The Predictive Power of Implied Yields and US Housing Prices

Author

William J. Noone
(George Washington University, MS Finance)

1. Introduction

The US Treasury Yield Curve is a function of yield and maturity; the slope acting as a fundamental indicator of future interest rates through derivation of implied future yields. The priori of this analysis to test the capacity for implied future yields to forecast actual yields. In addition, I gauge the power of US housing prices as an indirect predictor of short-term Treasury yields. First, the Treasury Yield Curve is examined over a conventional business cycle to capture such cyclical bias with the analytical lens focused upon yield curve slope and shifts. I then make assumptions regarding housing price methodology and liquidity preference theory before constructing empirical models and drawing conclusions.

1.1 Yield Curve Shifts and Slope[1]

Treasury Yield Curve slope conveys market expectations for future real demand for credit, growth and future inflation. Accordingly, shifts across all or specific maturities can be characterized by three "shock" factors, often called "level", "slope", and "curvature".[2] Because short term Treasury securities have low price sensitivity to interest rate changes, equilibrium typically dictates yields just slightly above the inflation rate.[3] As maturities increase, so must yield to compensate investors to any loss in purchasing power and additional price risk. If inflation was forecasted to change, but at a rate identical across all maturities, the yields would realize a "level" shift parallel to the former curve. If short term yields were expected to change by larger amounts than long term yields, the curve would realize a "slope" shift. Consider that the Federal Funds rate has been set to record lows over recent years by the Federal Reserve and how short term yields adjusted.[4] Finally, a "curvature" shift is characterized by changes to medium term maturities in proportions greater than short and long term yields.

The initial steep curves of *Figure 1.1* reflected market confidence for an expansionary period; indicating an expectation for a direct relationship between increasing risk and maturities. The ensuing flatter/inverted curves of *Figure 1.2* accompanied a climate of uncertainty with investor indifference to risk across maturities; anticipating a recessionary period. The successive positive (albeit gradual) curves of *Figure 1.3* marked for a hesitant recovery, as seen by the sub 1.0% yield through the 5 Year instrument as of 7/02/2012.

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[1] *Figures 1.1, 1.2, 1.3* each plot (3) spot yield curves over the term 07/01/02 to 07/02/12.
[2] See Wu (2003). Reference is made to empirical studies by Litterman and Scheinkman (1991).
[3] See Estrella and Hardouvelis (1991)
[4] See Estrella and Trubin (2006). *Figure 1.4* illustrates how closely the 3 Month Treasury Yield tracks the Federal Funds rate.

1.2 Variable Assumptions

It is reasonable to assume as lending interest rates decrease, home buyers are better able to qualify and afford loans, hence increasing the demand for funds. All other factors equal, housing prices would be expected to rise under this scenario. Higher interest rates dissuade borrowing as buyers cannot afford to make larger payments of interest and principal. Conversely, one's expectation would be for housing prices to fall. Consider a convex relationship[5] between house prices and interest rates; the lower the level of interest rates, the greater the sensitivity of housing prices to interest rate changes. Mayer and Hubbard reinterpret the Gordon Growth Model to Real Estate pricing as:

House Price = Periodic Rent/(Interest Rate – Rental Growth rate)

I do not intend to hypothesize a causal relationship between general housing prices and Treasury yields, yet I expect the impact of exogenous variables such as the Fed Funds rate, the recent credit freeze, and incremental demand for risk free securities during the mortgage crisis to reinforce my assertions.

The liquidity preference theory postulates that the implied yield should be equal to a maturity-consistent actual yield *plus* a premium factor. Under normal conditions, if quantified, this would be positive value, only becoming negative under the rare case of yield inversion. I expect this premium to be commensurate with the amount of relative risk associated with a longer term security due to increased price sensitivity. I also expect that implied yields will change in proportion to respective "level", "slope", and "curvature" shifts over time. I will juxtapose implied forward and resulting actual interest rates to validate these assumptions over the scrutinized time period.

2. Data

Monthly data[6] was collected from FRED of the St. Louis Fed for the 3-Month Treasury Constant Maturity Rate (3MTBill), 6-Month Treasury Constant Maturity Rate, 1-Year Treasury Constant Maturity Rate (1YrTBill), 2-Year Treasury Constant Maturity Rate, and the S&P/Case-Shiller 10-City Composite Index (indexed at 100.00 as of January 2000). The natural log of the S&P/CS10 has been calculated monthly for Model 1, noted as lnSPCS10. The calculation of implied interest rates is a straight forward operation equating the product of geometric averages of a shorter term actual yield(s) and an unknown implied forward yield to a longer term actual yield such that the sums of the shorter term actual and implied yield maturities equal that of the longer. Two sample sets of implied yields were derived: $3MTBILL_{Implied}$ and $1YrTBILL_{Implied}$. All samples consist of 121 observations for the term 07/01/02 – 07/02/12.

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[5] See Mayer and Hubbard pg 5.

[6] *Tables 2.*1and *2.2* display Descriptive, ANOVA, and Parameter Estimate statistics for each Model.

3. Empirical Test[7]

3.1 Model 1

The study first considers a simple linear model regressing the lnSPCS10 against the 3MTBill(dependent variable). In *Section 1.2*, I assumed housing prices to be a symptom of supply and demand for financing and to move inversely to long term interest rates all other factors held constant. The unchecked securitization of mortgages in the early to mid-2000s made low financing available at unsustainable rates (due to default) to unqualified participants in the deficit sector. Intuitively, one would think that housing prices would rise and fall with this housing bubble. The 3MTBill yield or risk-free rate realized a "slope" shift upward under recessionary pressure as evidenced by *Figures 1.1 and 1.2*. As I stated in *Section 1.1,* the Federal Reserve has kept the Fed Funds rate low in the post housing bubble years, having a concurrent effect on the risk free rate. The null hypothesis is that there is not a positive relationship between variables. The alternative hypothesis is that there is a positive relationship.

$$H_0: \beta_1 \leq 0$$
$$H_A: \beta_1 > 0$$

From the sample regression, the statistically significant parameter estimates are [β_0 = -50.46 and β_1 = 10.11] so I reject H_0 and accept H_A with 95% confidence. I will not make an interpretation of the β_0 estimate; a negative 3MTBill yield is not realistic. The β_1 estimate can be interpreted as: a 1% increase in the SPCS10 Index is associated with approximately a 10 basis point increase in the 3MTBill yield. I can construct the SRL as:

$$3MTBill_i = -\ 50.46 + (10.11)lnSPCS10_i + \mu_i$$

The coefficient of determination is [R^2 = 0.81] which indicates that 81% of the variation in 3MTBill yields can be explained by the model. The standard deviation of the 3MTBill(dependent variable) is [σ_{MTBILL} = 1.77]. From this, compared to the Root MSE [$\sigma\mu$ = 0.77] one can see that Model 1 is a much better predictor of 3MTBill than its mean alone.

3.2 Model 2

The next model first considers the descriptive statistics for $3MTBILL_{Implied}$ vs the $3MTBill_{Actual}$. Through the framework established in *Section 1.2*, I expect that the mean of the $3MTBILL_{Implied}$ yield will be greater than the $3MTBill_{Actual}$ yield for the sample.

$$Mean_{\ Implied} > Mean_{\ Actual}$$

For the sample, the means are: [$Mean_{\ Implied}$ = 2.05, $Mean_{\ Actual}$ = 1.73, Δ = 0.32%]. The study next considers a simple linear model regressing the $3MTBILL_{Implied}$ against the $3MTBill_{Actual}$(dependent variable). From the sample regression, the statistically significant parameter estimates are [β_0 = - 0.19 and β_1 = 0.94]. The β_0 estimate can be interpreted as $3MTBill_{Actual}$ will be [- 0.19] when $3MTBILL_{Implied}$ is zero. The β1 estimate and be interpreted

[7] Parameter estimates for β_1 are designated as negative by sign and not ( ).

as: a 100 basis point increase in the $3MTBill_{Implied}$ is associated with approximately a 94 basis point increase in the $3MTBill_{Actual}$ yield. I can construct the SRL as:

$$3MTBill_{Actual,i} = -0.19 + (0.94)3MTBill_{Implied,i} + \mu_i$$

The coefficient of determination is [$R^2 = 0.93$] which indicates that 93% of the variation in $3MTBill_{Actual}$ yields can be explained by the model. The standard deviation of the $3MTBill_{Actual}$ (dependent variable) is [$\sigma_{Actual} = 1.77$]. From this, compared to the Root MSE [$\sigma\mu = 0.48$] one can see that Model 2 is a much better predictor of $3MTBILL_{Actual}$ than its mean alone.

3.3 Model 3

The next model first considers the descriptive statistics for $1YrTBILL_{Implied}$ vs the $1YrTBill_{Actual}$. As with Model 2, I expect that the mean of the Implied will be greater than that of the Actual 1YrTBill yield for the sample.

$$\text{Mean}_{\text{Implied}} > \text{Mean}_{\text{Actual}}$$

For the sample, the means are: [$\text{Mean}_{\text{Implied}} = 2.81$, $\text{Mean}_{\text{Actual}} = 1.98$, $\Delta = 0.83\%$]. The study next considers a simple linear model regressing the $1YrTBill_{Implied}$ against the $1YrTBill_{Actual}$ (dependent variable). The statistically significant parameter estimates are [$\beta_0 = -0.70$ and $\beta_1 = 0.95$]. The β_0 estimate can be interpreted as the value of $1YrTBill_{Actual}$ will be [-0.70] when $1YrTBILL_{Implied}$ is zero. The β_1 estimate can be interpreted as: a 100 basis point increase in the $1YrTBill_{Implied}$ is associated with approximately a 95 basis point increase in the $1YrTBill_{Actual}$ yield. I can construct the SRL as:

$$1YrTBill_{Actual,i} = -0.70 + (0.95)1YrTBill_{Implied,i} + \mu_i$$

The coefficient of determination is [$R^2 = 0.54$] which indicates that 54% of the variation in $1YrTBill_{Actual}$ yields can be explained by the model. The standard deviation of the $1YrTBill_{Actual}$ (dependent variable) is [$\sigma_{Actual} = 1.73$]. From this, compared to the Root MSE [$\sigma\mu = 1.18$] one can see that Model 3 is a better predictor of 1YrTBILL than its mean alone.

3.4 Applying Model 2 to Yield Curve Shifts

Consider the following yield curve shift from *Figure 1.1*:

3 Month Treasury	6 Month Treasury
07/01/2002 = 1.72%	07/01/2002 = 1.78%
07/01/2003 = 0.89%	07/01/2003 = 0.96%
$\Delta = -0.89\%$	$\Delta = -0.82\%$

In *Section 1.2*, I made the assumption that implied yields must change proportionally to the actual yields from which they are derived for shifts in the yield curve. This is mathematically obvious when applied to Model 2.

Model 2: $3MTBill_{Actual,i} = -0.19 + (0.94)3MTBill_{Implied,i} + \mu_i$

07/01/2002 $1.72 = -0.19 + (0.94)3MTBill_{Implied}$
$3MTBill_{Implied} = 2.03\%$

07/01/2003 $0.89 = -0.19 + (0.94)3MTBill_{Implied}$
$3MTBill_{Implied} = 1.15\%$
$\Delta = -0.88\%$

4. Conclusions

The empirical results show that the 3 Month and 1 Year Treasury Bill yields are predictable with reasonable certainty given continuous and independent monthly observations for the natural log of a house price index and implied Treasury yields for respective models. An initial qualifier: my assertion is that this is the case *only* over the period 07/01/2002 to 07/02/2012 and *perhaps* over another comparable business cycle. In comparing all three models, Model 2 had the largest R-Squared [$R^2 = 0.93$] and the smallest Root MSE [$\sigma_\mu = 0.48$], so it has the best explanatory power. This is obvious though as the $3MTBILL_{Implied}$ is a function of the dependent variable, and has a shorter maturity than the $1YrTBILL_{Implied}$ of Model 3.

For Model 1, a natural log transformation of the S&P/CS10 was chosen to compare the percent change of the index with the yield. *Figure 1.4* indexes the lnSPCS10 and 3MTBILL to 1.0 to show that both generally move together over the time period. These results must be taken in the context that this is over ten major urban cities. There surely is bias between urban and rural location, proximity to landmarks and shoreline, and a myriad of construction inputs. There is a particularly high R-Squared [$R^2 = 0.81$] for the sample. Given the extraordinary circumstances of the mortgage crisis, such explanatory power of Model one may be a confluence of Federal Reserve action, swings in credit availability, and the insanity of crowds.

The predictive ability of implied yields appears to be quite accurate at shorter maturities, which seems to be lost to economic noise as maturities increase. *Figures 4.2 and 4.3* show that both implied yields for Model 2 and 3 over-predicted actual yield shifts with respect to timing. This may be due to forces of market efficiency at work; market participants acting on information implied by the current yield curve at a given moment. Models 2 and 3 analyses of the $Mean_{Implied}$ confirm that implied yields were on average greater than actual yields for respective maturities over the period. Note also the [$Mean_{Implied} - Mean_{Actual}$] values between Models 2 [$\Delta = 0.32\%$] and Model 3 [$\Delta = 0.83\%$]. As maturities increase, so does the average implied to actual spread. *Figure 4.4* illustrates this spread for both models over time. This is again due to the increase in risk, and thus premium as maturities increase under normal conditions. The predicted values of the actual yields for both models will always be less than implied yields given that the slope coefficients are less than 1.0 unless of course there is yield inversion. This is rare given intercept values: Model 2 [$\beta_0 = -0.19$] and Model 3 [$\beta_0 = -0.70$]. Note that as maturity increased from 3 Months to 1 Year, the value of the predicted actual yield is decreased by a larger intercept value to account for the premium of the respective implied yield. These results are consistent with the Liquidity Preference Theory.

Appendix

Figure 1.1

*Note: 30 Year Treasury Bonds were not available 2002-2004. The 20 Year rate was held constant as a proxy.

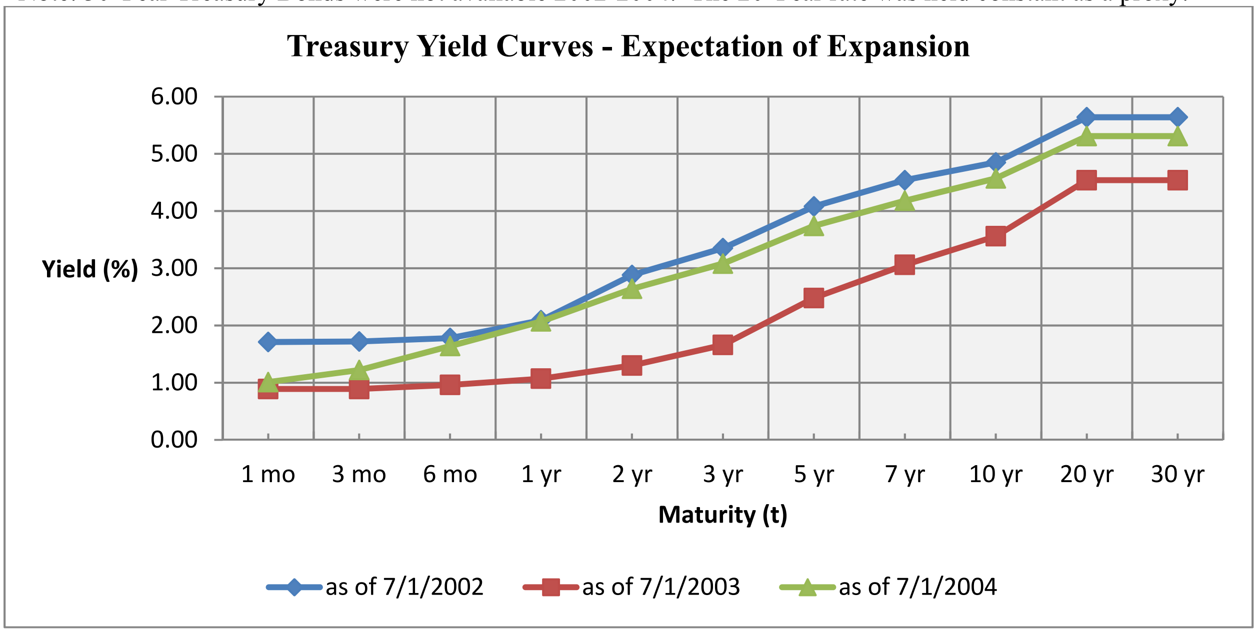

Figure 1.2

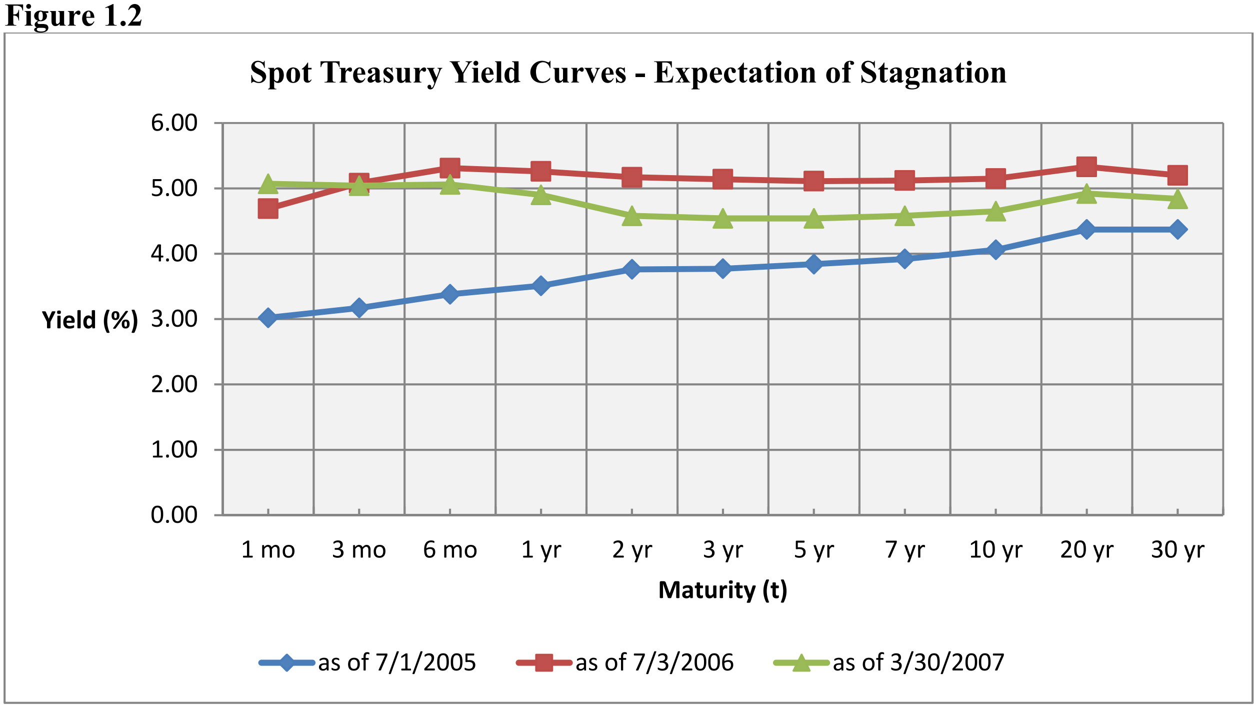

Figure 1.3

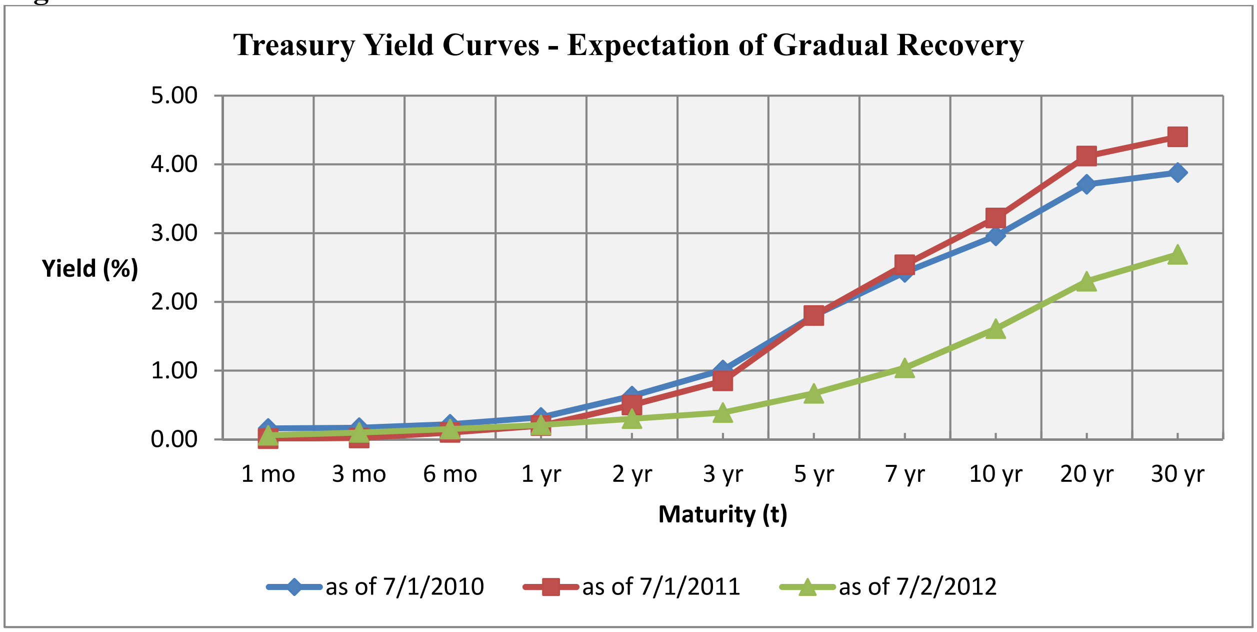

Figure 1.4

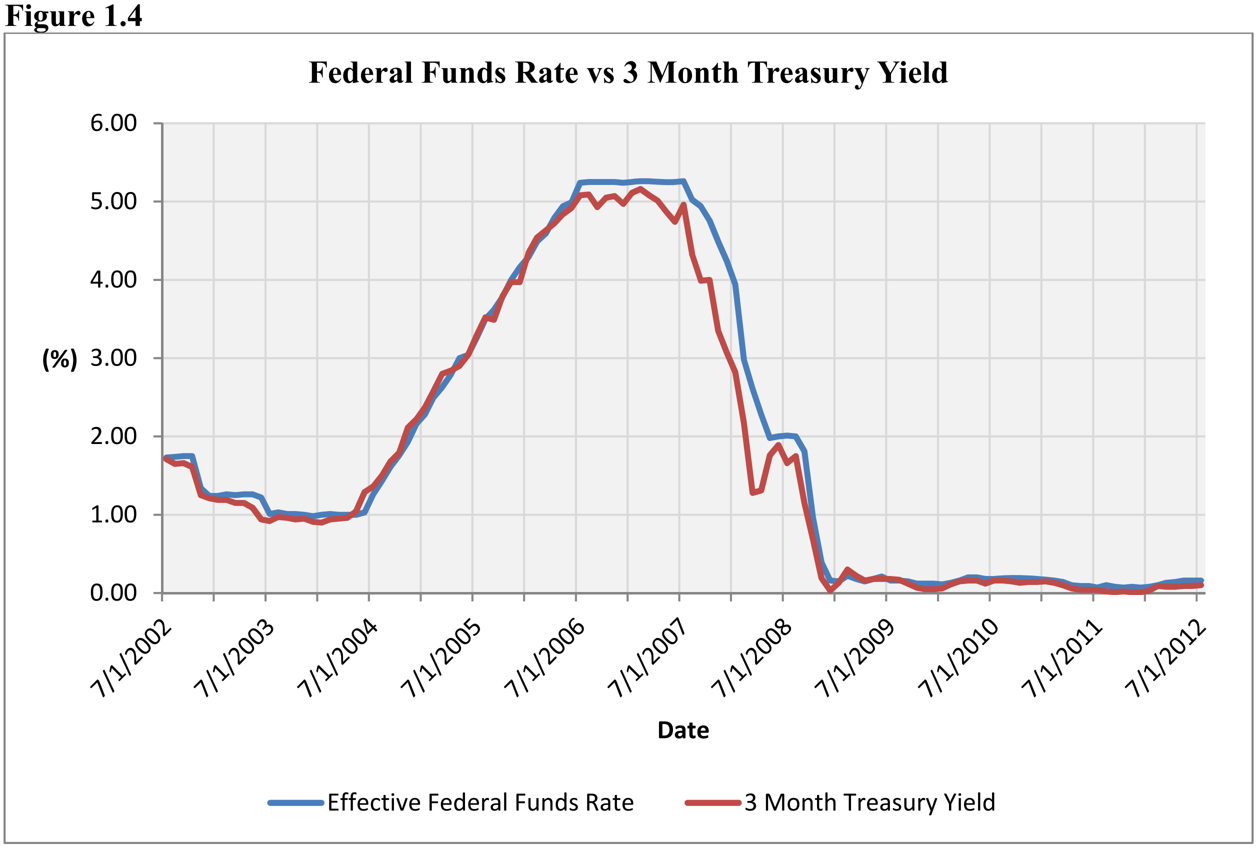

Figure 4.1

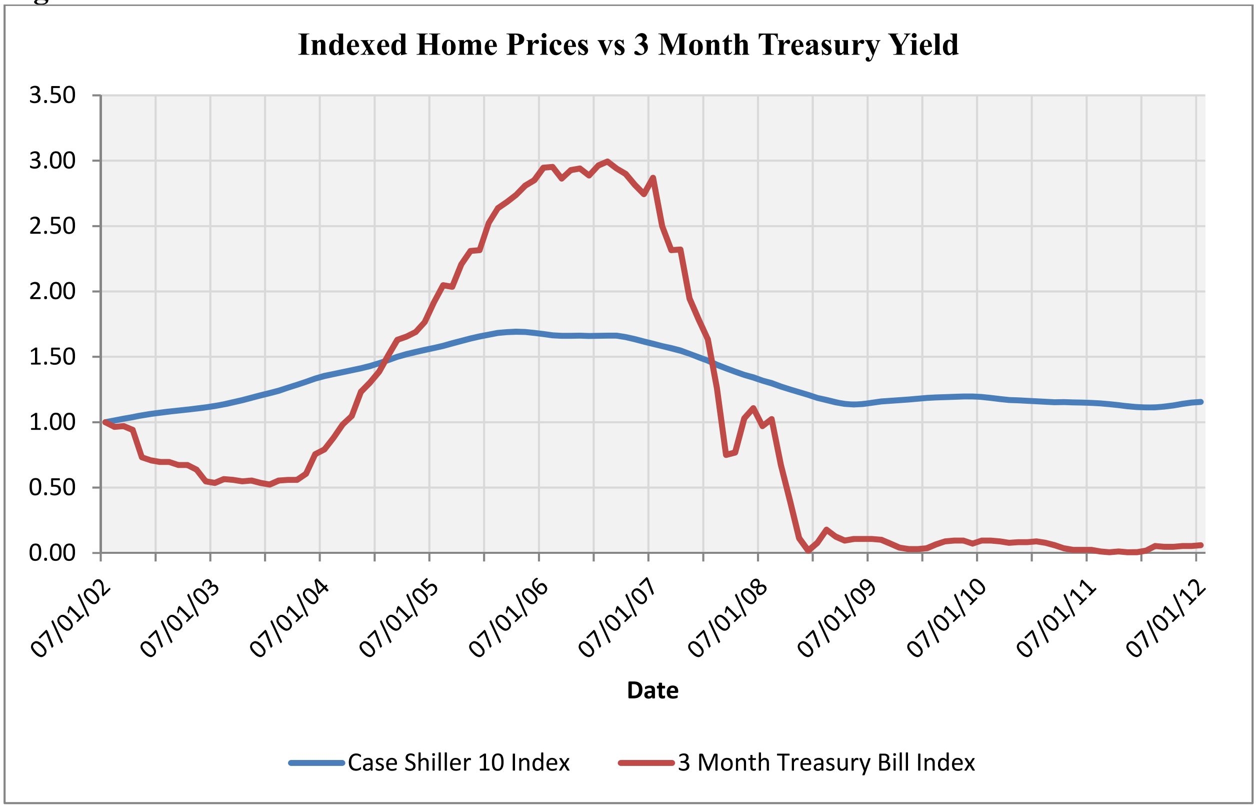

Figure 4.2

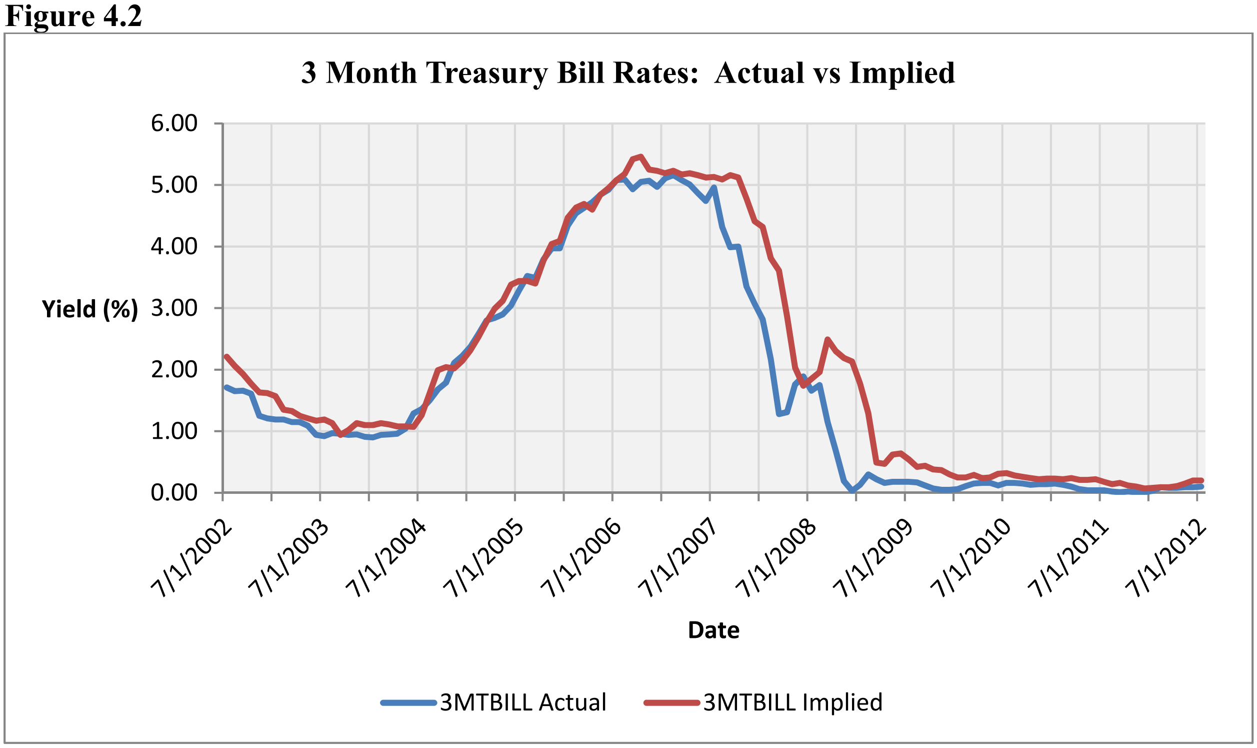

Figure 4.3

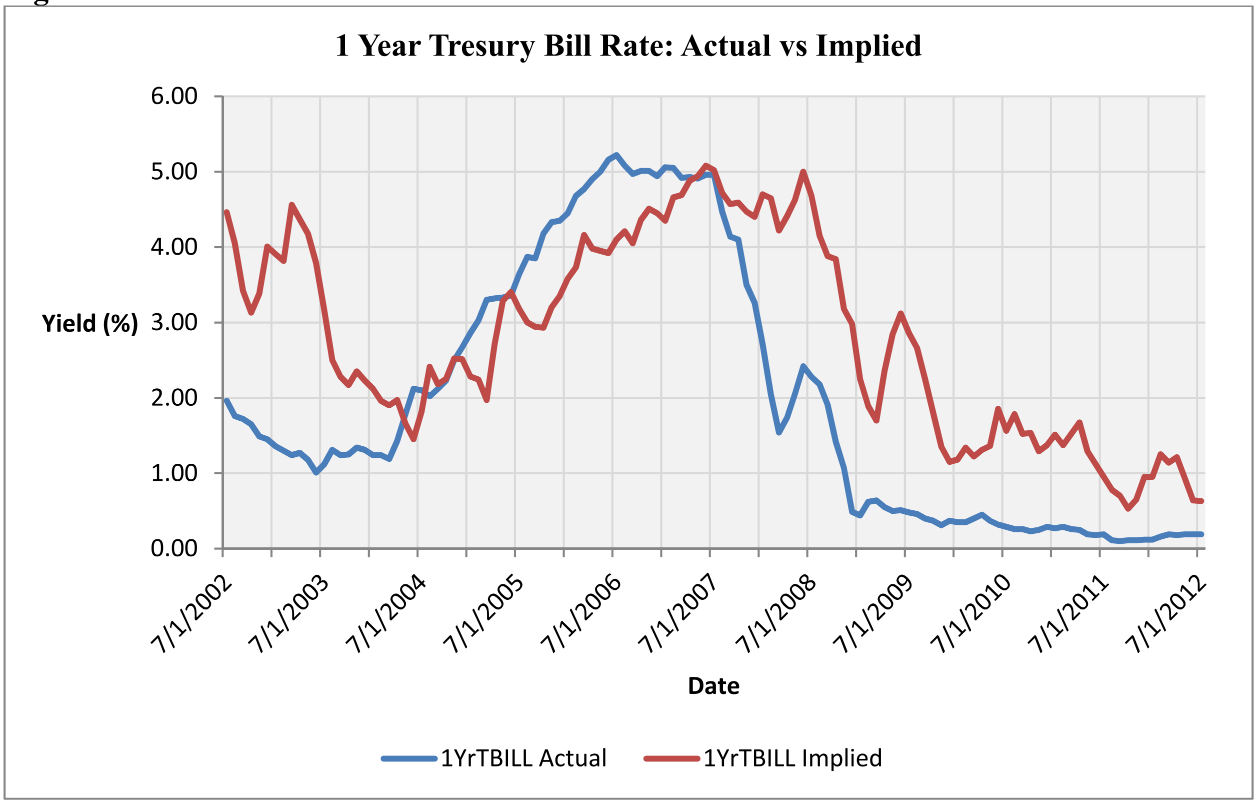

Figure 4.4

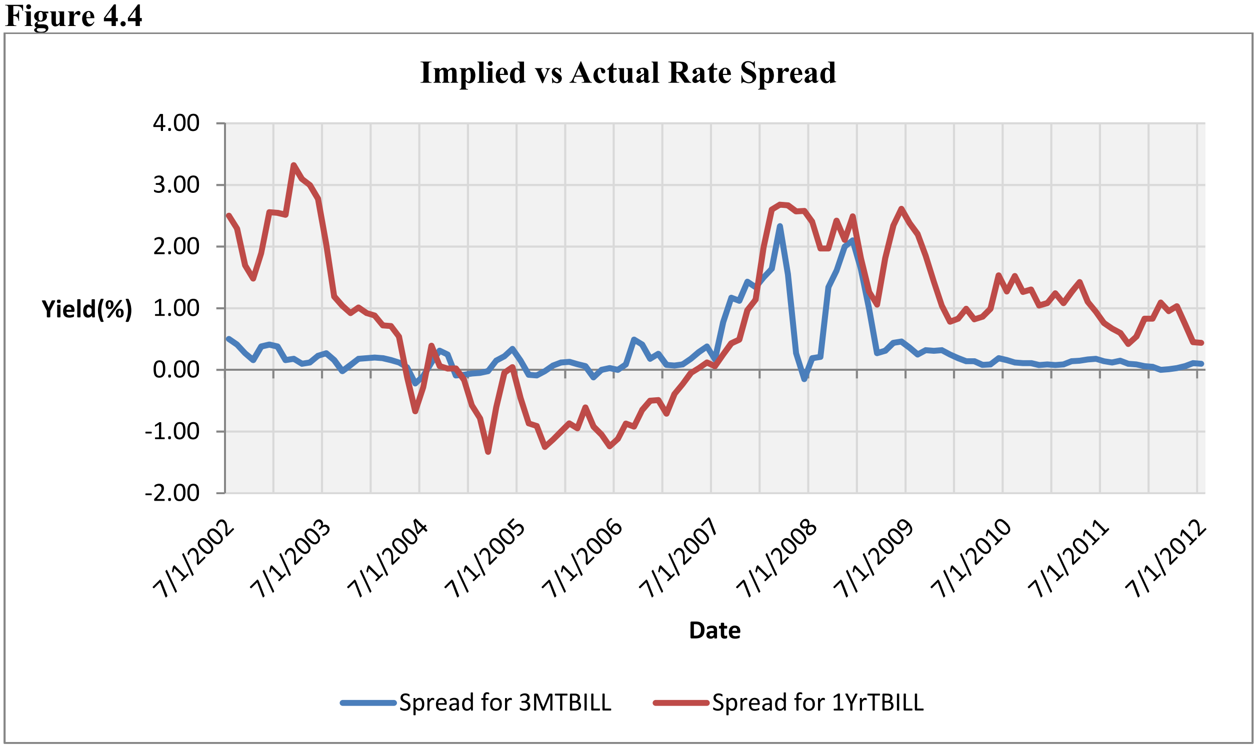

Table 2.1

-	Model 1	Model 2	Model 3
β_0	-50.4621	-0.1900	-0.7015
Pr > |t|	<0.0001	0.0045	0.0060
β_1	10.1111	0.9382	0.9531
Pr > |t|	<0.0001	<0.0001	<0.0001
Root MSE	0.7695	0.4775	1.1784
R-Square	0.8121	0.9276	0.5397

Table 2.2

-	3MTBillActual	lnSPCS10	3MTBillImplied	1YrTBillActual	1YrTBillImplied	2YrTBillActual
Mean	1.7350	5.1624	2.0521	1.9769	2.8112	2.2182
Standard Error	0.1607	0.0143	0.1650	0.1573	0.1212	0.1432
Median	1.1500	5.0854	1.5700	1.4200	2.7140	1.8600
Mode	0.1600	5.0412	0.0900	0.1900	1.5231	0.9300
Standard Deviation	1.7676	0.1575	1.8147	1.7298	1.3327	1.5750
Sample Variance	3.1246	0.0248	3.2933	2.9920	1.7761	2.4805
Kurtosis	-0.8401	-1.2958	-1.0466	-1.0287	-1.3470	-1.1352
Skewness	0.7806	0.4196	0.6356	0.6423	0.0524	0.4805
Range	5.1500	0.5259	5.3903	5.1200	4.5498	4.9100
Minimum	0.0100	4.8986	0.0700	0.1000	0.5302	0.2100
Maximum	5.1600	5.4245	5.4603	5.2200	5.0800	5.1200
Observations	121	121	121	121	121	121

References

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All data for supplemental figures was pulled from FRED of the St. Louis Fed for the term 07/01/02 – 07/02/12.