The Long Term Impacts of Short Term Fluctuations: Evidence from an Asymmetric Model with Correlated Shocks

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Abstract

This paper explores the long term impact of short term fluctuations by applying an unobserved components model to U.S. real GDP that allows for both asymmetric transitory movements and correlation between the permanent and transitory shocks. This model allows for two different potential channels for short term fluctuations to have long term impacts. The first channel is that the temporary asymmetric shocks are allowed to be correlated with the permanent movements. The second channel is that the temporary symmetric shocks are also allowed to be correlated with the permanent movements. The results suggest that 7 out of the last 11 recessions can be characterized as at least in part due to temporary asymmetric movements. Furthermore, the temporary asymmetric shocks appear to be uncorrelated with the permanent movements in US real GDP. There exists, however, a statistically significant negative correlation between *symmetric* transitory shocks and permanent shocks and four post-war recessions appear to only be characterized by permanent movements. These results imply that both permanent movements and asymmetric transitory shocks are important for explaining post-war output fluctuations in the U.S. and for explaining the recession that began in 2007 in particular.

[1]The paper is an update to "Asymmetry in the Business Cycle: Friedman's Plucking Model with Correlated Innovations," which is forthcoming in *Studies in Nonlinear Dynamics and Econometrics*. The author wishes to thank Fred Joutz and James Morley for helpful comments. I also thank Kavita Patel for helpful research assistance. All remaining errors are my own.

1 Introduction

This paper is an update to Sinclair (forthcoming). It re-estimates the unobserved components model developed in Sinclair (forthcoming) for updated data through the second quarter of 2009 in order to obtain additional insights on the most recent recession. This paper also recasts the discussion in terms of the evidence the results provide on the long term impact of short term fluctuations.

The model from Sinclair (forthcoming) is an extension of the correlated unobserved components (UC) model (developed by Morley, Nelson, and Zivot, 2003, hereafter MNZ). Based on estimates from their symmetric model, MNZ find that most of the fluctuations in US real GDP are due to permanent movements once they allow for correlation between permanent and transitory shocks. They find that permanent and transitory shocks are significantly negatively correlated and interpret this correlation to represent the series slowly adjusting over time to permanent shocks. Thus, they find a very tight connection between short run fluctuations and long run movements because their results suggest that fluctuations, including recessions, are primarily due to permanent shocks.

Sinclair (forthcoming) extends MNZ's model to include the possibility of asymmetric transitory movements, which allows for recessions to be fundamentally different from expansions. If recessions are at least in part due to temporary asymmetric movements, then the symmetric estimates of MNZ may over-emphasize permanent movements due to the dominance of expansions in the data. Recessions may also be characterized by exogenous shocks that are not connected to long run movements in real GDP. Milton Friedman described recessions in his "plucking" model as "occasional events producing contractions and subsequent revivals rather than a self-generating cyclical process," (1993, abstract), suggesting that recessions are driven by

exogenous shocks. It is also possible that not all recessions are alike, as suggested by Kim and Murray (2002) and French (2005). Some recessions may be characterized by temporary deviations, whereas others may arise due to permanent movements.

The asymmetry is modeled using Markov-switching in the transitory component, in the spirit of Kim and Nelson's (1999, hereafter KN) version of Friedman's (1993) plucking model. Importantly, the model allows for correlation not just between the shocks to the permanent and transitory components, but also with the shock that determines the realization of the Markov-switching state variable. This allows for two different potential connections between long run and temporary movements: one through the possible correlation between *symmetric* transitory movements and permanent movements and the other through the possible correlation between *asymmetric* transitory movements and permanent movements.

To preview the results, the estimates of the asymmetric correlated unobserved components (asymmetric UC-UR) model suggest that the transitory asymmetric shocks, although infrequent, are found to account for most recessions. Further, the transitory asymmetric shocks appear to be exogenous, suggesting that they arise from a different process than the "normal times" movements in the economy. This result adds to the evidence that recessions are fundamentally different from expansions. The permanent component, however, still captures the majority of output fluctuations, suggesting that expansions, and some recessions, are driven by variable permanent movements. There also remains a symmetric transitory component which is negatively correlated with the permanent shocks and can be interpreted primarily as adjustment to permanent shocks. Regarding the recession that began at the end of 2007, there appears to be important roles for both the permanent component and an asymmetric transitory shock.

This paper proceeds as follows. Section 2 presents the asymmetric UC-UR model from Sinclair (forthcoming). Section 3 presents and discusses the results of estimating this model for U.S. real GDP for the updated sample from 1947:1 – 2009:2. Section 4 examines more closely the recession that began in 2007. Section 5 provides conclusions and implications focusing on the long term impact of short term fluctuations based on the results of this paper.

2 The Model

The model of Sinclair (forthcoming) extends the correlated unobserved components (UC-UR[1]) model of Morley, Nelson, and Zivot (2003, MNZ) to allow for asymmetry in the spirit of Kim and Nelson's (1999, KN) version of Friedman's (1993) plucking model. Friedman envisioned a model where output can be captured as a string attached to a tilted, irregular board. In "normal times," the string follows along the board which represents the ceiling of maximum feasible output. Occasionally, however, the string is plucked away from the board by temporary asymmetric shocks which represent recessions.

The key features of the model of Sinclair (forthcoming) are that it allows for asymmetry in the transitory component via a Markov-switching process, and at the same time it allows for correlation between all of the shocks within the model. Allowing for correlation introduces the possibility of endogeneity if the Markov-switching state variable is also correlated with the other shocks. Thus, as discussed in Sinclair (forthcoming), this model also allows for endogenous regime switching, building upon the approach of Kim, Piger, and Startz (2008). A test of the exogeneity of the Markov-switching then provides evidence on whether or not the asymmetric shocks are correlated with the other shocks in the model, and in particular with permanent movements.

[1] MNZ call their model a UC-UR model to indicate that it is an unrestricted unobserved components model as compared to a traditional UC-0 model which imposes zero correlation between the permanent and transitory shocks.

The model decomposes output (y_t) into two unobserved components:

$$y_t = \tau_t + c_t \tag{1}$$

where τ represents the permanent (or trend) component and c represents the transitory component.

A random walk for the trend component, as suggested by Friedman (1993), allows for permanent movements in the series. The model also allows for a deterministic drift (μ) in the trend that captures the "tilted" nature of the trend described by Friedman. The permanent component is written as:

$$\tau_t = \mu + \tau_{t-1} + \eta_t \tag{2}$$

The transitory component is modeled as an AR(2) process. The novelty of this model, as compared to MNZ, is to include a discrete, asymmetric shock, γS_t, in the transitory component. The shock to the transitory component is now a mixture of the symmetric shock, ε_t, and the asymmetric discrete shock. This asymmetric shock captures the "plucks" of Friedman's plucking model, following KN. The model specifically focuses on this form of asymmetry in the transitory component to explore MNZ's finding of a small role of the transitory component in general, and during recessions in particular, for U.S. real GDP. The transitory component is written as:

$$c_t = \phi_1 c_{t-1} + \phi_2 c_{t-2} + \gamma S_t + \varepsilon_t \tag{3}$$

The shocks (η_t and ε_t) are assumed to be jointly normally distributed random variables with mean zero and a general covariance matrix, Σ, which allows for correlation between η_t and ε_t.

The unobserved state variable, S_t, is assumed to evolve according to a first-order Markov-switching process:

$$Pr[S_t = 1 \mid S_{t-1} = 1] = p \tag{4}$$

$$Pr[S_t = 0 \mid S_{t-1} = 0] = q \tag{5}$$

The state of the economy (whether $S_t = 0$ or 1) is thus determined endogenously in the model. For identification of the state variable, it is sufficient to restrict the sign of the discrete, asymmetric shock (γ). In the case of output, γ is restricted to be non-positive. This restriction forces the more persistent state, that of "normal times," to have a zero mean. The alternative, i.e. restricting γ to be positive, would result in long periods of positive mean with occasional zero-mean periods. When "normal times" have a zero-mean transitory component, the permanent component can be usefully interpreted as the steady state, as discussed in Morley and Piger (2009).

To take account of the possible correlation between the state variable and the other shocks, the model includes an extended version of Kim, Piger, and Startz's (2008) endogenous regime-switching model. Since the state is serially dependent, the lagged state variable can be used as the instrument for the current state, assuming the lagged state variable is exogenous from the contemporaneous error term. The model presented here extends Kim, Piger, and Startz's model to allow the shock to the latent state variable to be correlated with multiple shocks. The model then allows for an exogeneity test of the state variable as discussed in Sinclair (forthcoming).

In the case of endogenous switching, the realization of the state process is assumed to be represented using a Probit specification as follows:

$$S_t = \begin{cases} 0 \text{ if } S_t^* < 0 \\ 1 \text{ if } S_t^* \geq 0 \end{cases} \qquad (6)$$
$$S_t^* = a_0 + a_1 S_{t-1} + w_t$$

Then the joint distribution of w_t, η_t, and ε_t, is assumed to be multivariate Normal:

$$\begin{bmatrix} w_t \\ \eta_t \\ \varepsilon_t \end{bmatrix} \sim N(0, \Sigma), \quad \Sigma = \begin{bmatrix} 1 & \sigma_{\eta w} & \sigma_{\varepsilon w} \\ \sigma_{\eta w} & \sigma_{\eta}^2 & \sigma_{\eta \varepsilon} \\ \sigma_{\varepsilon w} & \sigma_{\eta \varepsilon} & \sigma_{\varepsilon}^2 \end{bmatrix}$$

The exogenous switching model is nested within the endogenous switching model with the restriction that $\sigma_{\eta w} = \sigma_{\varepsilon w} = 0$. This nesting allows for a simple test of exogeneity with a likelihood ratio test comparing the endogenous model with the restricted exogenous model (see further discussion in Sinclair, forthcoming). The results of this test are discussed in Section 3.1.

3 Empirical Results

The data (y) are the natural log of U.S. real GDP multiplied by 100, quarterly, from 1947:1 – 2009:2.[2] To estimate the model presented in the previous section, it is cast into state-space form, available in Sinclair (forthcoming). Kim's (1994) method of combining Hamilton's (1989) algorithm and a nonlinear discrete version of the Kalman filter is then used for an approximation to maximum likelihood estimation of the parameters and the components. If the state variable is endogenous, the regime-dependent conditional density function is no longer Gaussian (see discussion in Kim, Piger, and Startz; 2008). Assuming the density function is Gaussian results in quasi-maximum likelihood estimation. In this paper all models include

[2] The data come from the FRED2 database at the Federal Reserve Bank of St. Louis. They are in billions of chained 2005 dollars, seasonally adjusted annual rate. The data are the September 30, 2009 vintage from the Bureau of Economic Analysis (BEA). They include the benchmark revisions of July 2009 and the "third release" (formerly known as "final") estimates for the first two quarters of 2009.

asymmetry. Sinclair (forthcoming) tested the statistical significance of the asymmetry and found it to be an important aspect of US real GDP.

3.1 Testing for Exogenous Markov-Switching

First we must determine whether the Markov-switching is exogenous or endogenous. Estimating the endogenous Markov-switching UC-UR model for U.S. real GDP results in a log likelihood value of -323.3, whereas the restricted model of exogenous switching has a log likelihood value of -325.2. Thus, the likelihood ratio test statistic is 3.8 and the null hypothesis of exogenous switching cannot be rejected at conventional significance levels with a p-value of 0.15. Importantly, the estimates are qualitatively similar whether we allow for endogenous switching or restrict the model to exogenous switching, as can be seen in Table 1. This result suggests that the discrete, asymmetric shocks are due to a different process than the other shocks that affect output. Furthermore, this result provides support for previous research on U.S. aggregate output which assumed that the Markov-switching was exogenous (e.g. research building on the model of Hamilton, 1989). Finally, the finding that the asymmetric shock is uncorrelated with the permanent shock suggests that there is no residual asymmetry in the permanent component. Based on this result, the rest of the discussion will focus on the estimates using exogenous Markov-switching, which are presented in the first column of Table 1.

3.2 Testing for Correlation

Including the asymmetric transitory component does not eliminate the correlation between the shocks to the permanent component and the symmetric transitory component that was found by MNZ. Comparing columns (1) and (3) of Table 1 shows that the restriction of zero correlation between the permanent and symmetric transitory shocks for the asymmetric model (the asymmetric UC-0 model) is rejected, with a p-value for the likelihood ratio test statistic of

0.02. Allowing for correlation between the permanent and symmetric transitory shocks results in more permanent movements than if a zero-correlation restriction were imposed as in KN's model (note the higher standard deviation of the permanent shock in the correlated case in column (1) of Table 1 as compared to column (3)).

KN further find evidence that for U.S. real GDP there is no symmetric shock to the transitory component once they allow for the discrete, asymmetric shock. Here, however, the symmetric shock remains important and retains its interpretation from MNZ as an adjustment to permanent shocks. Restricting the variance of the symmetric transitory shock as well as the correlation between this shock and the permanent shock to both be zero results in a log likelihood value of -328.45. We can therefore reject the restrictions with a p-value of 0.04. Note that this log likelihood value is only slightly smaller than the log likelihood for the asymmetric UC-0 case, thus confirming KN's result. If the correlation between the shocks is restricted to zero, then the symmetric transitory shock is not statistically significant. However, again, the restriction that the correlation can be zero is rejected by the data.

3.3 The Estimated Components of U.S. Real GDP

Panels 1 and 2 of Figure 1 present the filtered estimates of the unobserved components of output based on the exogenous Markov-switching asymmetric UC-UR model.[3] The estimates of the asymmetric UC-UR model suggest that each recession differs in terms of the contribution of permanent and transitory movements. In particular, rather than finding that all recessions are characterized by asymmetric transitory movements, it appears that only 7 out of the last 11

[3] One movement that may appear out of place in the transitory component presented in Panel 2 of Figure 1 is the large (in absolute value) negative values from 1978:2 to 1979:1. As discussed in Sinclair (forthcoming), this is not a "pluck" but rather part of the symmetric transitory component where the series remained fairly smooth at that time but the permanent component briefly jumped well above the series (as can be seen in Panel 1 of Figure 1) resulting in the appearance of a negative transitory component as the difference between the permanent component and the series.

recessions are clearly characterized by transitory movements. The two types of recessions will be discussed further in Sections 3.4 and 3.5 below.

3.4 The "Pluck" Recessions

Although rare, the asymmetric shocks appear important in a few key episodes (Sinclair, forthcoming, further shows that the asymmetric shock is statistically significant). These episodes are represented in Panel 3 of Figure 1. This panel presents the probabilities of asymmetric shocks to the transitory component of real GDP. There is some positive probability of a transitory asymmetric shock for all of the NBER-dated recessions, with 7 of the 11 recessions in the sample having probability greater than 0.5. Figure 1 shows that for the recessions characterized by asymmetric shocks the series drops below the permanent component. These recessions have the appearance of a pluck as described by Friedman such that the permanent component appears to be a ceiling and the series is temporarily "plucked" away from that ceiling. As discussed by Friedman (1993) and KN, models that emphasize monetary or other demand-oriented shocks may be more appropriate for explaining these recessions. Furthermore, because we cannot reject exogeneity of these shocks, these shocks may be interpreted as something separate from what drives the economy in the long run.

3.5 The "No-Pluck" Recessions

The no-pluck recessions appear to represent a different type of recession from those characterized by asymmetric shocks. The four recessions where the probability of an asymmetric transitory shock remains below 0.5 are 1969:4 – 1970:4, 1973:4 – 1975:1, 1990:3 – 1991:1, and 2001:1 – 2001:4. For these recessions, the movement is in general largely permanent, as can be seen in Figure 1. In fact, for the 2001 recession, the transitory component remains positive for the entire recession. In the other three recessions without asymmetric

shocks, however, there is a noticeable peak-to-trough movement in the transitory component, but it is smaller in general than in the recessions that experienced asymmetric shocks.

The recession which occurred in 1973:4 – 1975:1 appears extremely close to the cutoff with a probability of 0.49 in 1975:1.[4] The remaining three no-pluck recessions were classified by Koenders and Rogerson (2005) as the three recessions characterized by jobless recoveries. These recessions therefore appear to have different features than the "pluck" recessions. In addition, for the 1969 – 1970 and 1990 – 1991 recessions, forecasters had particular difficulty predicting them, as discussed in Enzler and Stekler (1971) and Fintzen and Stekler (1999). Since the permanent component captures the unpredictable movements of the series, it is not surprising that these two recessions appear to be largely captured by the permanent component. Kim and Murray (2002) and French (2005) also find that the 1990-91 recession does not appear as a transitory movement. The 1973 – 1975 recession is often characterized as caused by a permanent shock due to the behavior of OPEC at the time.[5] Finally, for the 2001 recession, other econometric models also find that this recession looks different than other recessions (e.g. Kim, Morley, and Piger, 2005, and French, 2005), perhaps because it was particularly mild.

4 Exploring the Recession that began in 2007

According to the NBER Business Cycle Dating Committee, another recession began for the U.S. in the fourth quarter of 2007. Two caveats must be mentioned when exploring these results. First, the data released for 2009 by the Bureau of Economic Analysis (BEA) have not yet

[4] This is even closer to the cutoff than what was found with the data through 2007 and through 2008 reported in Sinclair (forthcoming). In those two samples the highest probability for the 1973:4 – 1975:1 recession was 0.44 and 0.45 respectively.

[5] The other "oil-shock" recession in 1979-1980 does appear to be characterized by an asymmetric transitory shock. Abel and Bernanke (2005, page 326**)** argue that people expected the oil shock of 1973 – 1975 to have permanent effects, but expected the shock of 1979 – 1980 to only have temporary effects. They note as evidence that the real interest rate rose in 1979 – 1980 whereas in 1973 – 1974 it did not. Friedman (1993) suggests that oil shocks may also be asymmetric shocks.

undergone the annual revisions that occur each year in July. Therefore, these data are subject to further revision as compared to the dataset through 2008. Second, it is unclear whether or not the recession has ended, so results may change dramatically with future information on the anticipated recovery.

Despite the caveats, the most recent recession (as of this writing) is clearly an interesting application of this model. Therefore, Figure 2 "zooms in" on the period from 2007.1 – 2009.2. As can be seen by comparing the results presented in this update with those of Sinclair (forthcoming), the addition of the 2009 data does not change our inferences about the prior recessions based on the estimates through 2007 or through 2008. In fact, all of the parameter estimates are quantitatively and qualitatively similar to those for the models estimated in Sinclair (forthcoming). This is particularly important because the data used in Sinclair (forthcoming) was before the major benchmark revision that the BEA performed in July of 2009. [6]

What is perhaps more interesting is to explore the inferences regarding the current recession. The probabilities presented in the third panel of Figure 1 suggest that a "pluck" recession began in the fourth quarter of 2008 (which matches the findings of Sinclair, forthcoming, when examining the data through 2008). One interesting change in the results as compared to the estimates reported in Sinclair (forthcoming) is that the probability in the third quarter of 2008 of a pluck is considerably higher than found when using the data only through 2008. It is still, however, well below 0.5. The results suggest that the first part of the current recession could be characterized as a "no-pluck" recession, with the "pluck" aspect of this recession beginning in the forth quarter of 2008. This is illustrated in Figure 2 where the permanent component drops below the real GDP series in the fourth quarter of 2007 and then the

[6] For a discussion of the impact of the 2009 revision on GDP data, see Seskin and Smith (2009). One key change was moving from a base year of 2000 to a base year of 2005.

series plunges below the permanent component as we move into the fourth quarter of 2008. If this recession follows historical patterns, the model suggests that the transitory peak to trough movement will last approximately 3.5 quarters, i.e. from the fourth quarter of 2008 to about the fourth quarter of 2009.

One additional interesting development since the writing of Sinclair (forthcoming) is that we can now more clearly see a return to an upward trend in the permanent component. This suggests that if the economy responds in a similar way as it has to past asymmetric transitory shocks, then we should have robust growth in 2010, returning to the trend line sometime in 2012. Also, if we look at the transitory component in Panel 2 of Figure 1, we can see that the transitory component of this recession is currently of approximately the same depth as the recessions of 1948-49, 1953-54, and 1981-82. We can therefore expect very strong GDP growth (similar to the recoveries for these past recessions) for the next two years in order to return to trend, assuming the trend continues to rise.

5 Conclusions

This paper updated the results of Sinclair (forthcoming), to include data from the first two quarters of 2009 and to specifically present evidence of the long run impact of short run fluctuations based on the estimates of the asymmetric correlated unobserved components model applied to US real GDP. This model allows for two different channels of potential long run impacts from short run fluctuations because there is both a symmetric transitory component as well as transitory asymmetric shocks, and both of these are allowed to be correlated with permanent shocks.

Based on a test of exogeneity, the transitory asymmetric shocks appear to be due to a separate process from long run movements in the economy. There remain, however, significant

permanent movements in the series, and the permanent shocks are negatively correlated with the symmetric transitory shocks. These results suggest the following conclusions. 1) Because the permanent component is variable, what could appear to be short run fluctuations may in fact be due to permanent movements. 2) In "normal times," these permanent movements are offset by symmetric transitory movements such that real GDP appears to slowly adjust to permanent shocks and there is a clear connection between permanent and temporary movements. 3) Some recessions are characterized wholly by "normal times" movements, i.e. permanent and symmetric transitory shocks. 4) Most recessions, however, are characterized by asymmetric transitory shocks which appear to be unrelated to the long run movements in real GDP.

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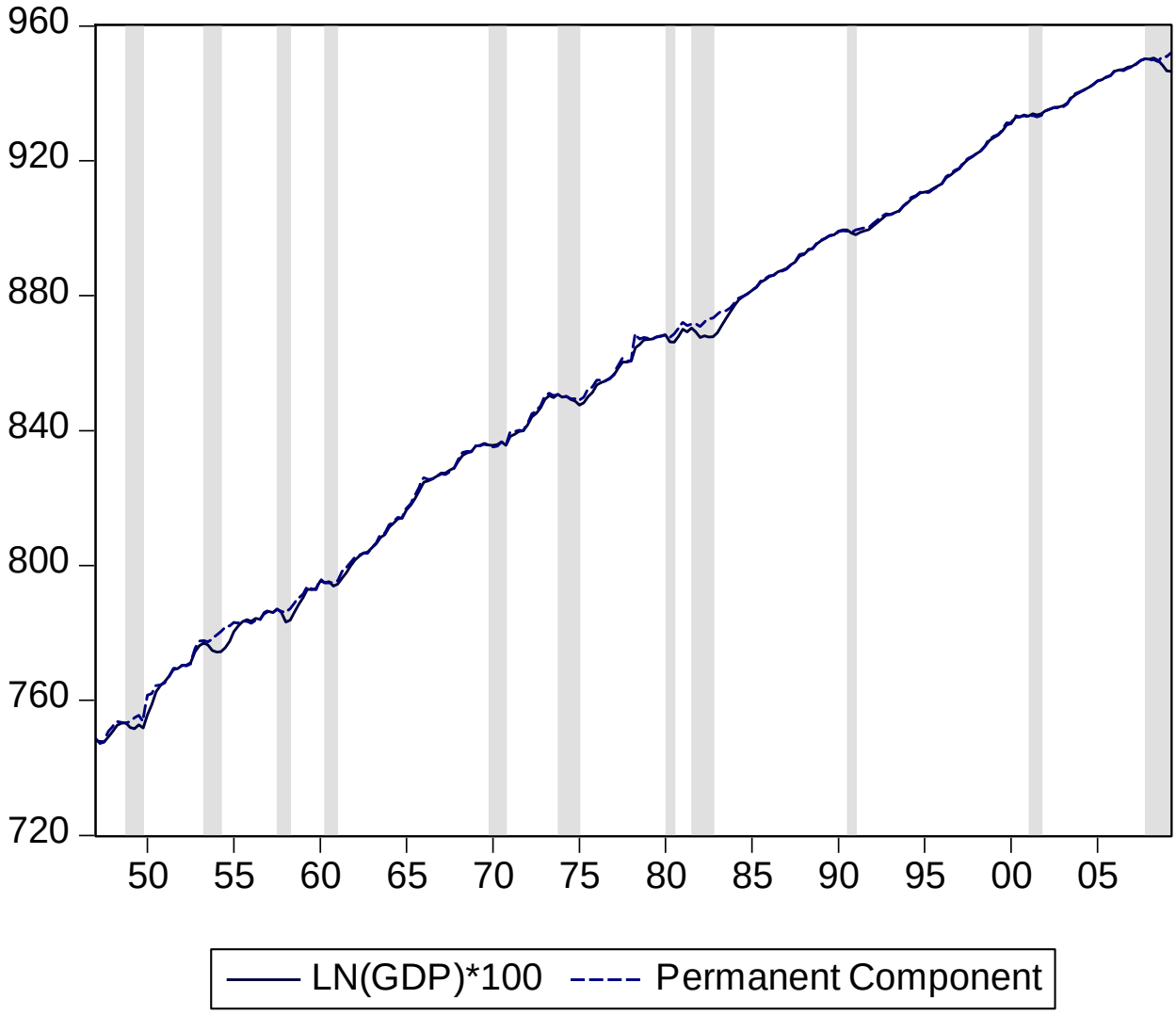
Table 1: Maximum Likelihood Estimation of the Three Primary Models[7]

Parameters		**(1) Exogenous Asymmetric UC-UR Estimate (Standard Error)**	**(2) Endogenous Asymmetric UC-UR Estimate (Standard Error)**	**(3) Asymmetric UC-0 Estimate (Standard Error)**
Log Likelihood		-325.169106	-323.283945	-327.99698
Standard deviation of the permanent shock	σ_η	1.052003 (0.135144)	1.118585 (0.1618)	0.636820 (0.107568)
Standard deviation of the transitory shock	σ_ε	0.590938 (0.195492)	0.647163 (0.21806)	0.353946 (0.178614)
Perm.-Sym. Trans Correlation	$\rho_{\eta\varepsilon}$	-0.81762 (0.086276)	-0.8017 (0.091341)	0 (restricted)
Perm.-Asym. Trans Correlation	$\rho_{\eta w}$	0 (restricted)	0.347792 (0.219138)	0 (restricted)
Sym.-Asym. Trans Correlation	$\rho_{\varepsilon w}$	0 (restricted)	0.281583 (0.258063)	0 (restricted)
Drift term	μ	0.814224 (0.068864)	0.82042 (0.075393)	0.794999 (0.042215)
AR(1) parameter	ϕ_1	1.135844 (0.095075)	1.039499 (0.090057)	1.177223 (0.103381)
AR(2) parameter	ϕ_2	-0.41693 (0.090348)	-0.3161 (0.103427)	-0.321999 (0.100248)
Asymmetric shock parameter	γ	-1.80278 (0.240883)	-2.64745 (0.330978)	-1.716629 (0.218842)
$\Pr[S_t = 1 \mid S_{t-1} = 1]$	p	0.720387 (0.090465)	0.655706 (---)	0.704914 (0.100688)
$\Pr[S_t = 0 \mid S_{t-1} = 0]$	q	0.963446 (0.015271)	0.961126 (---)	0.954338 (0.017256)

[7] Note that this Table 1 differs substantially from Table 1 in Sinclair (forthcoming). In this paper, asymmetry is assumed in all cases and therefore MNZ's symmetric model estimates are not reported. Instead, the estimates for the endogenous switching model are reported in column 2. These results were not reported in Sinclair (forthcoming), however, they are available upon request from the author for the samples considered in that paper.

Figure 1: Asymmetric UC-UR with Exogenous Switching

Panel 1: Real GDP and the Estimate of the Permanent Component



Note: Shading represents NBER recessions for all figures.

Figure 1: Asymmetric UC-UR with Exogenous Switching

Panel 2: Transitory Component of Real GDP

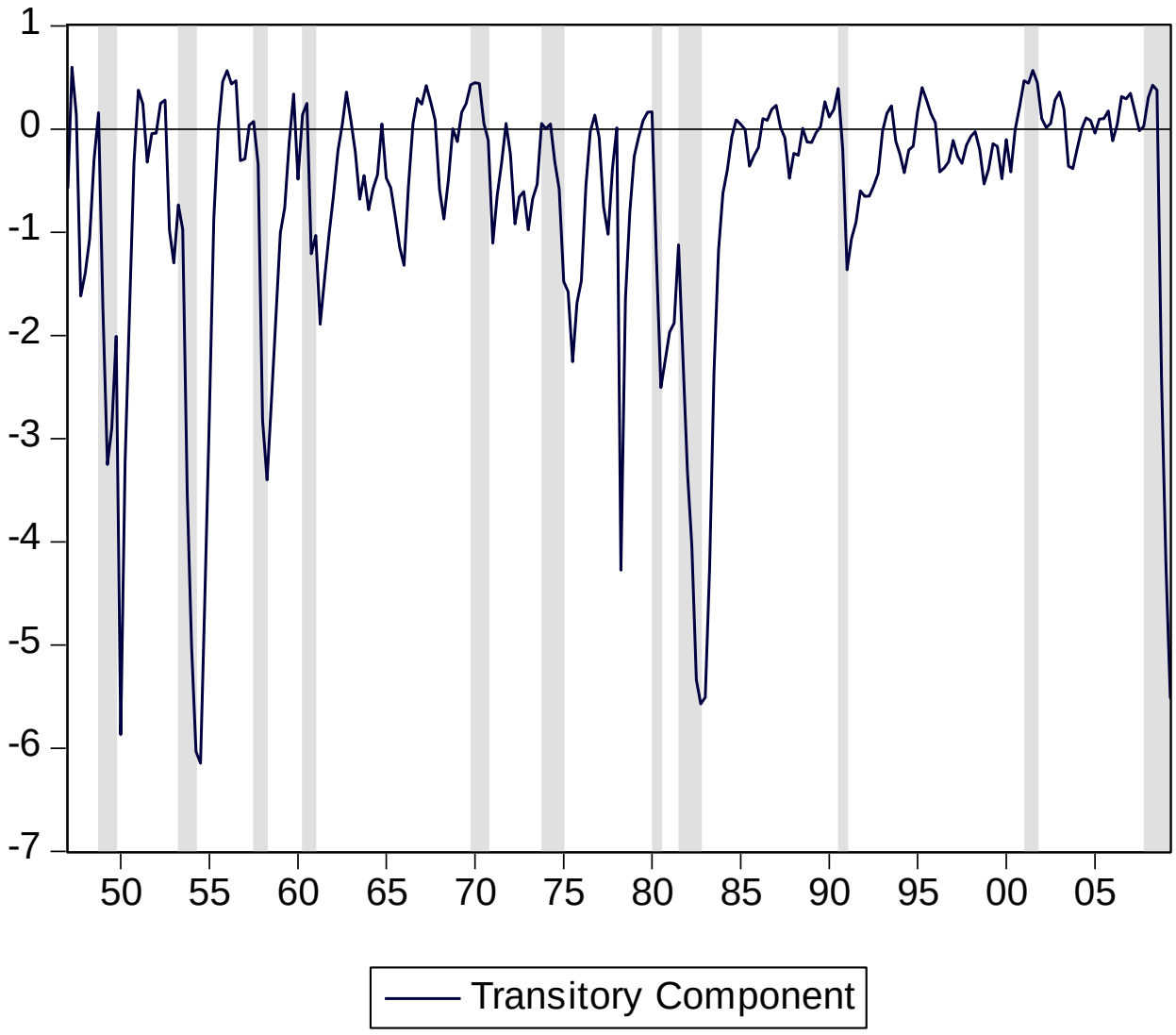


Figure 1: Asymmetric UC-UR with Exogenous Switching

Panel 3: Probabilities of Exogenous Asymmetric Shocks

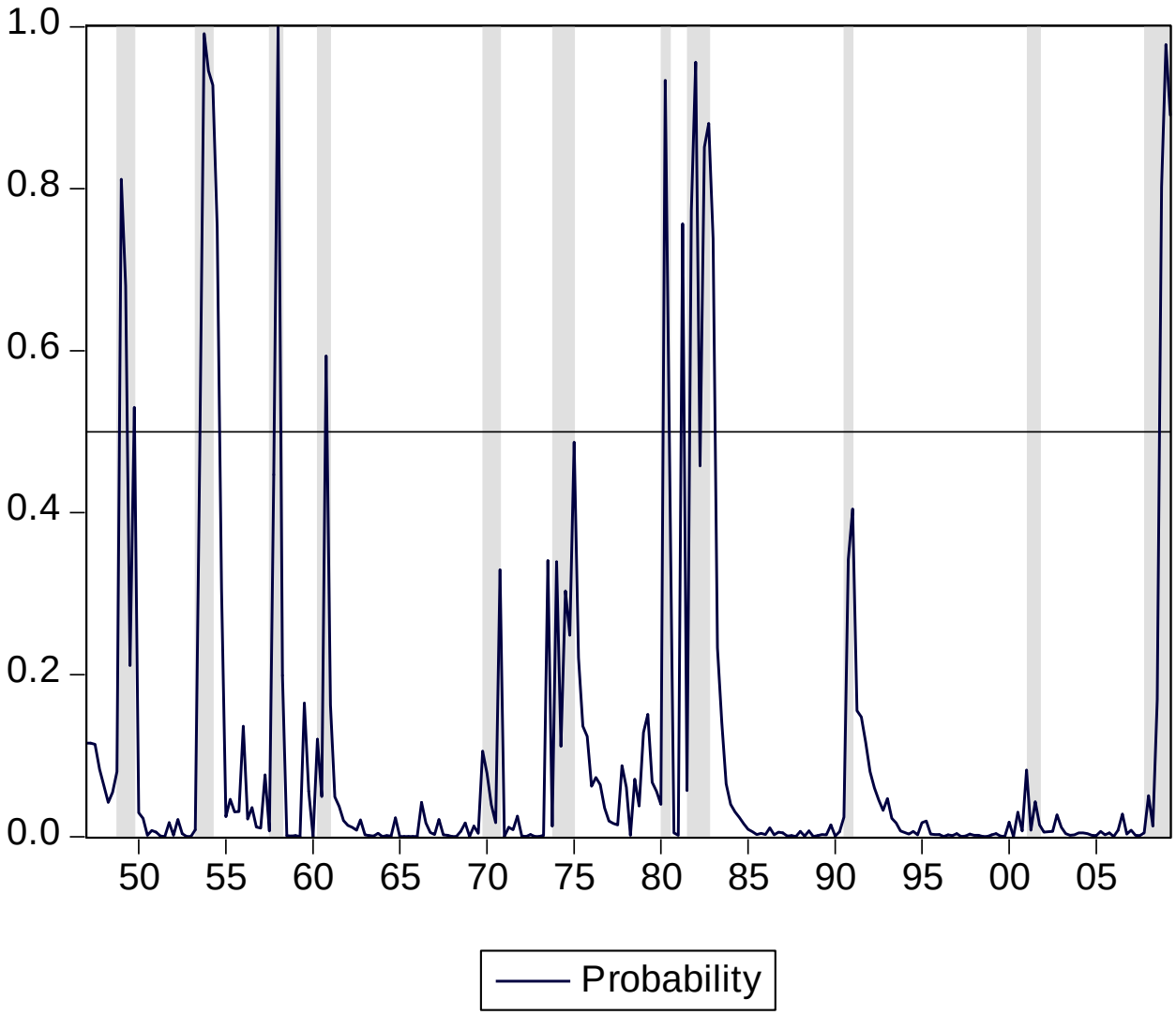


Figure 2: “Zoom-In” on the Current Recession