A Bayesian Comparison of the Classical Gold Standard and the Great Moderation

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October 2008

Abstract

Drawing on research about the sources of the Great Moderation, this paper investigates the extent to which the high macroeconomic volatility experienced in the classical Gold-Standard era of US history can be attributed to the monetary policy regime *per se* as distinct from other shocks. For this purpose, we estimate a small Dynamic Stochastic General Equilibrium model for the classical Gold-Standard and Great-Moderation eras. We use this model to investigate how a Taylor rule characterizing the Great-Moderation data would have led to different outomes for macroeconomic volatility and welfare in the Gold-Standard era. We find that the counterfactual Taylor rule reduces inflation volatility but does not impove welfare.

1 Introduction

There is an emerging consensus that up until 2008 the US economy had experienced a period of unusually low volatility in output accompanied by low and stable inflation since the mid-1980s [see, for example, Stock and Watson (2003)]. This stands in contrast to the high levels of macroeconomic instability which characterized the late 1960s and 1970s, now called the Great Inflation. There is an ongoing debate as to the sources of the improved performance, which has been dubbed the Great Moderation. Is it due to luck, reflected in the fact that the magnitude of the shocks hitting the economy have been much smaller, as Sims and Zha (2006) and Ahmed, Levin and Wilson (2004) argue? Alternatively, does it reflect the improved conduct of monetary policy, reflected in a stronger response of interest rates to inflation, as Clarida, Gali and Gertler (2000) and Benati and Surico (2008) suggest? Their analyses make use of historical counterfactual simulations: it asks how the economy would have performed in the Great-Inflation era if the policy rule of the Great- Moderation era had been in place. Volcker and Greenspan thus go back in time.

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The current discussion has interesting parallels with a debate which has long been underway among economic historians. Numerous studies have documented the fact that the classical Gold-Standard era (from 1879 to the start of World War I), although it delivered a low long-term average rate of inflation, was characterized by higher levels of volatility of output, shorter term inflation and interest rates relative to the post World War II era (see Bordo and Schwartz (1999)[1].

One influential line of argument holds that the Gold-Standard regime itself was responsible for the high degree of macroeconomic instability that was observed in this period since, as Niehans (1978) argued, the pure Gold Standard left no room for monetary policy to stabilize output. For example, Gramlich (1998) has summarized this view as follows:

"Monetary policy was not set consciously in terms of the economic needs of the country, but by the world gold market. The world gold stock would fluctuate in line with international discoveries, while the stock in particular countries reflected trade flows. There was no automatic provision for money or liquidity to grow in line with the normal production levels in the economy. John Taylor (1998) has shown that this regime was responsible for large fluctuations in real output, much less stability in real output than has been achieved in the post gold standard era. In the gold standard period of 1890-1905, for example, the US economy suffered five major recessions."

This view seems now to be an accepted wisdom, and is even reflected in some undergraduate textbooks. [2]

However, the recent debate about the sources of the Great Moderation highlights the need for caution in attributing high levels of macroeconomic volatility solely to the monetary policy regime in place. Indeed, there is some evidence to suggest that the US economy was subject to highly volatile demand and supply shocks in the Gold-Standard era (Bordo and Schwartz, 1999). As an example of a different view, for example, Chernyshoff, Jacks and Taylor (2005) argue that the Classical Gold Standard was an effective shock absorber.

This paper compares the performance of the monetary regimes in the Gold-Standard and the Great-Moderation periods in the United States using the technique of historical counterfactual simulation. Using Bayesian techniques, we estimate a dynamic stochastic general equilibrium (DSGE) model separately for the period of the classical Gold Standard (1879 to 1914) and for the Great-Moderation era (1984 to 2007). In principle, this approach allows us to identify

[1] There is some controversy as to whether output in the Gold-Standard era was in fact more volatilie than in the post World War II era and conclusions depend on the data sets used (see Romer (1990). Nonetheless, regardless of the data sets employed, macroeconomic volatility was clearly higher than what has been recorded in the Great-Moderation era.

[2] Burda and Wyplosz (1997) make similar arguments in an undergraduate macro textbook aimed at a European audience: "While average growth was comparable to the postwar experience and inflation was lower, the table also shows that both measures were more variable under the gold standard. Unstable economic conditions imposed serious costs on individuals at the time, as is made clear by the unemployment rates... Was it just a coincidence? In fact, the very automatic mechanisms that are often considered the main advantage of the gold standard imply such an outcome." [Burda and Wyplosz (1997), p. 516].

differences in the deep parameters of tastes and technology across periods, to identify the shocks which hit the economy in both periods and to estimate the policy rules in force in the two regimes. We then proceed to conduct a counterfactual experiment. Taking the parameters, including the estimated shock volatilities, from the of the Gold-Standard era, we simulate the model under two alternative monetary policy rules: first, the estimated historical rule for the era and second, the rule estimated for the Great-Moderation era. Finally, we compare the properties of the classical Gold-Standard economy under these different rules. This allows to assess how macroeconomic outcomes would have been different had the Great-Moderation rule been in place instead of the Gold-Standard regime.

The remainder of this paper is structured as follows. The next section examines the data from these two eras. Section 3 presents the model we use for our Bayesian estimation and subsequent simulation. The following section then examines the welfare and volatility distributions of key macroeconomic variables under the actual and counterfactual monetary regimes in the Gold-Standard Era.

2 The Data

The data we use for the Gold-Standard era come from Balke and Gordon (1989b), and are based on quarterly interpolations of the annual data reported in Balke and Gordon (1989a). Data for the Great-Moderation era comes from the FRED database of the Federal Reserve Bank of St. Louis. In our estimation, we use quarterly data for four macroeconomic variables: real GDP (y), the rate of change of the GDP deflator (π), the interest rate on commercial paper (r), and nominal base money (for the classical Gold Standard) and broad money (for the Great Moderation) . We transform the logarithm of real GDP with the Hodrik-Prescot filter. For the other variables we simply detrend the variables by taking deviations from a log-linear time trend. Figure 1 pictures these four variables.

Figure 1 presents the data for the Gold-Standard era. Figure 2 pictures the same four variables in the Great-Moderation era. We note a sharp reduction in the volatility of real GDP, inflation and the nominal money stock in the Great Moderation relative to the classical Gold Standard.

To facilitate a comparison of data for the two periods, Table 1 shows the means and standard deviations of the rate of growth of output, the inflation, interest rates and nominal base money.

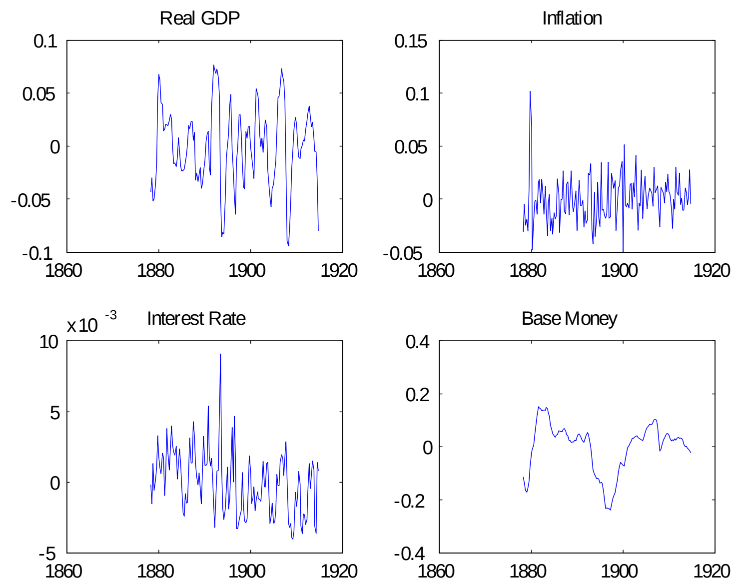


Figure 1: Gold Standard, HP Filtered and Detrended Data, 1878-1914.

Table 1. Statistics for Gold Standard and Great Moderation

	Means			
.	Δy	π	r	Δm
Gold Std.	3.48	0.35	5.94	6.37
Great Mod.	2.97	2.48	4.75	5.16
	Std. Deviation			
	Δy	π	r	Δm
Gold Std.	2.33	2.15	0.22	3.36
Great Mod.	0.49	0.24	0.50	0.74

As regards the averages, the following well known features can be highlighted. Output growth in the two periods is broadly comparable. Notwithstanding the good inflation performance in the Great-Moderation period, it is notable that inflation in the period 1879-1914 was almost zero, implying a modest rise in the price level over the whole period. Of course, this average masks the fact there was alternation between deflation and inflation over the period. The main feature of interest from the point of view of this paper, however, is the relative volatilities of the key variables. When measured in terms of growth rates. the standard deviation of output is practically four times larger in the Gold Standard compared to the Great Moderation, while inflation is 10 times more volatile. Nominal money growth rates are almost three times as volatile.

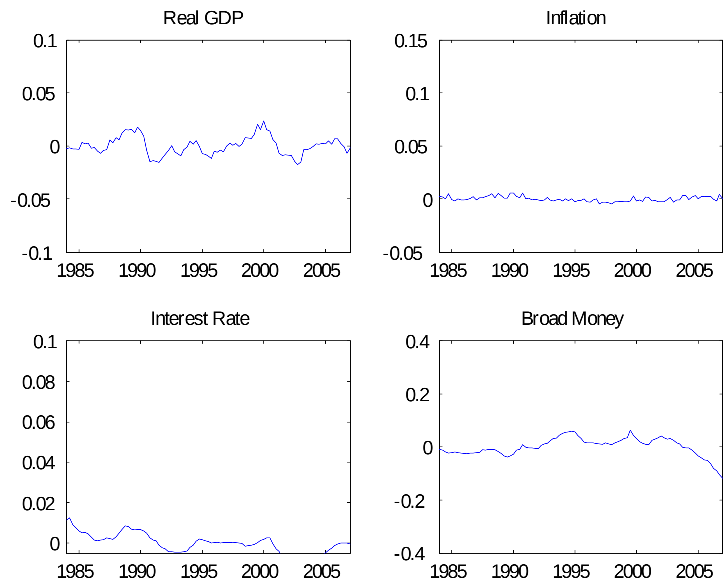


Figure 2: Great Moderation, HP-Filtered and Detrended Data 1984-2007

Surprisingly, interest rates are less volatile under the Gold Standard.

3 The Model

3.1 Theoretical Framework

Recent developments in DSGE modelling have involved the development of large scale models incorporating up to twenty variables [see, for example, Smets and Wouters (2003)]. Given the paucity of data for the Gold-Standard era, we confine ourselves to a relatively small-scale workhorse model, comprising four linearized equations: an Euler equation for consumption, a Phillips curve, a money-demand relation and a policy rule. Specifically, we employ the model put forth by Andrés, López-Salido and Vallés (2006). Given the empirical evidence reported in that paper and by Ireland (2004), we employ the version which assumes linear separability between money and consumption in preferences (ie, the utility function).. The model incorporates a number of frictions which in principle allow it to match the dynamics of the data: internal habit formation in consumption and sticky prices à la Calvo combined with indexation. The model specification is the same for both periods except for the treatment of monetary policy. For the Great-Moderation era we use a standard Taylor rule. For the Gold-Standard era, this is clearly inappropriate. Instead, we assume a money supply process, in which the growth rate of the money stock (base money) follows a univariate autoregressive approach. For estimation and simulation, we take the log-linearized model, expressed as percentage deviation of each variable from its steady-state.

The periodicity of the model is quarterly. We assume that there is a representative household in the model that maximizes the following intertemporal welfare with respect to the choice of real consumption expenditures C_t, labor N_t, nominal money holdings M_t, and nominal bonds B_t :

$$\max_{C_t, N_t, M_t, B_t} V_0 = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t a_t \left[\Psi \left(C_t^*, \frac{M_t}{e_t P_t} \right) - \gamma_N \left(\frac{N_t^{1+\varphi}}{1+\varphi} \right) \right], \tag{1}$$

$$C_t^* = \frac{C_t}{C_{t-1}^h}, \tag{2}$$

$$\Psi \left(C_t^*, \frac{M_t}{e_t P_t} \right) = \frac{1}{1-\sigma} \left(\frac{C_t}{C_{t-1}^h} \right)^{1-\sigma} + \gamma_M \left(\frac{1}{1-\delta} \right) \left(\frac{M_t}{e_t P_t} \right)^{1-\delta}. \tag{3}$$

The variables C_t and P_t are the CES aggregators of the quantities and prices of the different goods consumed:

$$C_t = \left(\int_0^1 C_t(j)^{\frac{\epsilon}{\epsilon - 1}} dj \right)^{\frac{\epsilon - 1}{\epsilon}},$$

$$P_t = \left(\int_0^1 P_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}.$$

The variable a_t is a preference shock and e_t is a velocity shock. The parameter $\beta \in (0,1)$ is the discount factor and $\varphi \geq 0$ is the inverse of the Frisch labor supply elasticity. The parameter h represents the importance of habit persistence in the utility function (with $h = 0$ we obtain the standard CRRA function). The symbol γ_N is the coefficient of the disutility of labor, while γ_M is the coefficient for the utility of real balances.

The budget constraint of the household has the following form:

$$\frac{M_{t-1} + B_{t-1} + W_t N_t + T_t + D_t}{P_t} = C_t + \frac{B_t / r_t + M_t}{P_5}. \tag{4}$$

The household receives nominal government transfers T_t from and nominal dividends D_t and nominal labor income $W_t N_t$ from firms. They enter period t with money and bond holdings, M_{t-1} and B_{t-1}. They can use these resources for consumption or to purchase bonds at cost B_t / r_t. The firm produces a differentiated output with the following production function:

$$Y_t(j) = z_t N_t(j)^{1-\alpha}. \tag{5}$$

The variable z_t is an economy-wide technology shock while $1 - \alpha$ is the elasticity of labor with respect to output. Aggregate output is obtained by the following CES aggregation function:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon}{\epsilon-1}} dj \right)^{\frac{\epsilon-1}{\epsilon}}.$$

Market clearing requires, of course, $Y_t = C_t$.

Prices are sticky. Firms set their prices through the familiar Calvo mechanism. Each firm resets its price with probability $(1-\theta)$ each period, while a fraction θ leave their price unchanged. Of those firms which change prices in a given quarter, a fraction ω sets their price in a fully forward-looking manner while the remainder set prices in a backward-looking manner, updating their previous price using the observed rate of inflation. In the special case of no constraints on price adjustment ($\theta = 0$), firms would set their prices as a mark-up over marginal costs:

$$P_t(j) = \left[\frac{\epsilon}{\epsilon - 1} \right] MC_t(j), \tag{6}$$

$$MC_t(j) = \frac{W_t}{\partial Y_t(j)/\partial N_t(j)}. \tag{7}$$

The following equations summarize this price-setting mechanism:

$$P_t^b = P_{t-1}\pi_{t-1}, \tag{8}$$

$$\pi_{t-1} = \frac{P_{t-1}}{P_{t-2}}, \tag{9}$$

$$P_t^f = \frac{E_t \sum_{i=0}^{\infty} \beta^i \theta^i Y_{t+i} \left[\frac{\epsilon}{\epsilon-1} \right] MC_{t+i}}{E_t \sum_{i=0}^{\infty} \beta^i \theta^i Y_{t+i}^j}, \tag{10}$$

$$p_t^* = (1-\omega) p_t^f + \omega p_t^b, \tag{11}$$

$$P_t = \left[\theta P_{t-1}^{(1-\epsilon)} + (1-\theta) p_t^{*(1-\epsilon)} \right]^{\frac{1}{1-\epsilon}}. \tag{12}$$

3.2 Log-linearized System

The following equations summarize log-linearized Euler equations for the Taylor-rule era with endogenous money supply:

$$\begin{aligned}\widehat{y}_t &= \frac{\phi_1}{\phi_1+\phi_2}\widehat{y}_{t-1} + \frac{\beta\phi_1+\phi_2}{\phi_1+\phi_2}\widehat{y}_{t+1} - \frac{1}{\phi_1+\phi_2}\left(\widehat{r}_t - \widehat{\pi}_{t+1}\right) \\ &\quad - \frac{\beta\phi_1}{\phi_1+\phi_2}\widehat{y}_{t+2} + \frac{1-\beta h\rho_a}{(1-\beta h)}\frac{1-\rho_a}{\phi_1+\phi_2}\widehat{a}_t, \qquad (13)\end{aligned}$$

$$\begin{aligned}\widehat{m}_t - \widehat{p}_t &= -\frac{\phi_1}{\delta}\widehat{y}_{t-1} + \frac{\phi_2}{\delta}\widehat{y}_t - \frac{\beta\phi_1}{\delta}\widehat{y}_{t+1} \\ &\quad - \frac{1}{\delta(r-1)}\widehat{r}_t + \frac{1-\beta h\rho_a}{(1-\beta h)\delta}\widehat{a}_t + \frac{\delta-1}{\delta}\widehat{e}_t, \qquad (14)\end{aligned}$$

$$\begin{aligned}\widehat{mc}_t &= -\phi_1\widehat{y}_{t-1} + (\chi+\phi_2)\widehat{y}_t - \beta\phi_1\widehat{y}_{t+1} \\ &\quad - (1+\chi)\widehat{z}_t - \left[\frac{\beta h(1-\rho_a)}{1-\beta h}\right]\widehat{a}_t, \qquad (15)\end{aligned}$$

$$\widehat{\pi}_t = \gamma_f\widehat{\pi}_{t+1} + \gamma_b\widehat{\pi}_{t-1} + \lambda\widehat{mc}_t. \qquad (16)$$

The first equation, given by (13), describes real GDP $\widehat{y}_t$ as a function of past and future GDP, as well as the expected real interest rate $(\widehat{r}_t - \widehat{\pi}_{t+1})$, and the current productivity shock, $\widehat{a}_t$.

The money demand function, $\widehat{m}_t - \widehat{p}_t$, given by equation (14), depends on past, present and future output, as well as the interest rate $\widehat{r}_t$, the demand shock, $\widehat{a}_t$, and an exogenous liquidity preference shock, $\widehat{e}_t$.

Marginal cost changes, $\widehat{mc}_t$, in equation (15), are a function of past, present and future output, productivity shocks $\widehat{z}_t$, and demand shocks, $\widehat{a}_t$.

Current inflation, $\widehat{\pi}_t$, in equation (16), responds both to past and expected future inflation as well as to marginal cost changes, $\widehat{mc}_t$. The markup coefficient is given by the parameter λ.

Four key parameters in the above model, ϕ_1,ϕ_2, γ_f and γ_b are themselves functions, of "deep" structural parameters, the constant relative risk aversion coefficient σ, the habit persistence parameter h, the discount parameter β, the Calvo forward-looking pricing parameter θ and the Calvo backward-looking indexing coefficient, ω :

$$\begin{aligned}\phi_1 &= \frac{(\sigma-1)h}{1-\beta h}, \\ \phi_2 &= \frac{\sigma+(\sigma-1)\beta h^2-\beta h}{1-\beta h}, \\ \gamma_f &= \frac{\beta\theta}{\theta+\omega[1-\theta(1-\beta)]}, \\ \gamma_b &= \frac{\omega}{\theta+\omega[1-\theta(1-\beta)]}.\end{aligned}$$

The parameters χ and λ are the respective coefficients for the effect of supply shocks on marginal costs, and the markup of inflation over marginal costs. Thus $\lambda = \epsilon/(\epsilon - 1)$.

The three exogenous shock processes, for demand ($\widehat{a}_t$), liquidity ($\widehat{e}_t$), and productivity ($\widehat{z}_t$) follow first order autoregressive processes with normally distributed innovations and constant variances..

$$\widehat{a}_t = \rho_a \widehat{a}_{t-1} + \epsilon_{a,t},$$
$$\epsilon_{a,t} \tilde{} N(0, \sigma_a^2),$$
$$\widehat{e}_t = \rho_e \widehat{e}_{t-1} + \epsilon_{e,t},$$
$$\epsilon_{e,t} \tilde{} N(0, \sigma_e^2),$$
$$\widehat{z}_t = \rho_z \widehat{z}_{t-1} + \epsilon_{z,t},$$
$$\epsilon_{z,t} \tilde{} N(0, \sigma_z^2).$$

3.3 Modelling monetary policy

In order to close the model, we need to add an equation which captures the determination of interest rates. For the Great Moderation period, we follow the existing literature (summarised, for example, in the NBER volume edited by Taylor (1999)) by assuming that the behaviour of the Federal Reserve can be adequately captured by a Taylor rule form:

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1 - \rho_r)\rho_y \widehat{y}_t + (1 - \rho_r)\rho_\pi \widehat{\pi}_t + \epsilon_{m,t}, \tag{17}$$
$$\epsilon_{m,t} \tilde{} N(0, \sigma_\nu^2).$$

In this case, the interest rate equation $\widehat{r}_t$, in equation (17), shows that current interest rates respond to past interest rates with a smoothing parameter ρ_r, and well as to output and inflation, $\widehat{\pi}_t$. The interest rate is also affected by an exogenous policy shock, given by $\widehat{v}_t$. The parameters of the rule will be estimated as part of estimation of the whole model.

For the Gold-Standard period, this is clearly inappropriate. Since the Federal Reserve was only established by the Federal Reserve Act of 1913, just one year before the end of our sample, it is clear that we cannot model interest rate determination as an outcome of decisions of a central bank. Instead, our approach is based on the theory of the working of the classical gold standard (see, for example, Niehans (1978), for a survey). In this approach, interest rates, and ultimately the price level, are determined by the interaction of the demand and supply of money. This approach will be econometrically valid if, in addition to a stable money demand, the money supply is largely exogenous. Cagan's (1965) classic study on the determinants of money stock, shows that changes in the stock of base money during this period was largely due to exogenous causes, in particular changes in the gold stock (reflecting new discoveries and improved production techniques as well as capital flows). In contrast, changes in broader measures of money (e.g. $M2$) reflected, in addition to the change in base money, movements the currency and reserve ratios. These ratios, though strongly influenced by banking panics, also contained important endogenous responses to the business cycle. In order to minimise the effects of this endogeneity, we choose to model the demand and supply of base money ($M0$) rather than M2. Given the evidence provided by Cagan, we approximate the monetary regime by an exogenous stochastic process for nominal base money growth, $\widehat{dM}_t$, given by (18).

$$\widehat{dM}_t = \rho_m \widehat{dM}_{t-1} + \epsilon_{m,t}, \tag{18}$$

$$\epsilon_{m,t}\tilde{\ } N(0, \sigma_m^2). \tag{19}$$

In this setup, the evolution of real money balances ($\widehat{m}_t - \widehat{p}_t$) is given by the identity:

$$\widehat{m}_t - \widehat{p}_t = \widehat{m}_{t-1} - \widehat{p}_{t-1} + \widehat{dM}_t - \widehat{\pi}_t.$$

In this regime, the nominal interest rate is given by the inversion of the money demand function (14).

Note the change in the interpretation of the stochastic shocks $\epsilon_{v,t}$. In the Taylor-rule framework, these shocks are the shocks to the interest rate, often referred to as "monetary policy shocks". In the Gold Standard, these are the shocks to the rate of growth of the nominal money stock, reflecting the factors mentioned earlier (changes in the gold stock due to discoveries etc.).

3.4 Bayesian Estimation

Table 2 presents the priors for Bayesian estimation. For each volatility and coefficient, we specify the distribution, the mean, standard deviation and the infimum and supremum. The volatility priors have inverse gamma distributions. Parameters restricted to fall between zero and one have a beta distribution, while coefficients outside this range are specified with a normal distribution with restrictions on their infimum and supremum. The choice of prior distributions as well as their mean and standard deviation values closely match those used by Smets and Wouters (2003).

We have also incorporated a measurement error term, relating observed real output to the model generated output with a stochastic term $\epsilon_{y,t}$, normally distributed with varaince σ_y^2.

$$\widehat{y}_t^o = \widehat{y}_t + \epsilon_{y,t}$$

$$\epsilon_{y,t}\tilde{\ } N(0, \sigma_y^2)$$

Table 2

Bayesian Priors: Distributions and Parameters

	Distribution	Mean	Std. Dev.	Inf	Sup
Volatility.					
σ_a	Inv. Gamma	.01	2	.005	4
σ_e	Inv. Gamma	.01	2	.005	4
σ_z	Inv. Gamma	.01	2	.005	4
σ_m	Inv. Gamma	.01	2	.005	4
σ_y	Inv. Gamma	.01	2	.005	4
Coefficient					
h	Beta	.7	.1	.2	.95
σ	Normal	1.25	.1	1.1	1.5
χ	Normal	.5	.05	.1	1.5
λ	Normal	1.15	.05	1	1.25
θ	Beta	.5	.1	.1	.85
ω	Beta	.1	.1	.1	.85
ρ_a	Beta	.5	.2	.1	.95
ρ_e	Beta	.5	.2	.1	.95
ρ_z	Beta	.5	.2	.1	.95
ρ_v	Beta	.5	.2	.1	.95
ρ_r	Beta	.5	.2	.1	.95
ρ_y	Beta	.5	.2	.1	.95
ρ_π	Normal	1.5	.2	1.1	2.5
δ	Normal	10	3	3	50

Table 3 shows the Bayesian posterior estimates of the model for the two eras. We present the mean and median estimates of the posterior distributions as well as the standard deviations. The estimates come from Metropolis-Hastings Monte Carlo Markov Chain replications with ten sets of 500,000 draws.

Table 3

Bayesian Posterior Estimates of Volatilities and Parameters

	Gold Standard			Great Moderation		
	Mean	Median	Std Dev.	Mean	Median	St. Dev
Volatility						
σ_a	0.021	0.027	0.008	0.008	0.012	0.004
σ_e	0.051	0.078	0.029	0.008	0.008	0.0006
σ_z	0.029	0.031	0.003	0.002	0.002	0.0003
σ_m	0.012	0.013	0.001	0.001	0.002	0.0003
σ_y	0.004	0.007	0.002	0.002	0.002	0.0004
Coefficient						
	Gold Standard			Great Moderation		
	Mean	Median	Std Dev.	Mean	Median	St. Dev
h	0.815	0.751	0.08	0.898	0.880	0.026
σ	1.250	1.34	0.109	1.1270	1.275	0.046
χ	0.488	0.471	0.054	0.506	0.503	0.049
λ	1.138	1.134	0.05	1.145	1.153	0.051
θ	0.593	0.537	0.10	0.557	0.513	0.102
ω	0.355	0.448	0.132	0.435	0.462	0.107
ρ_a	0.762	0.698	0.004	0.898	0.880	0.026
ρ_e	0.931	0.866	0.066	0.943	0.936	0.008
ρ_z	0.784	0.725	0.08	0.914	0.861	0.058
ρ_v	0.473	0.452	0.047	–	–	
ρ_r	–	–		0.667	0.633	0.048
ρ_y	–	–		0.241	0.285	0.069
ρ_π	–	–		1.514	1.517	0.020
δ	4.711	5.231	0.989	37.023	47.655	14.832

A striking feature of the estimates is the similarity of the taste and technology parameters across both eras, suggesting that they are deep structural parameters of the economy. For the utility function consumption coefficients, we note that the habit persistence parameter, by h , is slightly higher in the Great Moderation, while σ, the constant relative risk aversion coefficient, does not change appreciably across eras. The money utility parameter δ is much higher in the Great Moderation than in the Gold Standard. Since $\frac{1}{\delta}$is the interest elasticity of money demand, the higher δ means a lower interest elasticity of money demand in the Great Moderation. This may be due to financial innovations that have raised the rate of return on money relative to alternative rates. The aggregate money demand thus becomes less sensitive to changes in the alternative rates. The mark-up coefficient, given by λ, is greater than unity in both periods, as expected, and broadly the same in both eras. The Calvo indexing parameter ω, is slightly higher in the Great Moderation than in the Gold Standard while the Calvo price-resetting parameter θ is slightly lower. These parameter values, *ceteris paribus*, imply lower inflation persistence during the Gold-Standard era, in line with empirical evidence.

We also note that the volatility estimates drop dramatically as we move from the Classical Gold Standard to the Great Moderaiton. We also see that the measure error volatility term is the lowest of the volatility estimates in both eras. Not surprisingly, however, we see that the measurement error volatility is twice as large in the Classical Gold Standard than in the Great Moderation.

The persistence parameters for demand and money do not change very much, while the productivity persistence parameter is slightly higher in the Great Moderation.

The Bayesian estimates reflect the combination of prior information with evidence from the data liklihood. One concern with this approach is the priors may dominate the results, leading to potentially misleading inferences, particularly as regards differences in parameters across regimes. Thus, as a cross-check on the Bayesian estimates, we also report maximum liklihood estimates in Appendix A1. Overall the maximum liklihood are similar to the posterior means reported above, suggesting in particular that our comparison of the two periods is not an artefact of our use of Bayesian techniques.

Analyzing these structural parameters individually or in small subsets, of course, does not give much information about the implications of the fully-estimated model for inflation and output volatility. This is the subject of the next section.

4 Simulations

We first simulate the models for the two epochs, with random draws for the underlying parameters and standard deviations for the innovations, to assess the performance of the model in replicating the actual volatilities. We simulate the model 1000 times, each time with a sample size of 500.

4.1 Benchmark Volatility

Table 4 gives the actual means, the simulated means, and the supremum and infimum estimates based on 95% highest posterior density intervals.

Table 4
Volatility Estimates:
Fully Stochastic Posterior Simulations

	y	π	r	m
Gold Std				
Actual	0.0371	0.021	0.002	0.077
Mean	0.0450	0.0377	0.006	0.099
Sup	0.0532	0.0415	0.008	0.121
Inf	0.0354	0.0329	0.004	0.057
Great Moderation				
Actual	0.008	0.002	0.005	0.059
Mean	0.011	0.004	0.003	0.024
Sup	0.013	0.004	0.003	0.027
Inf	0.008	0.003	0.002	0.021

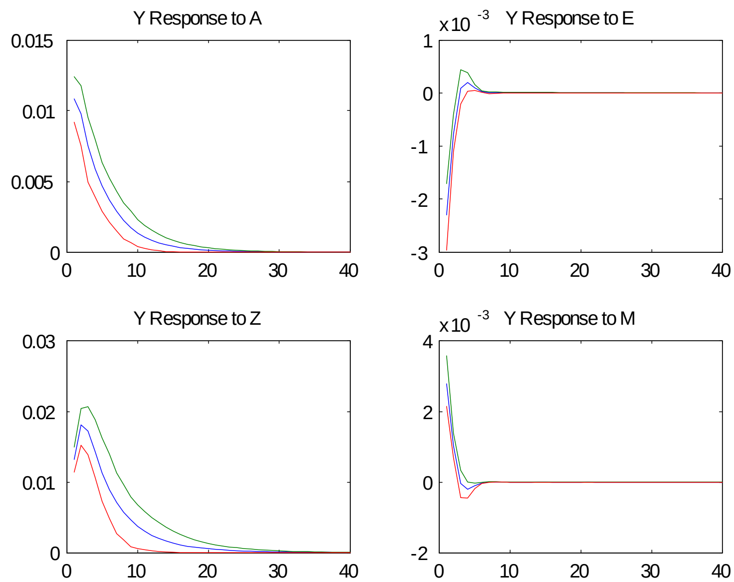


Figure 3: Output Response to Shocks under the Gold Standard

The overall assessment of these simulations is that they slightly overpredict inflation volatility and underpredict real money stock volatility in both eras. In the Gold Standard the model underpredicts interest rate volatility. But otherwise, these estimates are on target. In both eras, actual output volatility falls within the 95% confidence interval obtained from the stochastic simulations.

4.2 Impulse Response Functions

Figures 3 and 4 picture the impulse response functions of output and inflation following shocks to demand, liquidity preference, productivity and the money supply in the Gold-Standard era. The shocks are normalized shocks of one standard deviation. We leave out the measurement error shock for the sake of expositional clarity.

Figures 5 and 6 picture the impulse response paths to the same shocks for the corresponding variables in the Great Moderation. We see that the response of output and inflation to the shocks is considerably lower than in the Gold-Standard era. In particular, for money supply or Taylor-rule shocks, (which is an increase in the interest rate in the Taylor rule) the peak response of the later era is about 75% less. We also note in Figure 5 and 6 that both inflation and output do not respond to shocks to liquidity preference. Under the Taylor rule, such shocks are accommodated by the money supply process.

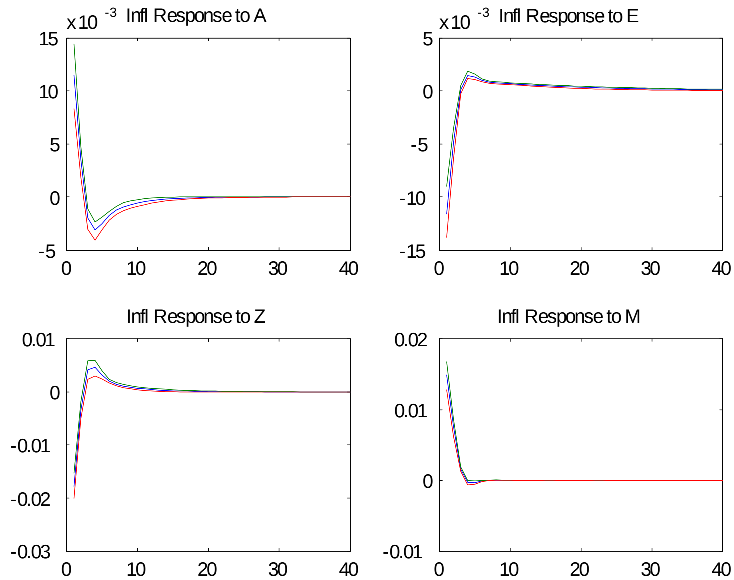


Figure 4: Inflation Response to Shocks under the Gold Standard

4.3 Variance Decomposition

Table 5 presents the variance decomposition after 20 periods for output and inflation in the two periods. We see clearly that productivity shocks dominate the variance of output in the Gold Standard, In the Gold Standard and Great Moderation, both money and productivity shocks dominate the effects of demand shocks for the evolution of inflation. In the Great Moderation, however, demand shocks matter more than both productivity and monetary policy shocks for the evolution of output. The finding that technology shocks dominate the variance of output in the Gold Standard era may at first glance seem surprising. However, this period was one of rapid transformation of the US economy, characterised by dramatic technical change, a major expansion in the labour force, driven by immigration, and a shift from an agricultural economy to an industrial economy[3]. The result is also consistent with existing evidence. For example, Bordo and Schwartz (1999) used a structural VAR methodology to examine the sources of volatility in the US over different monetary regimes. They report that technology shocks were much larger in the Gold Standard than in the post World War II era and, moreover, they were the dominant source of output volatility during the Gold Standard era.

[3] To give some examples, comparing 1880 and 1910, the labour force rose from 18.7 million to 37 million while the share of workers employed in agriculture fell from 48% to 35%. All data is taken from Bureau of the Census (1975),

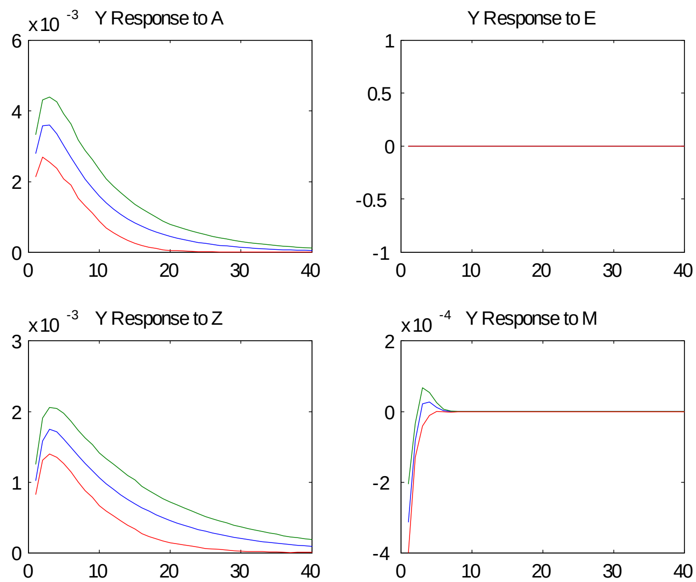


Figure 5: Output Response to Shocks under the Great Moderation

Table 5

Variance Decomposition of Output and Inflation

Shocks:	Demand	Liquidity	Productivity.	Money
	a	**e**	**z**	**m**
	GOLD STANDARD			
	Output			
Mean	0.225	0.009	0.739	0.005
Sup	0.381	0.017	0.903	0.009
Inf	0.045	0.0009	0.561	0.002
	Inflation			
Mean	0.1363	0.334	0.295	0.234
Sup	0.244	0.509	0.388	0.300
Inf	0.095	0.165	0.217	0.158
	GREAT MODERATION			
	Output			
Mean	0.748	–	0.250	0.001
Sup	0.867	–	0.377	0.001
Inf	0.622	–	0.132	0.000
	Inflation			
Mean	0.055	–	0.545	0.398
Sup	0.098	–	0.655	0.499
Inf	0.018	–	0.405	0.277

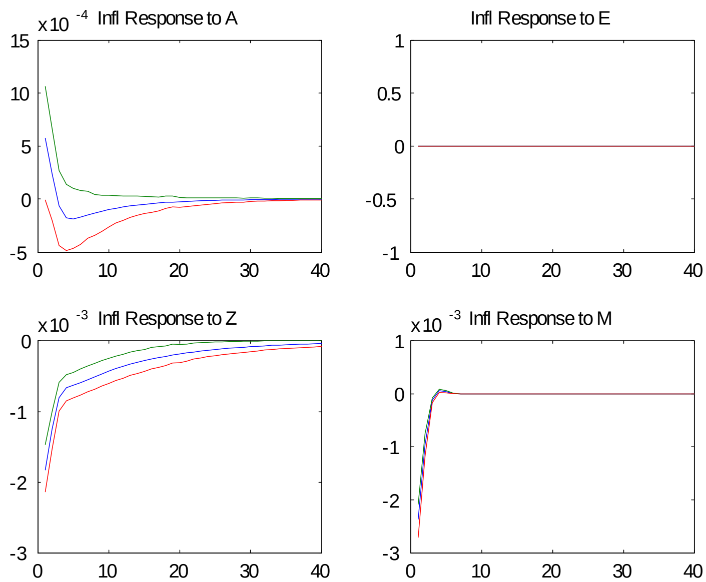


Figure 6: Inflation Response to Shocks under the Great Moderation

4.4 Counterfactual Simulations

Figure 7 pictures the Epanechnikov densities of the distribution of inflation and output/consumption growth volatility of 1000 simulations for the actual Gold-Standard policy (with the parameters and shocks of the Gold-Standard era) and the counter-factual of with the policy rule from the Great Moderation (but with all other parameters and shocks coming from the Gold-Standard era). We see quite clearly that transporting Volcker and Greenspan back in time would have decreased the volatility of inflation but it would have lessened only sightly the volatility of output. The mean of the distribution under the counterfactual simulation for inflation volatility is roughly half of the actual policy regime. The distributions of real GDP growth, however, are much closer, with considerable overlap.

Figure 8 pictures the corresponding densities for the real money stock and employment based on the same simulations. We see that the actual and counter-factual show little or no difference in the distribution of employment volatility. However, there is a much more noticeable and significant difference in the distributions for real balances. While Figure 7 shows that the counterfactual Taylor rule reduces the volatility of inflation, it does so at the cost of higher volatility in real balances.

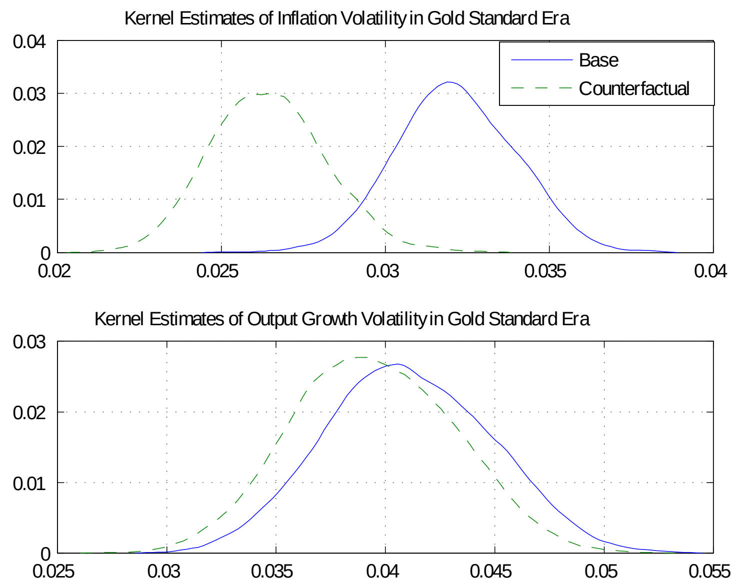


Figure 7: Actual and Counterfactual Simulations in the Gold Standard: Real GDP Growth and Inflation

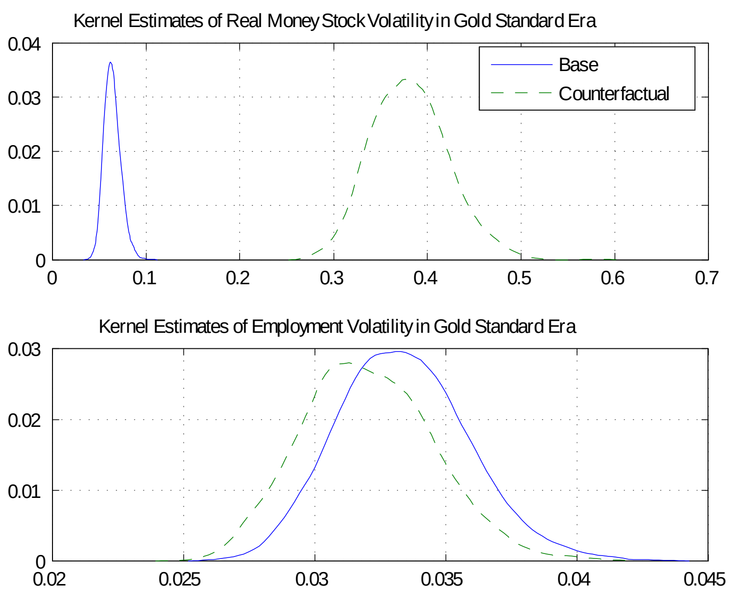
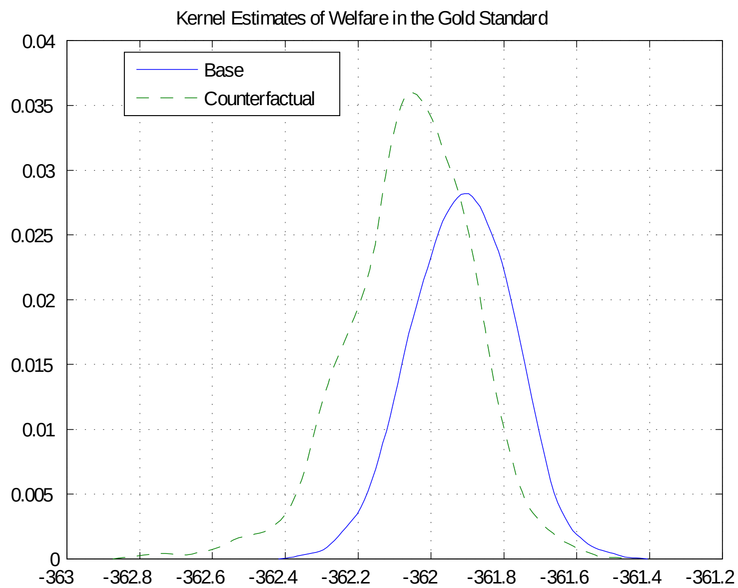


Figure 8: Actual and Counterfactual Simulations in the Gold Standard: Real Balances and Employment



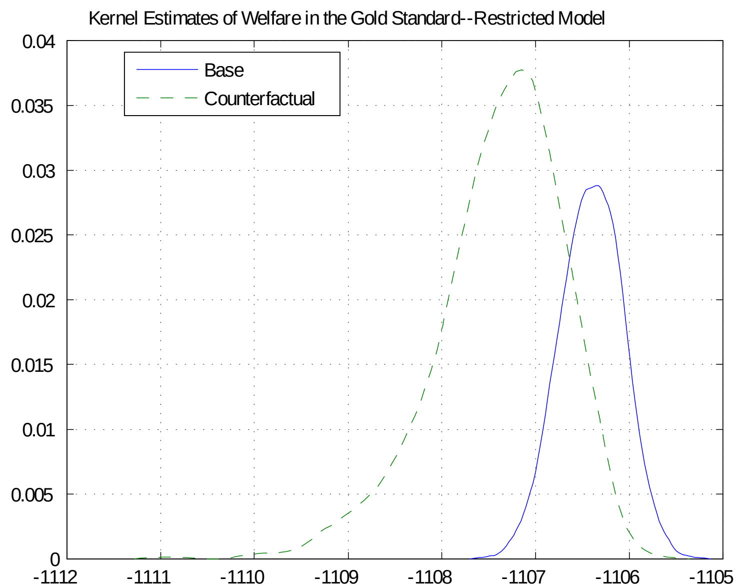
4.5 Welfare Comparison

While the above distributions pictured inflation, output, money, interest and employment volatilities, we need a suitable metric to judge the difference in economic outcomes. For this purpose, since we have a micro-founded model with an explicit utility function for the representative agent, we can compute overall welfare measures for both the baseline and counterfactual simulations. Our measure of welfare is based on expected value of the discounted utility function in equation (1).

Figure 9 pictures the distribution of overall welfare under the actual and counterfactual policy simulations. We see considerable overlap of the two welfare distributions, so that we cannot say that one regime is unambiguously better than the other. As shown in Figures 7 and 8, the counterfactual regime delivers lower inflation volatility but it does so at a cost of significantly higher real-balance volatility. These two effects balance out in the overall welfare performance of this regime relative to the actual regime.

5 Parameter Robustness

Our resutls suggest that the Classical Gold Standard exhibited more volatility and less persistence, both in real output and in inflation, relative to the Great Moderation. To assess this hypothesis in a Bayesian framework, we compute the Posterior Odds Ratio for an alternative model, in which the habit persistence



parameter h and the indexation coefficient ω are set at zero. We compute the posterior odds ratio using both the Laplace approximation and the Modified Harmonic Mean.

Table 6 presents the results of the Bayesian estimation of the alternative model. The Bayesian estimation suggests that we accept the restriction $h = \omega = 0$ for the Classical Gold Standard but not for the Great Moderation.

Table 6

Posterior Odds Ratio: $h = \omega = 0$

	Gold Std.	Great Mod
Laplace Approximation	1.0606	.9674
Modified Harmonic Mean	1.0637	.9686

To assess the robustness of the results from the unrestricted model, we once again compute the welfare distributions based on 1000 simulations, with the parameter estimates for the restricted model for the Classical Gold Standard. There is still significant overlap in the two welfare distribtuions. However, the case is even stronger that implementing a monetary policy rule of the Great Moderation would not have had beneficial effects on welfare in the Classical Gold Standard.

6 Conclusion

This paper compares the the macroeconomic performance of the US economy in the Classical Gold-Gtandard and the Great-Moderation eras. To determine the sources of the different behaviour of the economy (in particular the higher volatililty of macroeconomic aggregates) we estimate a DSGE model for both eras. We then use the model to conduct counterfactual simulations to assess the extent to which a different monetary policy - the estimated Taylor rule from the Great-Moderation period - would have led to differences in the behaviour of the economy in the Gold-Standard period.

The results show that sending Volcker and Greenspan back to the Gold-Standard era would not have improved welfare. Inflation volatility would have decreased, while output and employment volatility would not have fallen very much. but real money stock volatility would have increased. In short, there is no clearcut welfare gain from pursuing a Taylor-rule policy of the sort that has characterized the Great-Moderation era in the Gold-Standard era.

7 Appendix

Table A-1 pictures the maximum likelihood estimates for the parameters and standard deviations. These results are consistent with the Bayesian estimates in two important ways, when we examine the statistically significant estimates. The volatility of the shocks is lower in the Great Moderation relative the classical Gold Standard, while the peristence of the forcing variables driven by these shocks is higher.

Table A-1

Maximum Likelihood Estimates

	Gold Standard		Great Moderation	
	Estimate	T-Stat.	Estimate	T-Stat
Volatility				
σ_a	0.020	0.13	0.015	0.254
σ_e	0.023	16.67	0.007	9.53
σ_z	0.041	0.14	0.005	0.057
σ_v	0.013	5.22	0.005	6.85
σ_m	0.005	3.74	0.005	0.274
Coefficient				
	Gold Standard		Great Moderation	
	Estimate	Std Dev.	Estimate	St. Dev
h	0.695	1.96	0.919	0.737
σ	1.265	0.440	1.50	0.05
χ	0.498	0.364	0.679	0.097
λ	1.152	1.295	1.25	0.435
θ	0.499	1.694	0.85	1.32
ω	0.499	2.539	0.10	0.407
ρ_a	0.551	12.37	0.937	17.37
ρ_e	0.915	250.3	0.98	85.25
ρ_z	0.511	36.44	0.98	96.22
ρ_m	0.502	60.20	–	
ρ_r	–		0.42	13.3
ρ_y	–		0.10	22.1
ρ_π	–		2.5	50.0
δ	50.00	177.73	25.023	14.11

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