Are Tax Effects Important in the Long-Run Fisher Relation?
Evidence From the Municipal Bond Market

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Abstract

Recent studies of the Fisher relation have yielded contradictory conclusions on the importance of taxes in determining the long-run response of nominal interest rates to changes in expected inflation, i.e., Evans and Lewis (1995) and Crowder and Hoffman (1996). The present study uses data on taxable U.S. treasury and tax exempt municipal bond interest rates to shed light on the effects of inflation on nominal interest rates. The results show that the so-called "Darby effect" is evident in the post-war data, a result that is robust with respect to the particular estimator employed.

1. Introduction

The Fisher relation is one of the oldest equilibrium relationships in financial economics. Fisher's proposition was that the real rate of interest is relatively constant over time therefore implying that a fully perceived change in the purchasing power of money, as proxied by the inverse of the rate of inflation, would be accompanied by a proportional increase in the nominal interest rate. Until very recently the empirical evidence with respect to the Fisher relation was not very supportive. In a seminal paper, Fama (1975) presented evidence to support the hypothesis that the real interest rate on short-term U.S. Treasury securities is constant implying that changes in nominal interest rates reflected changes in expected inflation. The subsequent research contradicted most of Fama's original conclusions (see Nelson and Schwert (1977), inter alia). Virtually all estimates of the response of nominal interest rates to changes in inflation, the Fisher effect, were much less than the value suggested by Fisher's relation. The problem was exacerbated when Darby (1975) pointed out that when nominal interest income is taxed the Fisher relation implies a response from nominal interest rates that is greater than the change in (expected) inflation in order to maintain the constant ex-ante real interest rate. Summers (1983) suggests that given average marginal tax rates in the U.S. the appropriate value of the Fisher effect is 1.3 to 1.5.

There have been two hypotheses put forward to explain the low Fisher effect estimates. The oldest is due mainly to Tobin (1965, 1969) in which agents shift out of nominal assets into real assets in response to increases in (expected) inflation. This Tobin effect results in a negative relationship between inflation and the real rate of interest.[1] Lucas (1980) argues that the Tobin effect should be a short run phenomenon if monetary policy superneutrality is assumed. More recently Evans and Lewis (1995) hypothesize that regime switches in the U.S. inflation process may lead to estimates of the Fisher effect that are less than that implied by theory. They state, "... the hypothesis that the tax-adjusted Fisher equation holds in the long-run is rejected." When the regime changes are modeled explicitly, Evans and Lewis obtain a Fisher effect estimate that is statistically insignificantly different from unity, still below the values suggested by Summers (1983).

Crowder and Hoffman (1996) find fairly strong evidence in favor of the Fisher effect in the post war U.S. data. Their estimate of the Fisher effect is within the range advocated by Summers (1983) and statistically greater than unity. Using data on average marginal tax rates to adjust nominal interest rates to after-tax values Crowder and Hoffman get Fisher effect estimates that are statistically insignificantly different from one. They interpret these results as strong support for not only the Fisher effect but the Darby effect as well. Crowder and Hoffman (1995) reconcile their findings with those of Evans and Lewis (1995) by demonstrating that, given the empirical univariate processes of the data, the estimator used by Evans and Lewis, the dynamic OLS (DOLS) estimator of Stock and Watson (1993), suffers from small sample bias, a bias that is not as severe in the estimator used by Crowder and Hoffman (1996), Johansen's (1991) maximum likelihood estimator (FIML).[2]

In this paper we sidestep the issue of which estimator is most appropriate for the Fisher equation and focus instead on direct comparisons between Fisher effect estimates for Treasury Bills and tax-free Municipal Bonds. If taxes are an important element in the determination of the relationship between nominal interest rates and inflation the regardless of the estimator employed, one should consistently observe that Fisher effect estimates on taxable bonds are greater than those on tax-free bonds. We employ three estimators that are asymptotically equivalent but may have differing small-sample properties. These are FIML, DOLS, and the fully-modified OLS (FM-OLS) estimator of Phillips and Hansen (1990). The results clearly demonstrate that, regardless of estimator, taxes have a profound influence on the size of the estimated Fisher effect.

The rest of the paper is organized as follows. Section 2 gives a short theoretical description of the relationship between nominal interest rates and inflation, section 3 presents the empirical results and section 4 concludes with a discussion of the results within the context of the existing Fisher literature.

2.The Fisher Equation

The Fisher equation encapsulates the simple relationship hypothesized to exist between nominal interest rates and expected inflation first delineated by Irving Fisher (1930). If the ex-ante real rate of interest is assumed constant, then self-interested economic agents will require a nominal return that not only compensates for the marginal utility of foregone current consumption (measured by the real interest rate), but a nominal return that compensates for the decline in the purchasing power of money over the term of the loan. The decline in the purchasing power of money is commonly proxied by the price inflation that is expected to occur over the life of the loan. Therefore the Fisher equation is given in its most simple form as,

$$(1) \quad i_t = r_t + E_t \pi_{t+1}$$

where i_t is the nominal interest rate, r_t is the real interest rate, π_{t+1} is the inflation rate from period t to t+1 and E_t is the expectation operator conditioned on information available in period t. Imposing rational expectations implies that equation (1) can be rewritten in terms of observable variables as,

$$(2)\quad \mathbf{i_t = r_t + \pi_{t+1} + \varepsilon_{t+1}}$$

where $\boldsymbol{\varepsilon}_{t+1}$ is a rational expectations forecast error.[3] Equation (2) demonstrates that changes in inflation should be reflected by equal changes in nominal interest rates when the real rate is assumed to be constant. The response of nominal interest rates to (expected) inflation has been called the "Fisher effect". Equation (2) implies a Fisher effect of one. However, when nominal returns are subject to taxation, the tax-adjusted "observable" Fisher equation is given in equation (3),

$$(3)\quad \mathbf{i_t = \left[\frac{1}{1-\tau}\right]\pi_{t+1} + \left[\frac{1}{1-\tau}\right]r_t + \left[\frac{1}{1-\tau}\right]\varepsilon_{t+1}}$$

where τ is the average marginal tax rate. Equation (3) is derived by noting that when nominal interest is taxed at rate τ, the after-tax nominal return is $i_t(1-\tau)$ in equation (2). Equation (3) implies a Fisher effect greater than one for all tax rates greater than zero. The interest income derived from U.S. Treasury securities is subject to ordinary income tax[4] and equation (3) represents the appropriate Fisher relation, while the Municipal securities examined here are free from most forms of taxation implying that equation (2) is the relevant form of the Fisher equation for this type of asset. If economic agents do not suffer from what Tanzi (1980) calls "fiscal illusion" then we should observe that Fisher effect estimates from Municipal securities are significantly smaller than analogous estimates from Treasury securities. Specifically, if Tobin effects and changing inflation dynamics are short-run in nature, as implied by the long-run superneutrality hypothesis, the estimate of the Municipal Fisher effect should be insignificantly different from one while that based upon Treasury securities should be greater than one.

3. Empirical Analysis

Monthly data, over the period January 1950 to December 1995, are employed for i) 1-year Treasury bill yield, ii) Consumer Price Index, iii) 1-year prime grade municipal bond yield. The Treasury bill data and the municipal bond data are from Salomon Brothers. The consumer price index is from Citibase.[5] Annualized percentage changes in the CPI are used as proxies for expected inflation.

The top panel of Figure 1 plots the one-year Treasury bill interest rate, the middle panel shows the one-year prime grade municipal bond yield and the bottom panel displays the annualized CPI inflation rate. Standard augmented Dickey-Fuller (ADF) τ-tests are presented in Table 1. Using the critical value for this test given by Dickey and Fuller (1976) of -2.79, the null hypothesis of a unit root cannot be rejected for any of the three series when a lag of 6 or larger is used.[6]

The non-stationarity of the data and the assumption that Tobin effects are negligible in the long run implies that the use of cointegration techniques is most appropriate in analyzing the Fisher equation.[7] The discussion in section 2 suggests that the cointegrating vectors should be of the form $[1\ -\beta_{Muni}]'$ where $\beta_{Muni} = 1$, for Municipal bonds and $[1\ -\beta_{tb}]'$; $\beta_{tb} > 1$ for Treasury bills. These cointegrating vectors would yield a stationary ex-post real interest rate. In addition, if one assumes an average marginal tax rate of 0.3 the cointegrating vector between the 1-Year Treasury and the inflation rate should be [1,-1.42].[8]

These hypotheses are tested using four different estimators. The first estimator used in testing these hypotheses is the full information maximum likelihood (FIML) procedure proposed by Johansen (1988, 1991). The second estimator used is the dynamic OLS estimator of Stock and Watson (1993). This is a least squares estimator in which the nominal interest rate is regressed on current inflation and augmented with leads and lags of changes in inflation, as well as the contemporaneous change in inflation, with adjustments made to obtain appropriate standard errors.[9] The third estimator is the Fully Modified OLS (FM-OLS) estimator suggested by Phillips and Hansen (1990). The fourth estimator employed is standard ordinary least squares (OLS).[10]

Table 2 presents the estimated Fisher effect parameters for both Treasury bill and Municipal bond data using each of the four estimators.[11] In every case the estimated Fisher effect is smaller for the Municipal bond series than for the Treasury bill series. This is consistent with Darby's extension of the Fisher equation to account for the effects of taxes on interest income. This result does not depend upon a particular estimator. It is also interesting to note that the FM-OLS and FIML estimates are statistically insignificant from the values implied by average marginal tax rates in the U.S. lending strong support to a full Fisher effect in the U.S.

4. Conclusion

In this paper we use four different estimators to examine whether taxes are important in determining the long-run response of nominal interest rates to changes in (expected) inflation. A finding that the effect of taxes on returns was not incorporated into economic agents investment calculus would indicate a bizarre violation of rational expectations that Tanzi (1980) has termed "fiscal illusion". The results we presented demonstrate that regardless of which estimator of the long-run parameter is employed the response of tax-free Municipal bond rates is always smaller than the response on similar taxable Treasury bills and the difference is statistically significant and the magnitudes are economically meaningful.

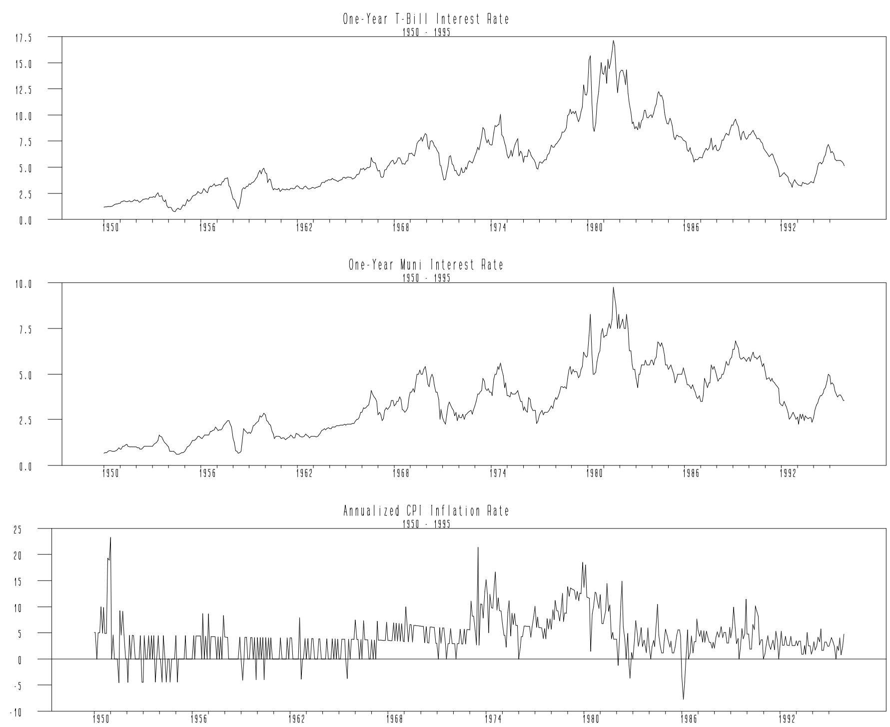

Figure 1

Table 1

Dickey-Fuller τ-tests

Lag Length	1-Year T-bill	1-Year Muni Bond	1-Year Inflation
4	-1.84	-2.07	-3.26
6	-1.74	-1.97	-2.46
8	-1.67	-1.74	-2.00

Test statistics were calculated from the regression $\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \Sigma\zeta_j \Delta X_{t-j} + \varepsilon_t$, where j is the lag length referred to in column one. A time trend was not included in the regression since there is no evidence of a significant trend in any series. 95% critical value for augmented Dickey-Fuller statistic = -2.79.

Table 2

Fisher Effect Estimates

Estimator	OLS	DOLS	FM-OLS	FIML
	Treasury Bill			
Estimate	0.890	1.180	1.454	1.494
Standard Error	0.031	0.130	0.101	0.147
	Municipal Bond			
Estimate	0.513	0.681	0.882	0.904
Standard Error	0.019	0.092	0.066	0.129

Three leads and lags were used in calculating the DOLS estimates. DOLS standard errors were obtained by using the Newey-West estimate based on the Parzen kernel with lag truncation set to 50. The FM-OLS estimates were obtained using a VAR(1) pre-whitening of the residuals and an automatic bandwidth selection.

Endnotes

1. Throughout we refer to *the* real rate of interest recognizing that there is no one appropriate real rate.

2. The two estimators are asymptotically equivalent under very general regularity conditions as demonstrated by Stock and Watson (1993) and Phillips and Loretan (1991).

3. When economic agents are uncertain about their future consumption path there will also be a risk premium term in the Fisher equation. Smith (1993) and Ireland (1996) demonstrate that in the U.S. this risk premium term is negligible.

4. This is true unless the securities are held in a qualified tax-deferred annuity or similar investment.

5. The CPI series is PUNEW. The results are insensitive to alternative measures of inflation.

6. It is well documented that post war U.S. inflation has a large negative MA component, see Crowder and Hoffman (1996), Ball and Cecchetti (1990) and Crowder (1996). Said and Dickey (1984) suggest using a high order AR polynomial to approximate the MA component.

7. Mishkin (1992) was one of the first to make this point.

8. This is the approximate average marginal tax rate as computed by Barro and Sahasakul (1986).

9. A Newey-West correction to the variance-covariance matrix is required to obtain valid statistical inferences on the parameters.

10. Each of these estimators is common in the cointegration literature. Therefore we will forgo a discussion of them and direct the uninitiated reader to the relevant citations.

11. All of the estimates were produced with constants excluded. Estimation allowing for constants and/or linear trends resulted in the trends always being statistically insignificant and the constant usually so. The only cases where the constant was significant are in the DOLS and OLS regressions. The OLS standard errors are usually inappropriate for conventional hypothesis testing in non-stationary regressions and thus can be discounted. The DOLS results, however, should be valid, at least asymptotically. It is interesting to note, though, that the point estimates of the constant in OLS and DOLS regressions are of magnitudes several times larger than those obtained using FM-OLS or FIML, i.e. 3.009 versus 0.515. This may imply that the DOLS estimator is not purging the second order bias effectively. Crowder and Hoffman (1995) demonstrate in a Monte Carlo experiment that including a superfolous constant and/or trends in the estimation of the cointegrating vectors may yield severely biased estimates. In any event, allowing constants and/or linear trends in the estimation does not change our qualitative results in any way. For example, the DOLS estimate of the Muni Fisher

effect with constant in regression is 0.343 with a standard error of 0.070. The DOLS estimate of the T-bill Fisher effect with a constant included is 0.695 with a standard error of 0.114. These are both much smaller than the estimates obtained without a constant (consistent with Crowder and Hoffman's (1995) findings) but the relationship between the two Fisher effects is left unchanged, i.e. $\beta_{tb} > \beta_{Muni}$.