source: WDI**
Canada	GDP 1870-1960 *(CAD)* **Source: Urquhart (1988)** GDP 1960-2009 *(CAD)* **Source: WDI**	PGDP 1870-1960 *(1981 GDP deflator)* **Source: Urquhart (1988)** GDP 1960-2009 *(2000 CAD)* **Source: WDI**
Australia	GDP 1861-1965 *(AUD)* **Source: Maddock &McLean (1987)** GDP 1965-2009 *(AUD)* **Source: WDI**	GDP 1861-1965 *(1911 AUD)* **Source: Maddock &McLean (1987)** GDP 1965-2009 *(chain-weighted 2007 AUD)* **Source: WDI**

Sources: WDI refers to World Development Indicator issue by the World Bank.
NIPA refers to National Income and Product Accounts issued by the Bureau of Economic Analysis.
See the paper's references for the sources of historical data.

TABLE 2: Posterior Standard Deviation Estimates

		Postwar Moderation: 1947 - 1965			**Great Moderation: 1983 - 1995**			**Full Sample**	
Country	Variable	1947	1965	*% Reduction*	1983	1995	*% Reduction*	**Max**	**Min**
United States (1902-2009)	Output Growth	0.0672	0.0272	*59.4%*	0.0249	0.0158	*36.4%*	0.0819 **1933**	0.0150 **1997**
	Inflation	0.0617	0.0122	*80.2%*	0.0211	0.0072	*65.5%*	0.1218 **1922**	0.0070 **1997**
United Kingdom (1863-2009)	Output Growth	0.0375	0.0162	*56.8%*	0.0191	0.0135	*29.3%*	0.0629 **1920**	0.0123 **1998**
	Inflation	0.0616	0.0194	*68.4%*	0.0291	0.0134	*53.8%*	0.1207 **1917**	0.0134 **1996**
Sweden (1894-2009)	Output Growth	0.0222	0.0185	*16.5%*	0.0171	0.0224	***-31.0%***	0.0543 **1918**	0.0165 **1958**
	Inflation	0.0449	0.0229	*48.8%*	0.0340	0.0359	***-5.7%***	0.1923 **1922**	0.0187 **2003**
Italy (1894-2009)	Output Growth	0.1941	0.0301	*84.5%*	0.0231	0.0157	*32.0%*	0.1941 **1947**	0.0117 **1999**
	Inflation	0.3147	0.0355	*88.7%*	0.0457	0.0327	*28.4%*	0.4158 **1945**	0.0118 **2004**
Finland (1893-2009)	Output Growth	0.0562	0.0278	*50.5%*	0.0192	0.0280	***-46.1%***	0.1002 **1918**	0.0186 **1986**
	Inflation	0.2090	0.0505	*75.8%*	0.0282	0.0301	***-6.5%***	0.2421 **1918**	0.0217 **2004**
Denmark (1851-2009)	Output Growth	0.0638	0.0325	*49.1%*	0.0226	0.0192	*14.9%*	0.0713 **1941**	0.0168 **1999**
	Inflation	0.0726	0.0354	*51.2%*	0.0267	0.0223	*16.2%*	0.1782 **1922**	0.0188 **2000**
Canada (1903-2009)	Output Growth	0.0486	0.0244	*49.7%*	0.0250	0.0199	*20.4%*	0.1144 **1905**	0.0195 **1997**
	Inflation	0.0600	0.0135	*77.4%*	0.0237	0.0140	*40.7%*	0.1574 **1925**	0.0126 **1963**
Australia (1894-2009)	Output Growth	0.0529	0.0249	*52.8%*	0.0207	0.0152	*26.6%*	0.0720 **1916**	0.0119 **2006**
	Inflation	0.0611	0.0398	*34.8%*	0.0334	0.0219	*34.2%*	0.0850 **1952**	0.0157 **2009**

Note: Negative signs on percentage reductions denote that volatilities increased for Sweden and Finland at the time when all the other countries in the sample experienced the Great Moderation.

Figure 1: United States Time-Varying Standard Deviations: 1902-2009

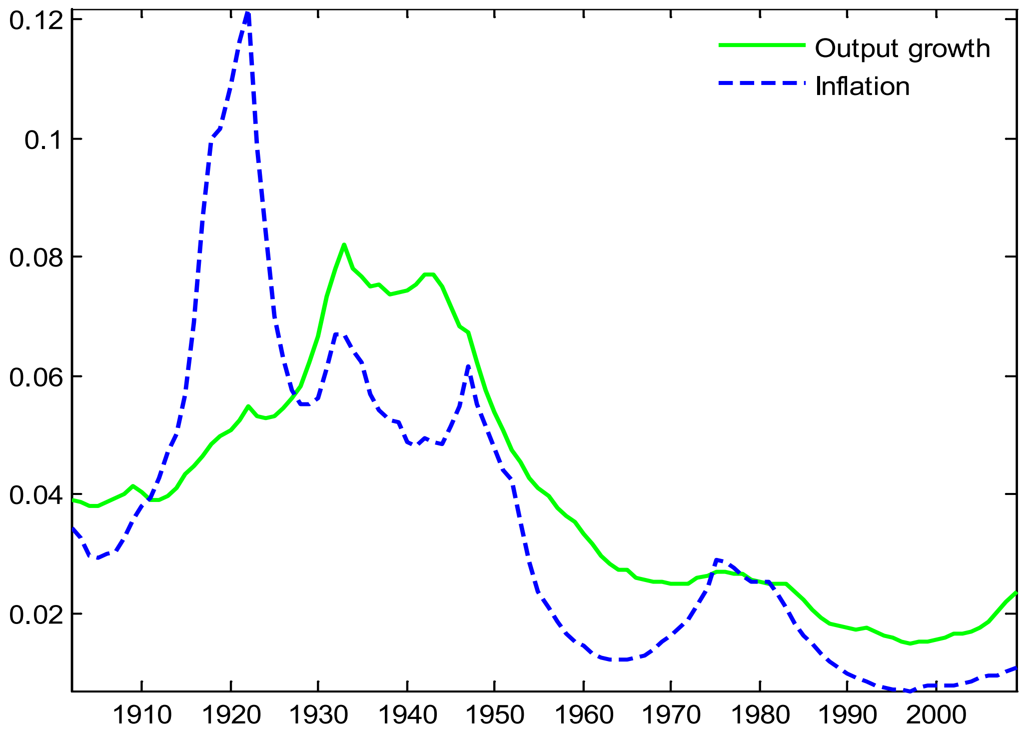


Figure 2: United Kingdom Time-Varying Standard Deviations: 1863-2009

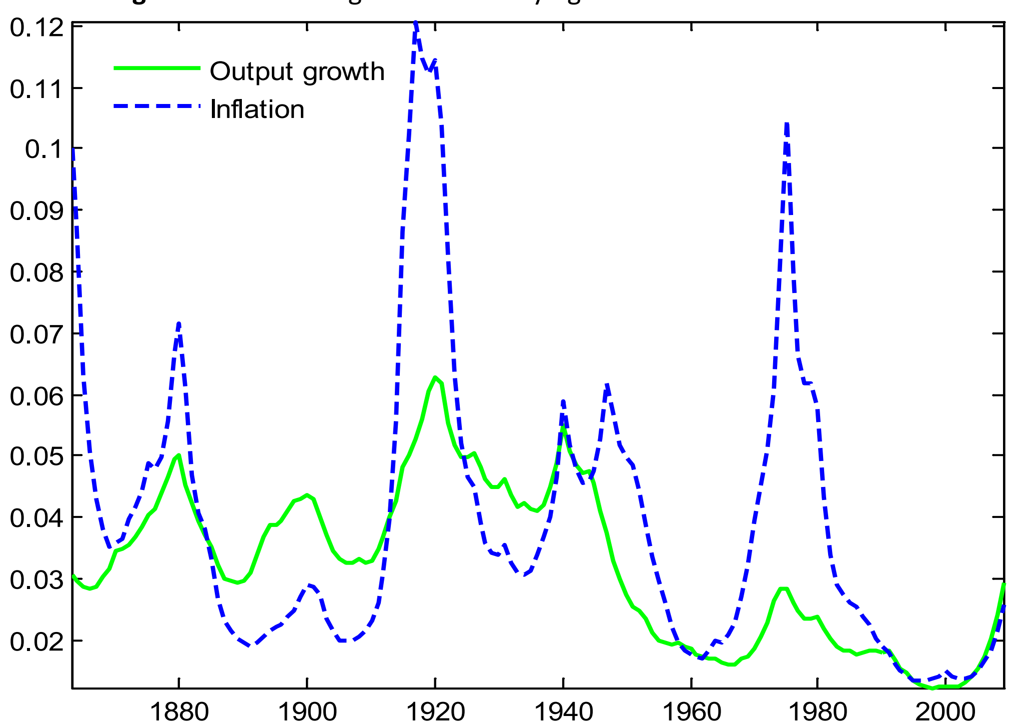


Figure 3: Sweden Time-Varying Standard Deviations: 1894-2009

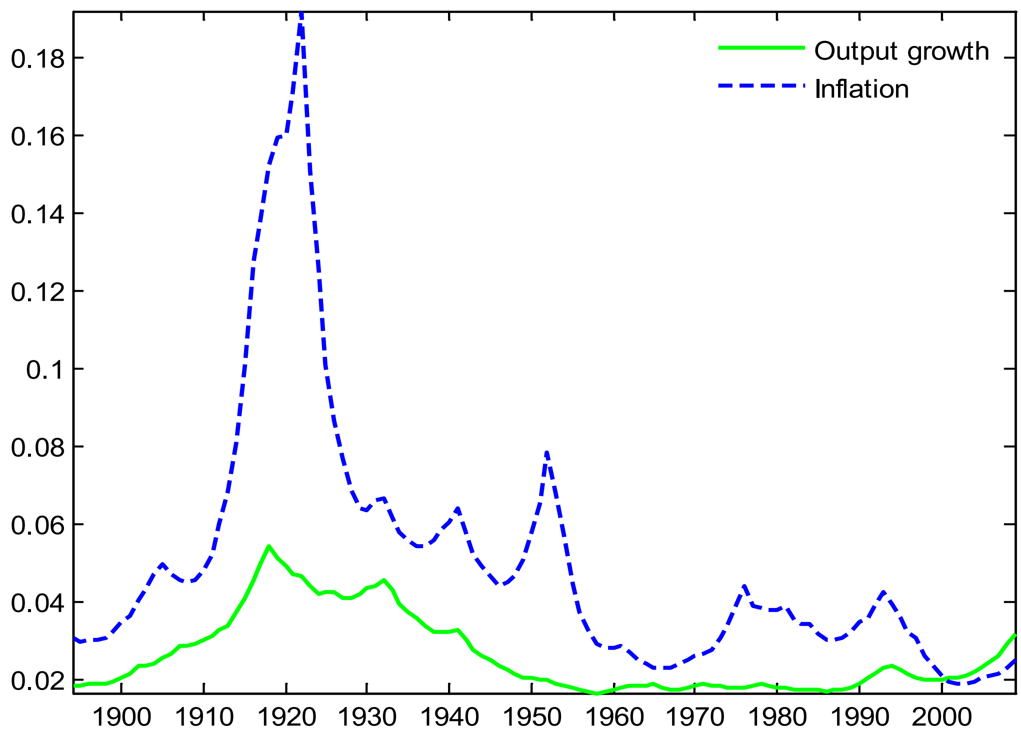


Figure 4: Italy Time-Varying Standard Deviations: 1894-2009

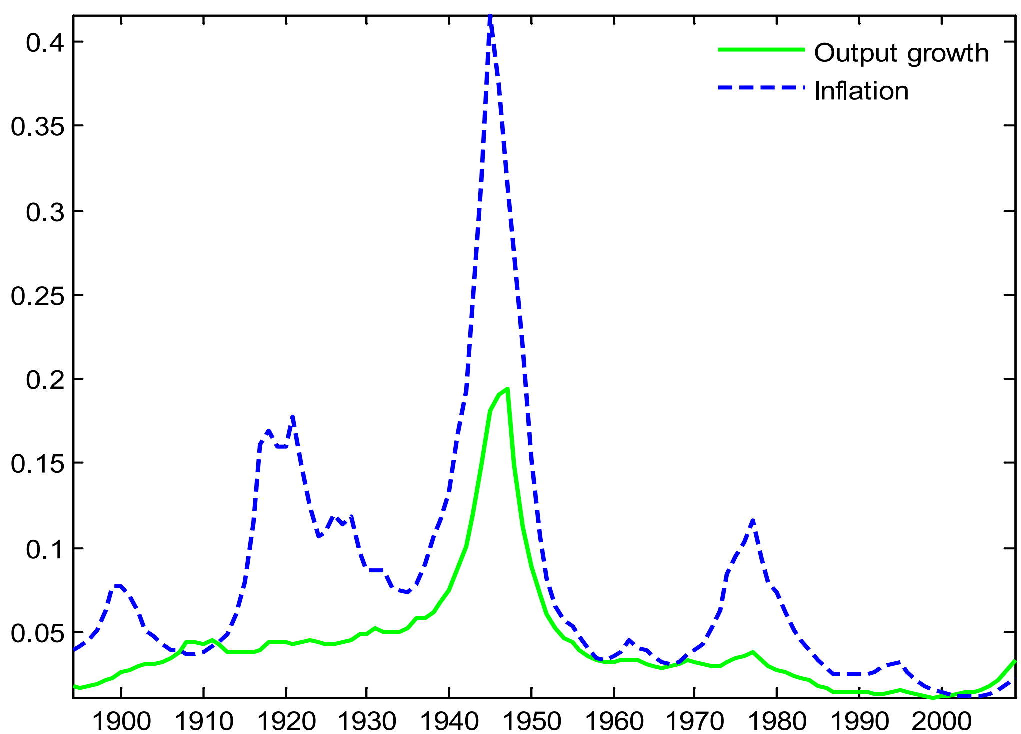


Figure 5: Finland Time-Varying Standard Deviations: 1893-2009

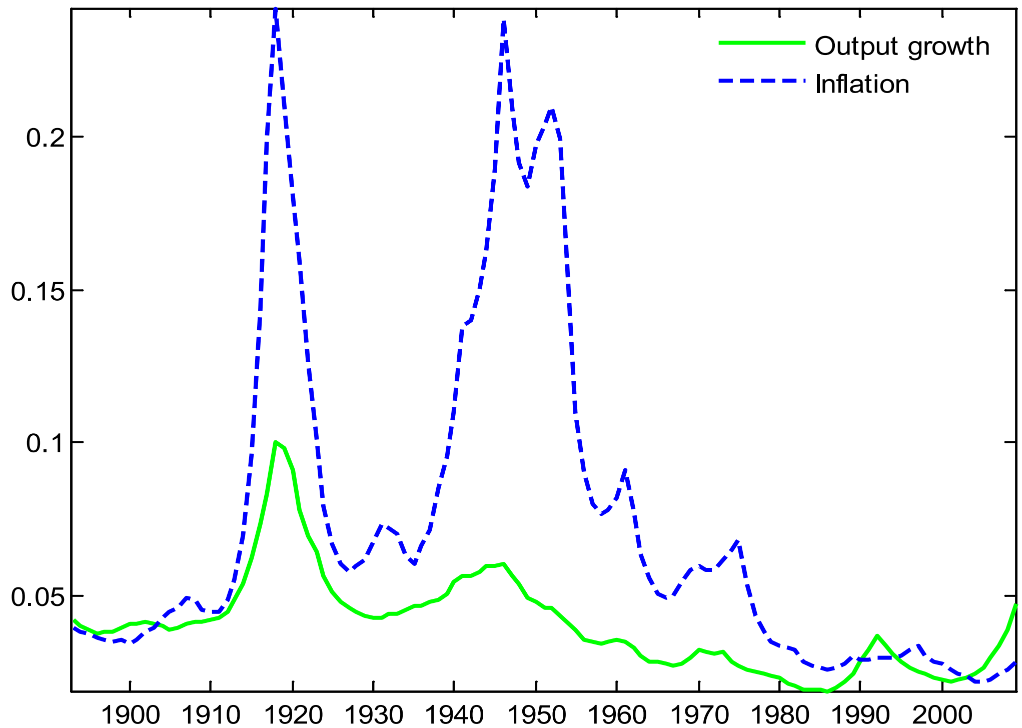


Figure 6: Denmark Time-Varying Standard Deviations: 1851-2009

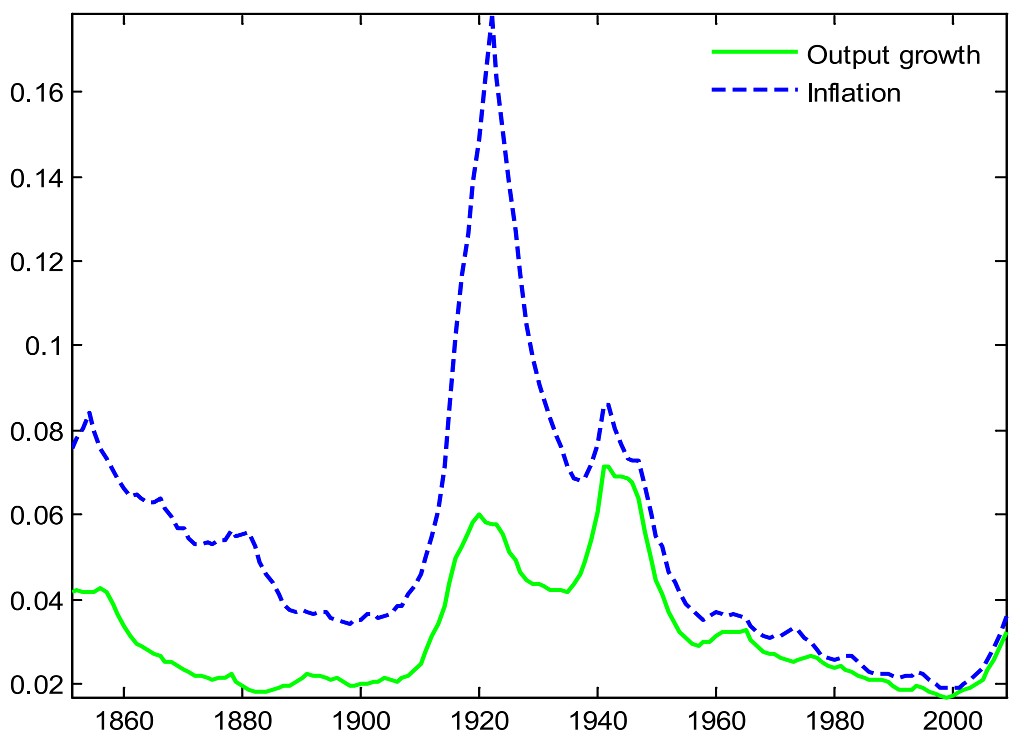


Figure 7: Canada Time-Varying Standard Deviations: 1903-2009

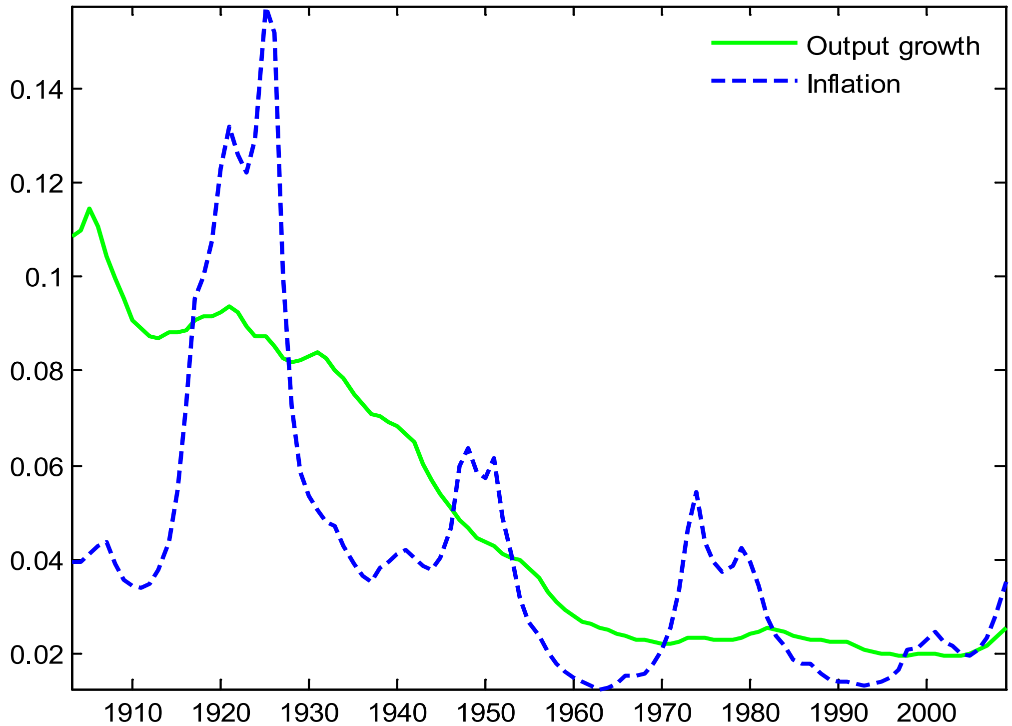


Figure 8: Australia Time-Varying Standard Deviations: 1894-2009

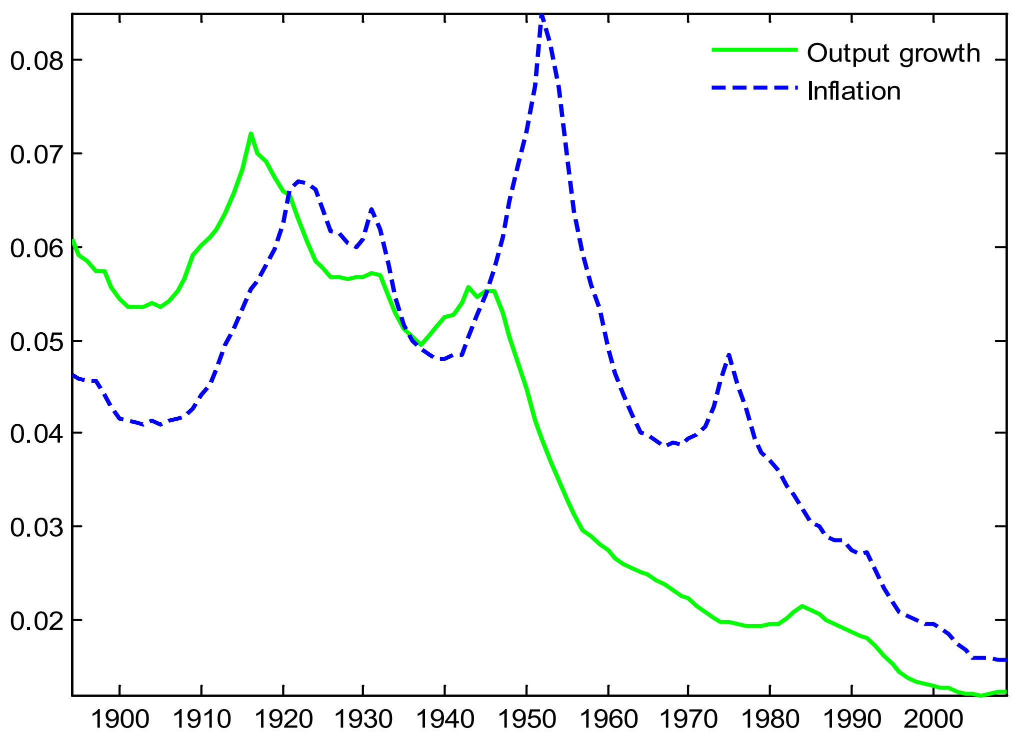


Figure 9: Conditional Time-Varying Standard Deviations of Output Growth

Figure 9A: United Sates Real GNP Growth: 1902-2009

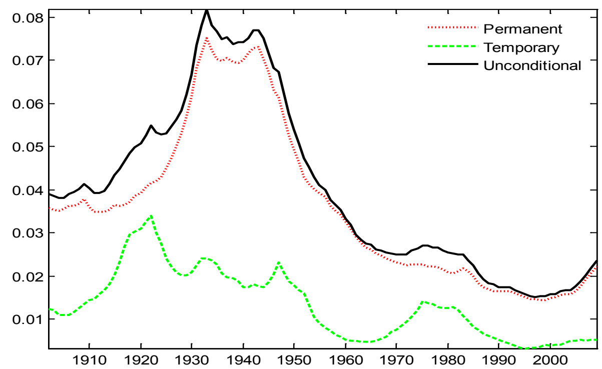


Figure 9B: United Kingdom Real GDP Growth: 1863-2009

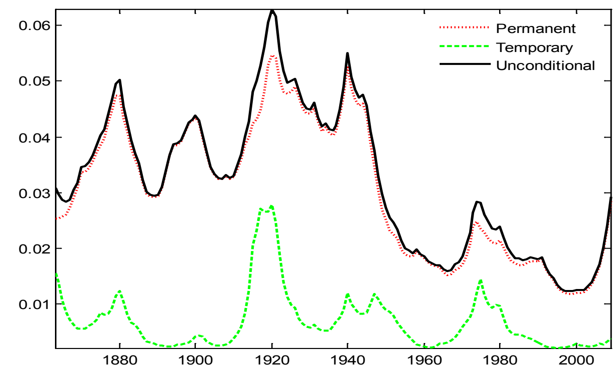


Figure 9C: Sweden Real GDP Growth: 1894-2009

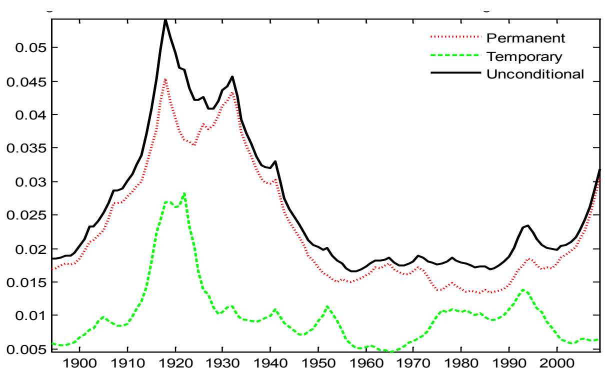


Figure 9D: Italy Real GNP Growth: 1894-2009

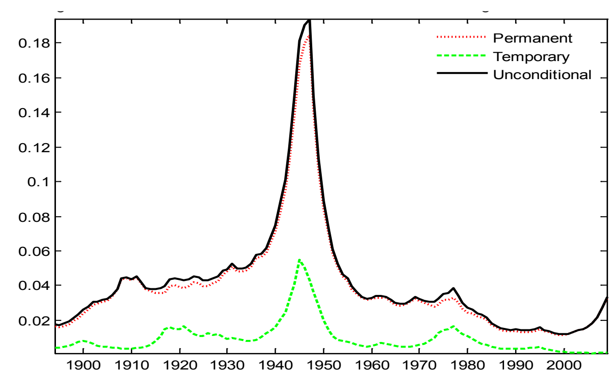


Figure 9E: Finland Real GDP Growth: 1893-2009

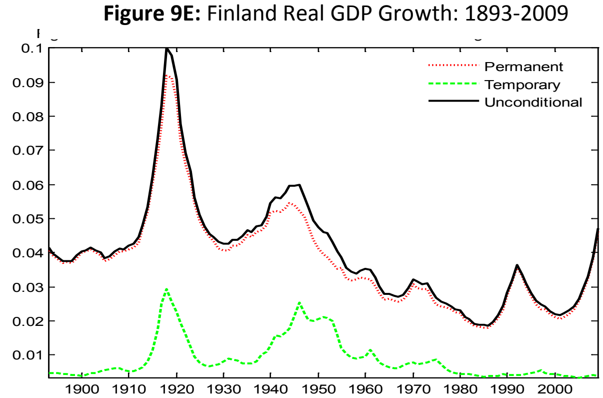


Figure 9F: Denmark Real GDP Growth: 1851-2009

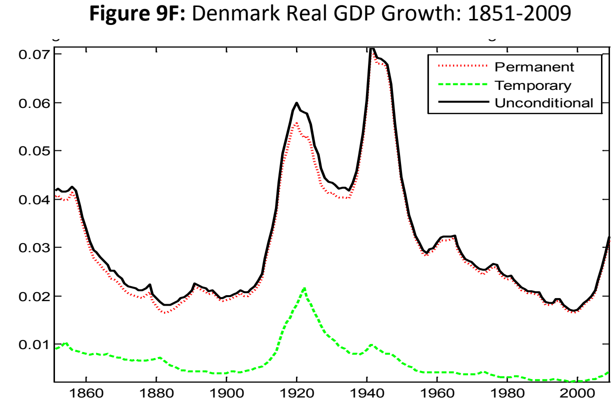


Figure 9G: Canada Real GDP Growth: 1903-2009

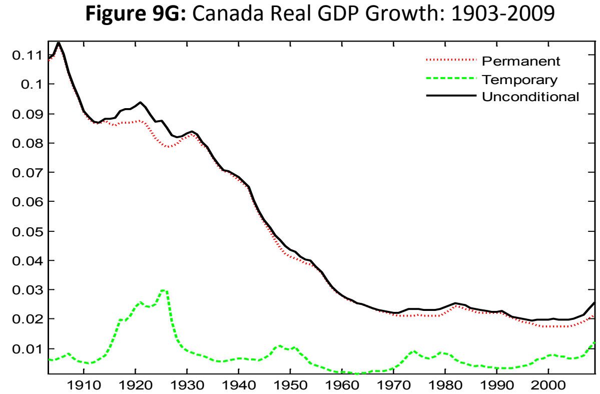


Figure 9H: Australia Real GDP Growth: 1894-2009

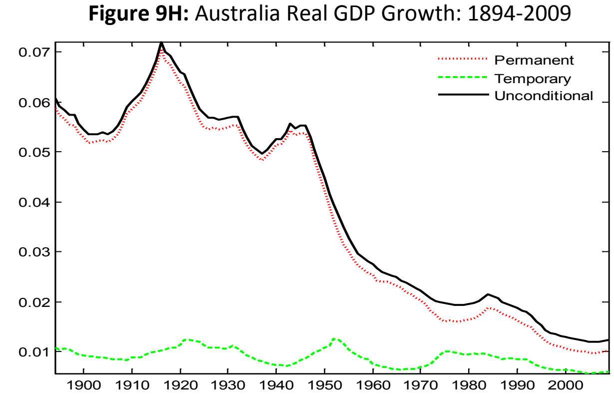


Figure 10: Conditional Time-Varying Standard Deviations of Inflation

Figure 10A: United States Inflation: 1902-2009

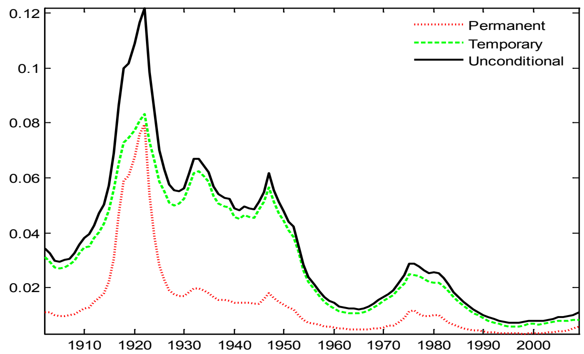


Figure 10B: United Kingdom Inflation: 1863-2009

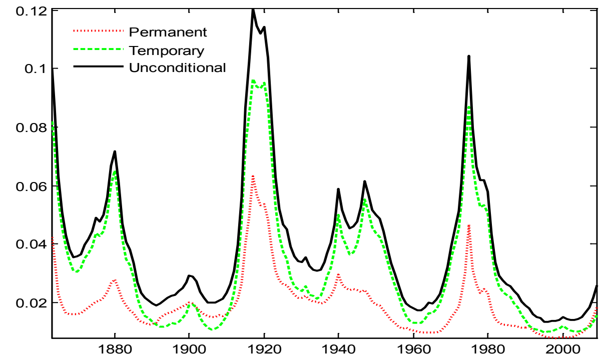


Figure 10C: Sweden Inflation: 1894-2009

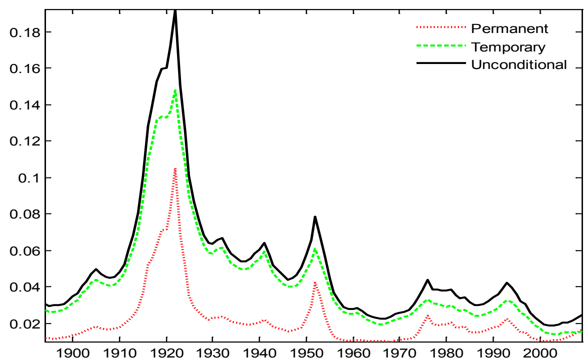


Figure 10D: Italy Inflation: 1894-2009

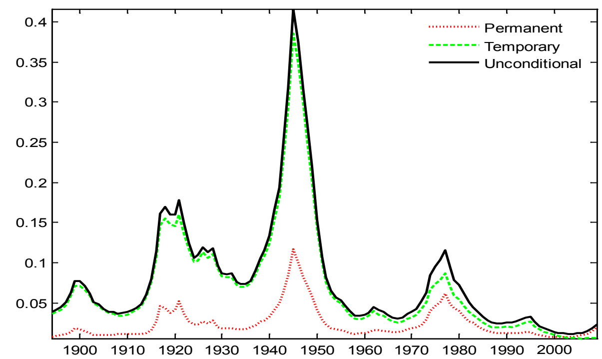


Figure 10E: Finland Inflation: 1893-2009

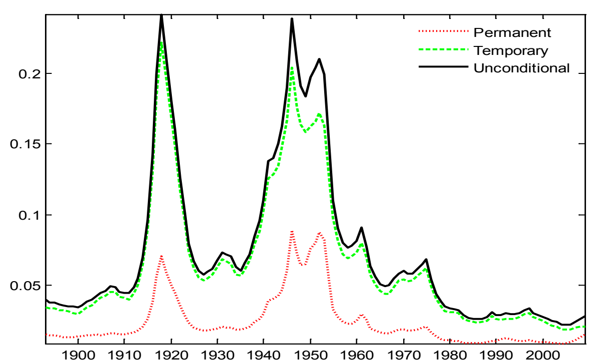


Figure 10F: Denmark Inflation: 1851-2009

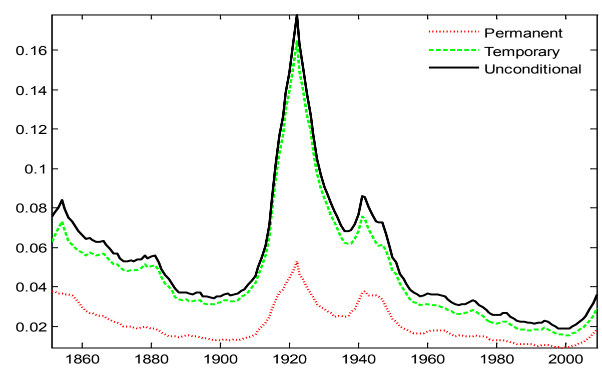


Figure 10G: Canada Inflation: 1903-2009

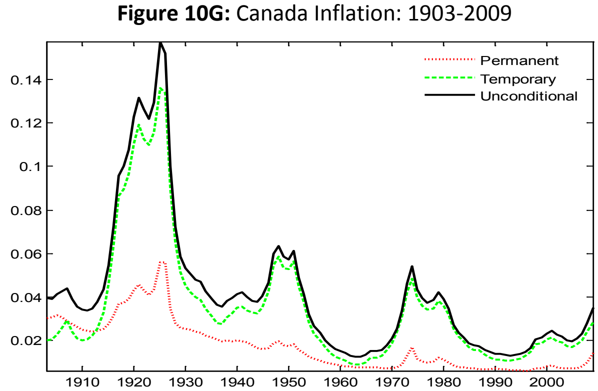
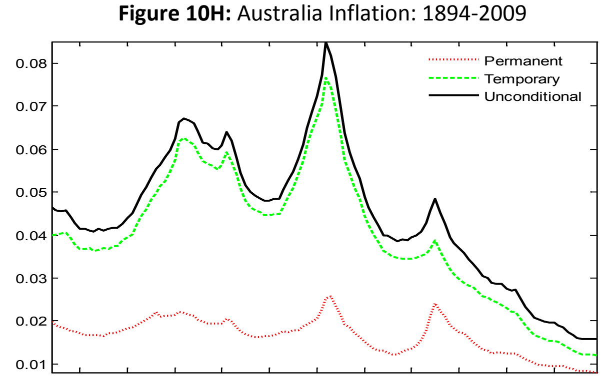


Figure 10H: Australia Inflation: 1894-2009



Appendix: Real Output Growth Rate and Inflation Rate for Eight Countries

Figure A1: United States Real GNP Growth: 1871-2009

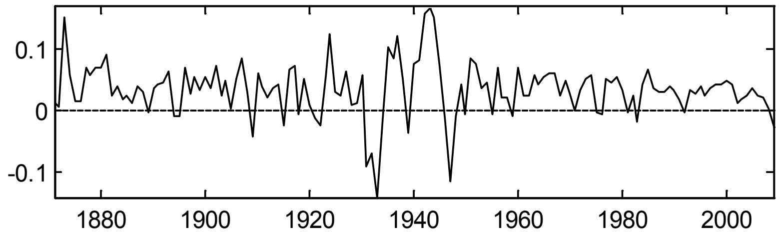


Figure A2: United States Inflation Rate: 1871-2009

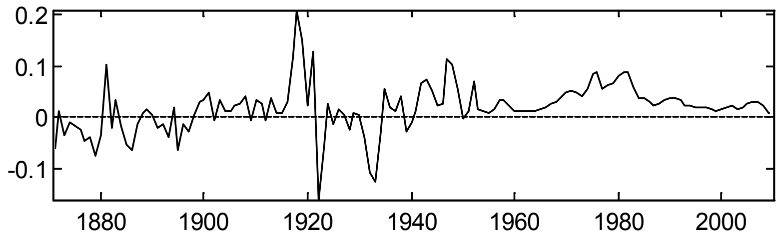


Figure A3: United Kingdom Real GDP Growth: 1831-2009

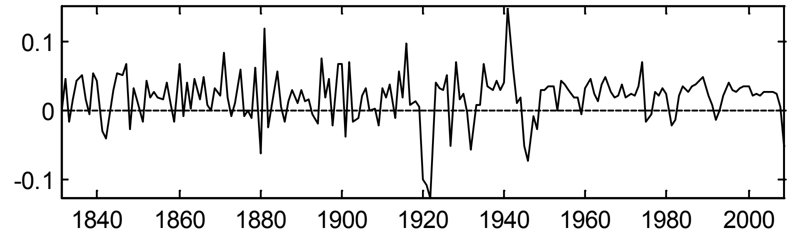


Figure A4: United Kingdom Inflation Rate: 1831-2009

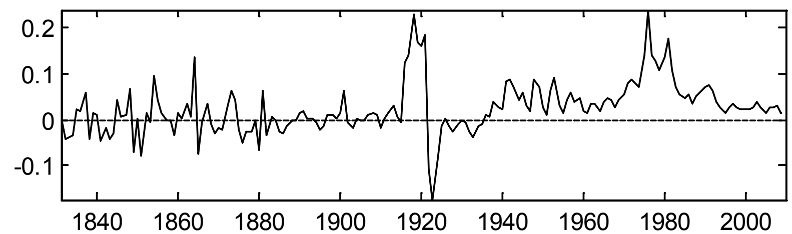


Figure A5: Sweden Real GDP Growth: 1862-2009

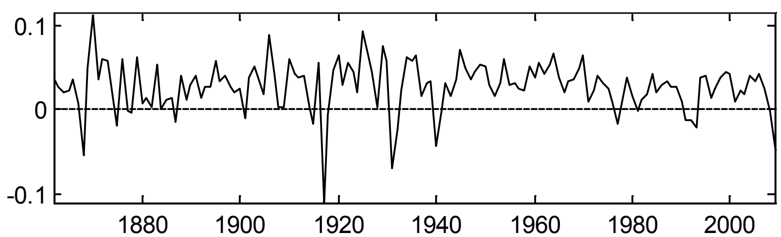


Figure A6: Sweden Inflation Rate: 1862-2009

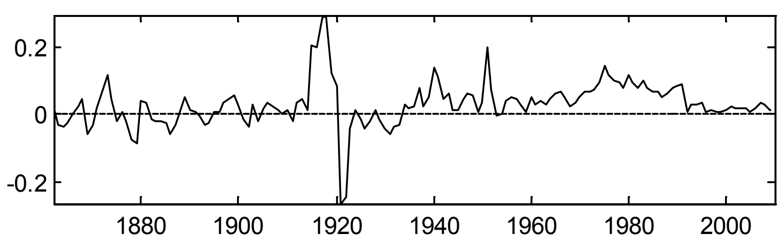


Figure A7: Italy Real GNP Growth: 1862-2009

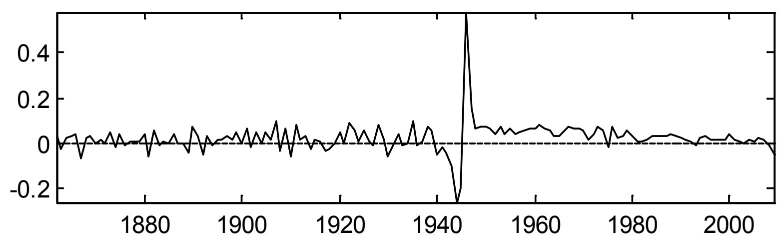


Figure A8: Italy Inflation Rate: 1862-2009

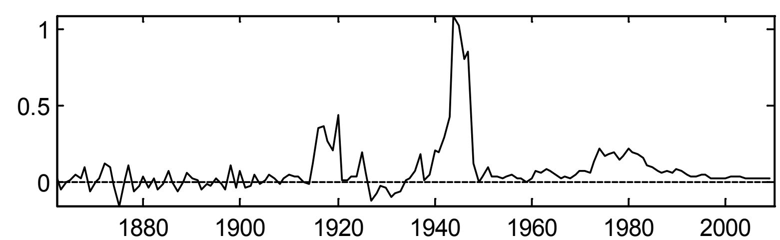


Figure A9: Finland Real GDP Growth: 1861-2009

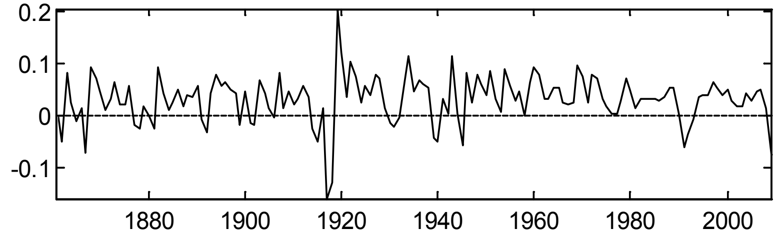


Figure A10: Finland Inflation Rate: 1861-2009

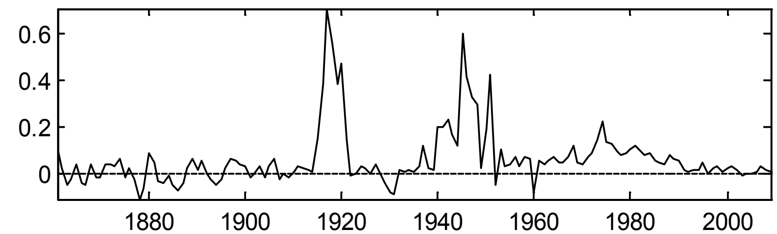


Figure A11: Denmark Real GDP Growth: 1819-2009

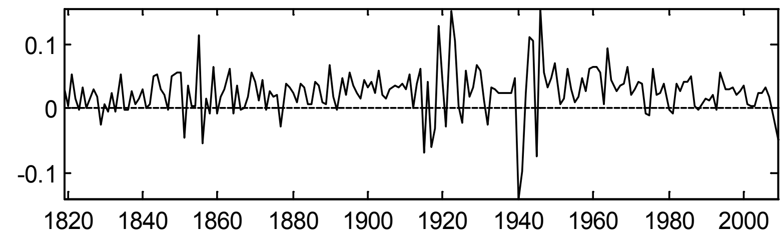


Figure A12: Denmark Inflation Rate: 1819-2009

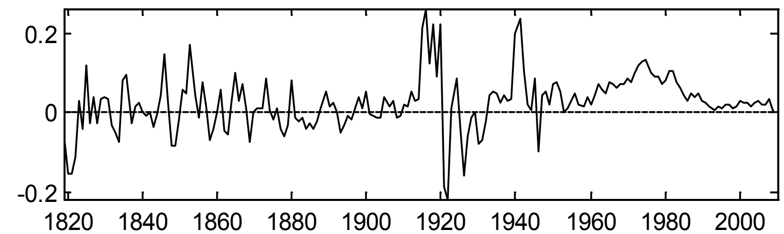


Figure A13: Canada Real GDP Growth: 1871-2009

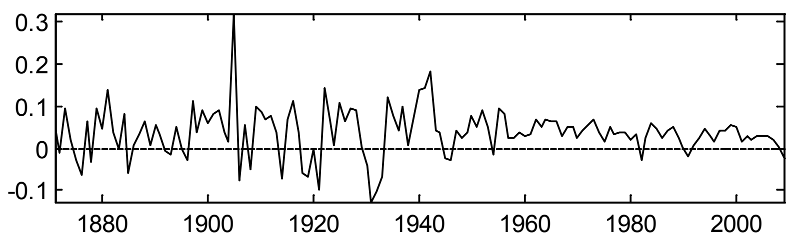


Figure A14: Canada Inflation Rate: 1871-2009

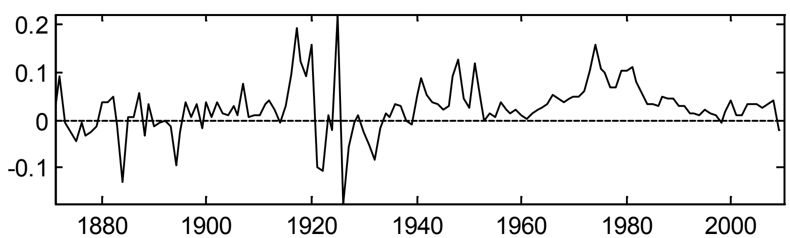


Figure A15: Australia Real GDP Growth: 1862-2009

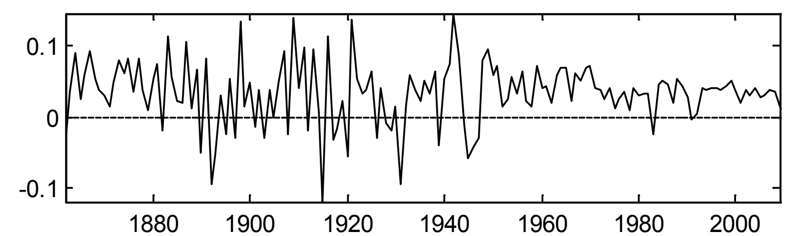


Figure A16: Australia Inflation Rate: 1862-2009