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A re-examination of growth and growth uncertainty relationship in a stochastic volatility in mean model with time-varying parameters

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Abstract

By means of stochastic volatility in mean model to allow for time-varying parameters in the conditional mean and monthly data for G-7 countries, we examine the variability of the business cycle and the economic growth. The results show that the impact of output uncertainty on growth is substantially time-varying and positive with frequent breaks, except for Italy. Besides, the effect of growth on uncertainty is insignificant except for UK.

Keywords: Output Growth; Output Growth Uncertainty; Nonlinearity; State–space.
JEL Classification: C22; E32.

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I. Introduction

The prominent studies of Kydland and Prescott (1982), Long and Plosser (1983) and King et al. (1988) integrated the real business cycle (RBC) and economic growth. Recently, a few studies (e.g. Blackburn and Pelloni, 2005) examined the cyclical fluctuations and long-run economic growth relationship. Blackburn and Pelloni (2005) showed that real growth and output variability are negatively correlated. Pindyck (1991) showed the negative impact of real variability on growth relies on uncertainty with the investment channel. Fuhrer (1997) mentioned the nature of the long-run variance trade-off. There exists economic theories explaining the positive impact of output variability on growth, developed by Mirman (1971), Black (1987) and Blackburn (1999). Further, McConnell and Perez-Quiros (2000) and Stock and Watson (2002) investigated the US GDP growth volatility and its effect on growth theory. Numerous studies to date obtained mixed results when evaluating RBC variability-economic growth relationship, which motivated us to add to literature by providing and a new empirical perspective.

In Grier and Perry (2000), Grier et al. (2004), Elder (2004) and Fountas and Karanasos (2008), volatility is specified as a GARCH model, where the volatility is deterministic. The SV model, on the other hand, allows additional uncertainty in the volatility with volatility shocks. Hence, the SV model does not impose restrictions on conditional moments, while the GARCH model does, as stated by Meddahi and Renault (2004). Moreover, the SV model usually has a better in-sample fit as well as out-of-sample forecasts (Danielsson ,1994; and Kim, et al., 1998). Using the time varying parameter stochastic volatility in mean (TVP-SVM) model, we, therefore, contribute to the existing literature by allowing time-varying impact of growth uncertainty on growth and modeling growth volatility with the SV specification. The results show substantial evidence of the time variation in the impact of growth uncertainty on growth.

The paper is outlined as the following; Section 2 introduces the methodology and Section 3 reports the empirical results, while Section 4 presents the conclusions.

2. Methodology

An optimal approach for modelling structural instability is the time-varying parameter (TVP) approach in which some parameters of a model evolve over time in stochastic manner. In this paper, we allow the impact of output uncertainty on output growth to be time-varying, capturing any structural instability in the macroeconomic environment that may alter the output uncertainty-output growth relationship. The stochastic volatility (SV) model of Koopman and Hol Uspensky (2002) fits better to time series with conditional heteroskedasticity. Compared to the GARCH models, volatility in the SV models is specified as a latent stochastic process that allows volatility shocks. In this paper, we combine the TVP and SV approaches that robustly allow structural breaks and volatility shocks. Additionally, we allow the past output growth affect the output uncertainty. The TVP-SV model is specified as follows:

$\boldsymbol{\theta} = (\tau_t, \alpha_t)'\boldsymbol{\Omega} 2 \times 2 \varepsilon_t^y \varepsilon_t^h h_t \phi < 1 \exp(h_t)\, \varepsilon_t^y y_t \alpha_t \beta$

$$y_t = \tau_t + \alpha_t e^{h_t} + \varepsilon_t^y, \qquad \varepsilon_t^y \sim \mathcal{N}(0, e^{h_t}) \tag{1}$$

$$h_t = \mu + \phi(h_{t-1} - \mu) + \beta y_{t-1} + \varepsilon_t^h, \qquad \varepsilon_t^h \sim \mathcal{N}(0, \sigma^2) \tag{2}$$

$$\boldsymbol{\theta}_t = \boldsymbol{\theta}_{t-1} + \boldsymbol{\varepsilon}_t^{\theta}, \qquad \boldsymbol{\varepsilon}_t^y \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Omega}) \tag{3}$$

where $\boldsymbol{\theta} = (\tau_t, \alpha_t)'$, $\boldsymbol{\Omega}$ is a 2×2 covariance matrix, ε_t^y and ε_t^h are mutually and serially uncorrelated disturbances. The log volatility h_t follows a stationary ARX(1) process with $\phi < 1$. In the model given in Equations (1)-(3), $\exp(h_t)$ is the variance of the transitory component (ε_t^y) of y_t, therefore, we can interpret α_t as the impact of the transitory output growth volatility on the level of output growth. The parameter β measures the impact of output growth on its volatility. In the empirical section, the model in Equations (1)-(3) is estimated using the efficient Markov chain Monte Carlo (MCMC) sampler developed in Chan (2017).[1]

3. Empirical results

We use seasonally adjusted Industrial Production (IP) as a proxy for the output. Data were obtained from International Financial Statistics for Canada, France, Germany, Japan and Italy; the Federal Reserve Bank of St. Louis for US; and Bank of England for UK. The growth series are calculated as the annualized monthly log differences of the Industrial Production Index (y_t = log(IP_t/IP_{t-1})*1200). Growth series for G-7 countries are plotted in Figure 1.

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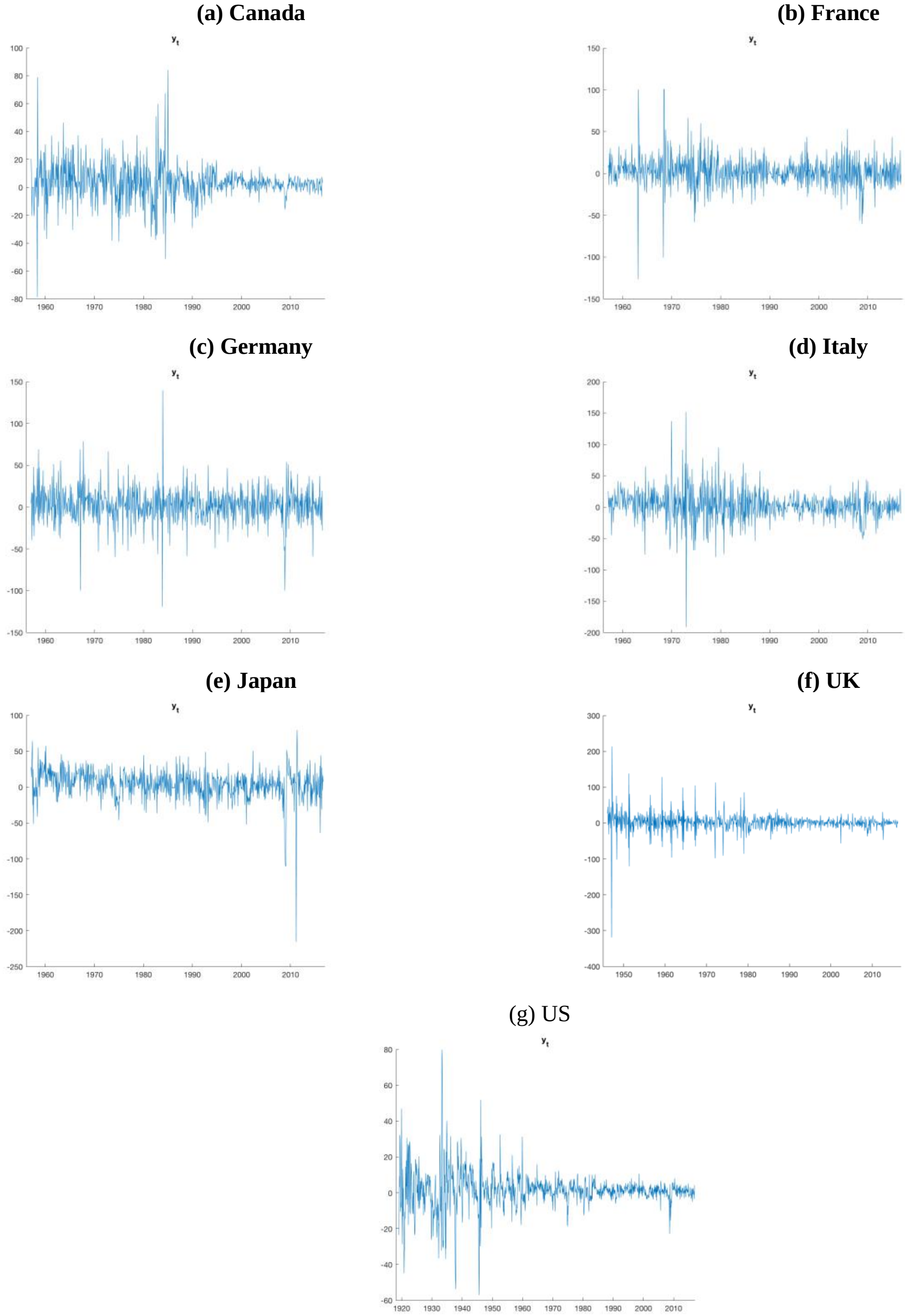
[1] See Chan (2017, p. 27) for the priors used in the estimation.

Figure 1. Time Series of Output Growth



To test the stationarity properties of the series, we use the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests. We reject the unit root hypothesis.[2] Descriptive statistics[2] show that all the series are skewed to the left, with excess kurtosis, resulting in non-

[2] Unit root test and descriptive statistics are not reported to save space, but available from the authors upon request.

normal distributions for all countries with the exceptions of Canada and US, where the skewness is positive. The values of Ljung-Box and ARCH statistics show there is serial correlation and ARCH effects in all series.

The results of posterior moments and quantiles of the SV in mean model parameters estimates are reported in Table 1. Growth series has a negative and statistically significant effect on the real variability as predicted by Pindyck (1991) and Blackburn and Pelloni (2005) for Canada, France, Germany, Japan and US. But, the results show that the effect of growth on its uncertainty is positive as predicted by Mirman (1971), Black (1987) and Blackburn (1999) for Italy, while statistically not different from zero for UK.

Table 1. Estimated Posterior Moments and Quantiles of the SV in Mean Model Parameters

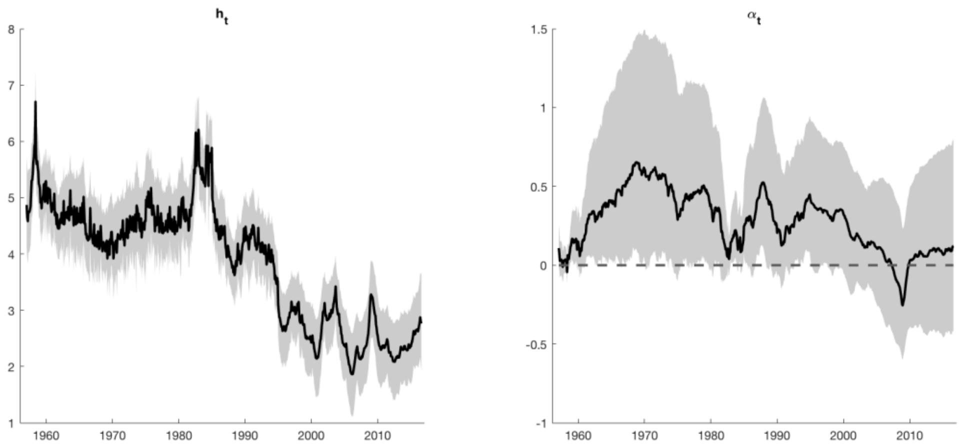
	Canada				***France***		
Parameter	Posterior mean	Standard error	90% credible interval	Parameter	Posterior mean	Standard error	90% credible interval
μ	3.578	0.645	(2.493, 4.357)	μ	5.324	0.119	(5.126, 5.518)
β	-0.010	0.003	(-0.014, -0.004)	β	-0.011	0.001	(-0.013, -0.008)
ϕ	0.977	0.011	(0.958, 0.995)	ϕ	0.918	0.019	(0.882, 0.944)
σ^2	0.044	0.010	(0.030, 0.061)	σ^2	0.039	0.008	(0.027, 0.054)
ω_α^2	0.004	0.001	(0.002, 0.006)	ω_α^2	0.001	0.000	(0.001, 0.002)
$\omega_{\alpha,\tau}^2$	-0.012	0.016	(-0.046, 0.002)	$\omega_{\alpha,\tau}^2$	-0.002	0.003	(-0.007, 0.002)
ω_τ^2	0.858	0.788	(0.063, 2.349)	ω_τ^2	0.429	0.326	(0.119, 1.045)
	Germany				***Italy***		
μ	5.839	0.130	(5.638, 6.040)	μ	5.599	0.142	(5.365, 5.823)
β	-0.008	0.001	(-0.010, -0.006)	β	0.007	0.001	(0.006, 0.008)
ϕ	0.916	0.023	(0.871, 0.945)	ϕ	0.948	0.012	(0.926, 0.966)
σ^2	0.037	0.008	(0.025, 0.053)	σ^2	0.026	0.005	(0.018, 0.036)
ω_α^2	0.001	0.000	(0.001, 0.001)	ω_α^2	0.002	0.000	(0.001, 0.002)
$\omega_{\alpha,\tau}^2$	-0.001	0.002	(-0.004, 0.002)	$\omega_{\alpha,\tau}^2$	-0.026	0.017	(-0.059, -0.004)
ω_τ^2	0.344	0.262	(0.090, 0.880)	ω_τ^2	7.987	3.334	(3.735, 14.332)
	Japan				***UK***		
μ	5.239	1.076	(2.517, 6.283)	μ	5.051	0.250	(4.632, 5.446)
β	-0.002	0.001	(-0.004, -0.001)	β	-0.002	0.002	(-0.005, 0.001)
ϕ	0.967	0.022	(0.931, 1.000)	ϕ	0.945	0.015	(0.918, 0.967)
σ^2	0.030	0.006	(0.022, 0.041)	σ^2	0.121	0.022	(0.088, 0.159)
ω_α^2	0.001	0.000	(0.001, 0.002)	ω_α^2	0.001	0.000	(0.001, 0.002)
$\omega_{\alpha,\tau}^2$	0.000	0.001	(-0.002, 0.001)	$\omega_{\alpha,\tau}^2$	-0.001	0.001	(-0.003, 0.001)
ω_τ^2	0.096	0.058	(0.042, 0.189)	ω_τ^2	0.096	0.046	(0.041, 0.185)
	US						
μ	2.536	0.430	(1.847, 3.140)				
β	-0.005	0.001	(-0.008, -0.003)				
ϕ	0.978	0.007	(0.966, 0.990)				
σ^2	0.059	0.010	(0.044, 0.077)				
ω_α^2	0.012	0.004	(0.007, 0.019)				
$\omega_{\alpha,\tau}^2$	-0.014	0.014	(-0.043, 0.002)				
ω_τ^2	0.102	0.061	(0.041, 0.224)				

Note: The results are based on 50,000 posterior with a burn-in period of 50,000.

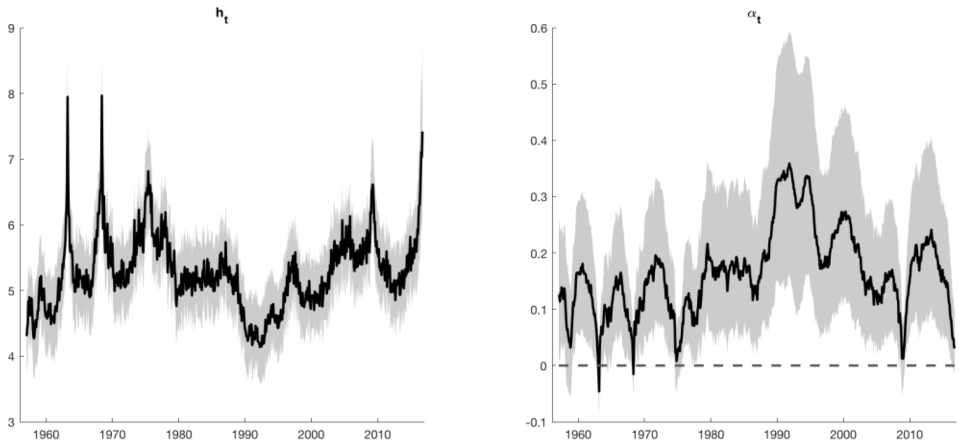
Figure 2 presents the estimated h_t and α_t and the associated 90% credible intervals. The results in Figure 2 parallels to the previous literature. For instance, considering the Great Moderation, the oil shock in the 1970s, Global financial crisis and WW II (only for US) there is substantial high variability of growth volatility. According to the right panel of the Figure 2, the extent of time variation is substantial, underlining the significance of time-varying parameters. According to the results, growth uncertainty has a negative impact on growth following the beginning of the 2000s for Canada, while it has a positive effect up to the beginnings of the 2000s. Considering France and Germany, growth uncertainty has a positive effect on growth, while it is close to zero or even negative in the second part of the sample. For Italy, it has a negative effect. Estimates of α_t for Japan are analogous to France and Germany. For the UK, α_t estimates are close to zero or even positive/negative until the mid-1990s, while the impact is negative after the mid-1990s. Findings draw an analogy for US with the UK. Further, variability fluctuates more frequently for Japan, UK and US are observed.

Figure 2. Evolution of Volatility and Impact of Volatility on Growth

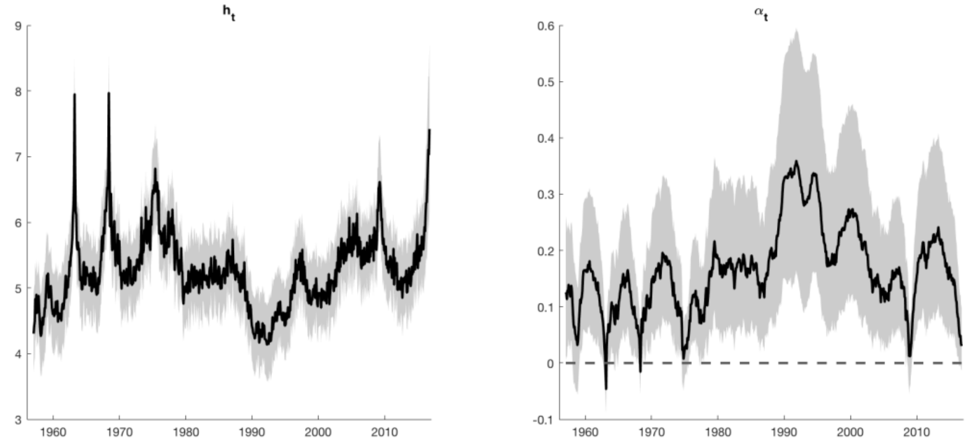
(a) Canada



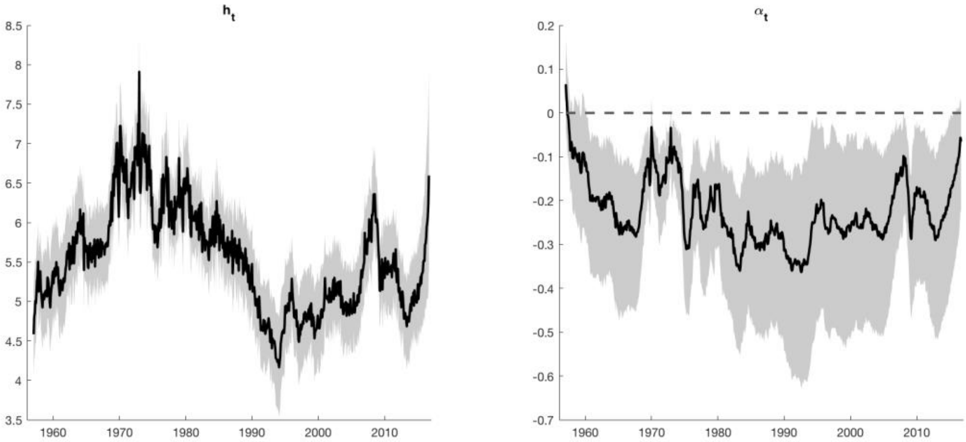
(b) France



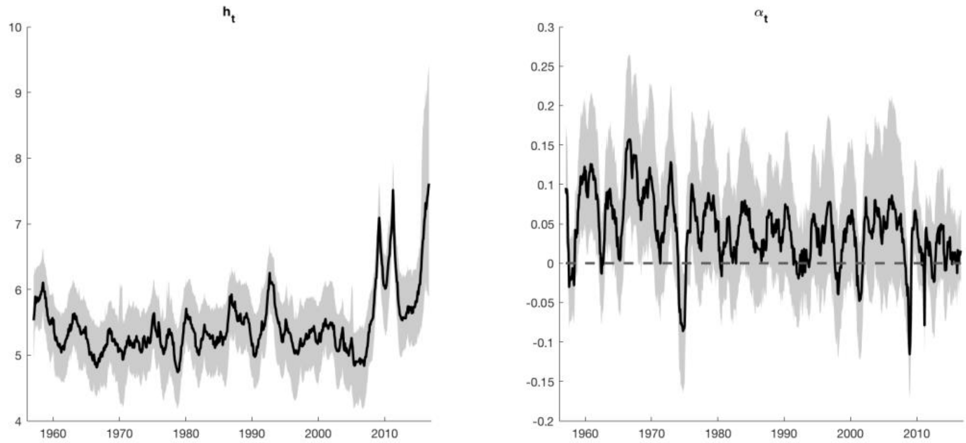
(c) Germany



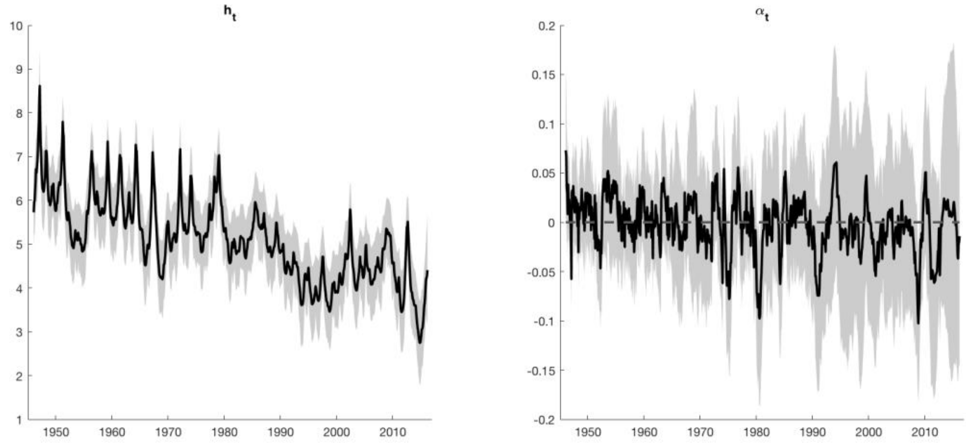
(d) Italy



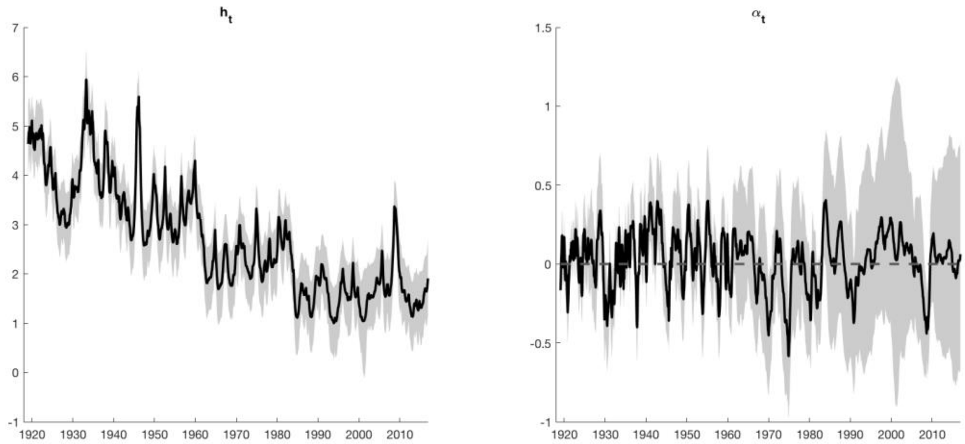
(e) Japan



(f) UK



(g) US



Note: The figure plots the evolution of the output volatility h_t (left panel) and time-varying impact of the output volatility on output growth α_t (right panel). The solid lines are the estimated posterior means and the shaded regions denote the 90% credible confidence intervals. The results are based on 50,000 posterior with a burn-in period of 50,000.

6. Conclusions

The results show substantial time-variation in the coefficient associated with the volatility. Besides, more uncertainty leads to a higher rate of growth in six of the G-7 except for Italy. Growth reduces its uncertainty in all countries, excluding Italy and UK, where it increases its uncertainty for Italy. The impact of output growth on its uncertainty is zero for UK. Our results are robust to alternative specifications with strong support to the examination of economic growth and the variability of the business cycle.

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