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Are Net Discount Rates Stationary?: Some Further Evidence

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Abstract: Gamber and Sorensen provide evidence suggesting that the net discount ratio experienced a level shift in the mean between 1977 and 1981. If such a shift occurred, the nonlinearity in the data shows up as a failure to reject the null hypothesis that a unit root is present; that is the series is I(1). In this paper, evidence is presented--the Phillips-Perron test and a univariate version of the Stock-Watson q-test--suggesting that the net discount ratio is stationary. Hence, the mean is constant. In addition, if one extends the analysis to include the 1989-93 period, the net discount ratio appears to be reverting.

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In Haslag, Nieswiadomy, and Slottje (1991) (hereafter, HNS), the authors provided evidence consistent with the notion that the net discount ratio was a stationary time-series. Gamber and Sorensen's (1993) comment re-examines this issue. In contrast to HNS, Gamber and Sorensen claim that the net discount ratio is nonstationary. Using techniques developed in Balke and Fomby (1991), the nonstationarity reflects a nonlinearity in the time series; more precisely, a mean shift is identified as having occurred sometime during the period 1977-81. The upshot of the Gamber-Sorensen analysis is that HNS substantially underestimated the post-level-shift mean by using the full-sample mean.

The primary concern Gamber and Sorensen have is that HNS chose to use only four lagged values of the change in the net discount ratio in augmented Dickey-Fuller (ADF) specifications. Gamber and Sorensen proceed, selecting the "optimal" lag length by applying both the Akaike Information Criterion and a procedure seeking the longest lag specification in which the coefficient is significant. While the lag-length selection procedure was ad hoc in HNS, the procedures employed in Gamber and Sorensen do not really address the critical issue. Including extra lags is one way to reduce serial correlation in the residuals. Since the Dickey-Fuller tests assume that errors are not serially correlated errors, the appropriate lag length is one in which the observed residuals are not serially correlated.[1] The procedures employed by Gamber and Sorensen focus on the trade-off between efficiency and explanatory power. They report,

[1] See Schwert (1987) and Phillips-Perron (1988) for discussions on the effects of serially correlated errors on unit-root tests.

but never discuss, their tests for serial correlation. In effect, Gamber and Sorensen's real concern is presumably that the parameter of interest is imprecisely estimated.

In this article, the econometric evidence is reconsidered in light of the serial correlation issue. Our evidence focuses on two issues: one is serially correlated errors, and the other is robustness, using alternative unit-root tests. In one sense, the results in HNS are flawed; the ad hoc lag-length specification still suffers from serially correlated errors. Using lag length specifications in which the errors are not serially correlated, the ADF test fails to reject the null hypothesis that a unit root is present. Alternative unit-root tests, however, strongly reject the unit-root hypothesis: more specifically, the Stock-Watson (1988) q statistic and the Phillips-Peron (1988) test for unit roots strongly reject the null that a unit-root is present.[2] Based on such mixed evidence, we cannot reject the hypothesis of nonstationarity.

In addition, when one includes data over the 1989-93 period, the net discount ratio has been rising and is now nearly identical to the full-sample mean. In light of the evidence from the last four years, Gamber and Sorensen's conclusion that a mean shift in the net discount ratio occurred seems less compelling. Thus, the evidence still suggests that the net discount ratio is stationary and has not experienced a (permanent) mean shift. Thus, the interpretations made in HNS are still appropriate.

[2] Schwert (1989) uses Monte Carlo analysis to examine the usefulness of various unit-root tests when a moving-average component is present. The Phillips-Perron test tends to frequently identify unit roots in stationary series when the moving-average term is large. For the net discount ratio, the moving-average component appears to be small.

The Evidence

Table 1 reports the results obtained from augmented Dickey-Fuller specifications. The general form of the test is to estimate a regression of the form:

$$\Delta x_t = a + bx_{t-1} + \sum_{i=1}^{n} c_i \Delta x_{t-i} + u_t, \quad (1)$$

where Δ is the difference operator, $x = (1+g_t)/(1+r_t)$ is the net discount ratio with g as the growth rate of real wages and r the (ex post) real interest rate, u is the error term, and a, b, and c are parameters. The equations reported in Table 1 differ only by the number of lagged values, n, in equation (1). The by-now familiar test-statistic is calculated under the null hypothesis that b = 0; that is, a unit root is present.

As in the HNS article, the sample period is 1964-1989. The results are reported only for the three-month Treasury bill. The results for the six-month, one-year and three-year notes are qualitatively similar and avialable from the authors upon request.

The results in Table 1 indicate that one can reject the null hypothesis that b = 0 when only four lagged values of Δx are included in the specification.[3] However, the third column in Table 1 reports the Breusch-Godfrey statistic calculated under the null that the u's are not serially correlated. According to the Breusch-Godfrey statistic, the residuals are serially correlated. Thus, the evidence suggests that the residuals are serially correlated in the regression with only four lagged values of Δx, casting doubt on

[3] It should be noted that these results differ somewhat from those presented in HNS. One reason is that the CPI was re-benchmarked since we initially conducted our analysis.

the validity of the inference. Indeed, when one includes more lags (10, 12 or 17), the evidence suggesting serial correlation fades, but a unit root is suggested. Thus far, the evidence concurs with Gamber and Sorensen's findings.

Our next question is to consider additional tests for unit roots. The low power of the ADF test is demonstrated in DeJong, Nankervis, Savin and Whiteman (1992) and is chiefly responsible for the proliferation of unit-root tests. Specifically, the tests proposed by Stock and Watson and Phillips and Perron are employed. The test results for the 1964-89 period are reported in the top half of Table 2. At each lag length, both the Stock-Watson q and Phillips-Perron statistics strongly reject the notion that a unit root is present in the net discount ratio, contradicting the augmented Dickey-Fuller results.

In addition, Figure 1 plots the net discount ratio over the 1964:4 - 1993:5 period. Gamber and Sorensen argue that the mean net discount ratio shifted, and consequently, that using the full-sample is inappropriate. Since 1989, Figure 1 shows that the net discount ratio has been rising and now appears close to the average level that existed in the pre-1980 sample. This figure suggests that a single, sample-wide mean is appropriate and is corroborated by the the unit-root test results.

Gamber and Sorensen make an important point in one other sense, What is the "optimal" forecast of the net discount ratio? The evidence does not suggest that a permanent shift in the mean occurred. However, the first two coefficients for the autocorrelation function are 0.90 and 0.82, suggesting that there is substantial persistence in the net discount ratio. While the evidence supports the notion that the net discount ratio is stationary, an "optimal" forecast would take the persistence into account.

Summary and Conclusion

Gamber and Sorensen raise an important issue in the unit-root literature and apply their question to the issue of whether the net discount ratio is stationary. As they demonstrate, the specification of lag lengths in the augmented Dickey-Fuller regression can be important. The appopriate guide should be that the residuals from the regression are not serially correlated. In HNS, four lags were used. The evidence, however, suggests that this ad hoc lag length selection was too short to satisfy not-serially-correlated errors criterion. Based only on the augmented Dickey-Fuller tests, longer lag lengths would lead one to <u>not reject</u> the hypothesis that a unit root is present in the net discount ratio. In this article, however, two additional pieces of evidence are considered. First, other unit-root tests strongly reject the presence of a unit root. Second, plotting the data reveals that the net discount ratio has been rising over the last several years and is approximately equal to the full-sample mean initially reported in HNS. This additional evidence leads one to conclude that significant nonlinearities are not present in the net discount ratio and that the variable can be represented as a stationary time series.

The Gamber-Sorensen comment raises an important, heretofore unresolved, methodological issue. Plotting the time series is useful, but temporary trends can show up as nonlinearities in the time-series representations. In short, there is an inherent danger in identifying a recent experience as a permanent shift in the time series.[4] Such an identification means that the series is subject to permanent shocks in the future. Clearly, the series might revert, making such an identification wrong. In the case of the net discount ratio, the series has some persistence and can (temporarily) deviate from its mean for periods long-enough to appear to have experienced a permanent shift. Indeed, an "optimal" forecast of the net discount ratio should take this persistence into account.

Overall, we maintain that the additional evidence supports the original conclusion presented in HNS: the net discount ratio is a stationary series.

[4] Christiano and Eichenbaum (1990) argue that the most important feature of a nonstationary series is that the forecast error variance is infinitely large as the forecast horizon becomes infinitely long.

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Table 1

Results from Augmented Dickey-Fuller
Unit-Root on the Net Discount Ratio

Number of lags	Unit-Root Test Statistic	Serial Correlation Test Statistic
4	-3.49**	3.01**
10	-2.35	0.72
12	-2.23	0.13
17	-2.53	0.01

Legend: ** indicates that the test statistic is significant at the 5% level.

Table 2

Results from Alternative Unit-Root Tests

1964 - 1989 Sample:

Number of lags	Stock-Watson	Phillips-Perron
10	-47.32**	-41.93**
12	-47.02**	-45.06**
17	-44.98**	-51.43**

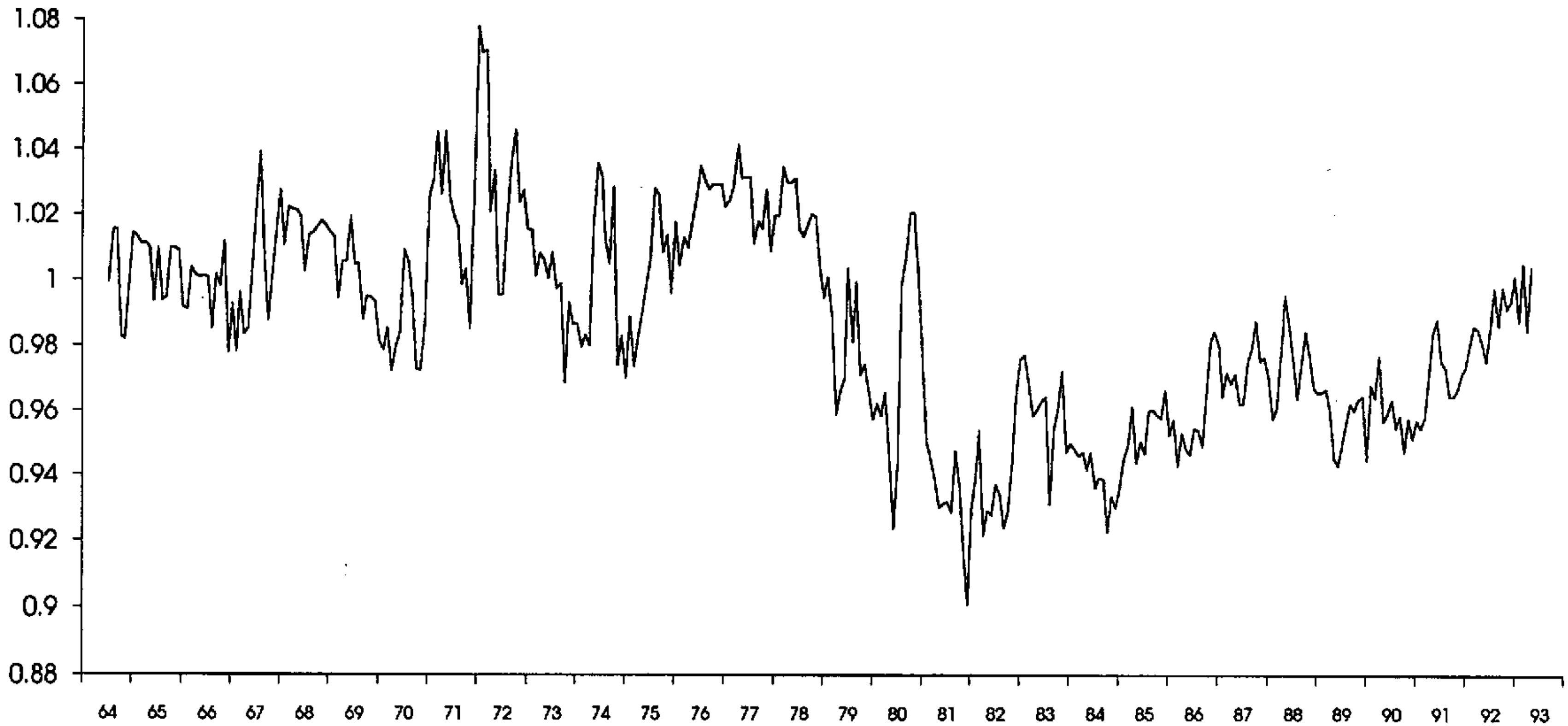
1964 - 1993 Sample:

Number of lags	Stock-Watson	Phillips-Perron
10	-48.08**	-43.86**
12	-48.23**	-47.35**
17	-46.89**	-54.63**

Legend: ** indicates that the test statistic is significant at the 5% level.

Note that the 5% critical value for the q-statistic is -27.9 and the Phillips-Perron ($T(\rho-1)$ test is -21.8.

Chart 1
Net Discount Ratio
1964-1993, monthly



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