TWO THUMBS UP: AN EXCEL-BASED "MOVIE" TO TEACH TERM STRUCTURE DYNAMICS

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Comments are welcome.

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Abstract

For twenty years, the modern theory of the term structure of interest rates has been based on dynamic models of how interest rates and other relevant factors evolve randomly over time. Yet most undergraduate and M.B.A. textbooks say nothing about the term structure's dynamic features, because of the rigorous demands of continuous time mathematics. We offer a new approach; using Excel to construct a "movie" of the term structure. This movie dramatically illustrates the important dynamic features of the term structure, including:

1. short rates are more volatile than long rates,
2. occasional sharp reactions to government intervention,
3. volatility is correlated with the level, and
4. reversal in the slope of the yield curve is a noisy predictor of the business cycle.

We also make available the finished product to download at a Web address:

www.bus.indiana.edu/finweb/holden.htm

For twenty years, the modern theory of the term structure of interest rates has been based on dynamic models of how interest rates and other relevant factors evolve randomly over time.[1] Yet most undergraduate and M.B.A. textbooks that cover the term structure say nothing about its dynamic features. The only exception to this rule is a handful of specialized textbooks intended for advanced courses in fixed-income securities or derivative securities. The insurmountable obstacle to covering term structure dynamics has always been the rigorous demands of continuous time mathematics.

We offer a new approach. We explain simple techniques by which Microsoft Excel can be used to construct a "movie" of the term structure. This movie dramatically illustrates the important dynamic features of the term structure, including:

1. short rates are more volatile than long rates,
2. occasional sharp reactions to government intervention,
3. volatility is correlated with the level (i.e., volatility is lower when the level is lower), and
4. reversal in the slope of the yield curve is a noisy predictor of the business cycle.

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The raw material for this movie is a historical term structure database of monthly U.S. yield curves over the past 26 years. With a standard computer / projection setup, the instructor can show this movie in class. After seeing the visual history of the yield curve, students will immediately recognize the "stylized facts" about the term structure. In addition to the dynamic features mention above, the spreadsheet has a series of stand-alone graphs to illustrate each of the following static features:

1. different shapes, such as upward-sloping, downward-sloping, flat, and humped,

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[1] The term structure of interest rates is one of the most fundamental relationships in finance. It allows us to calculate the price of risk-free bonds of all maturities and all coupon rates. It is a key input to determining the price of all interest-sensitive derivatives. It is useful in forecasting expected stock returns, expected currency changes,

2. different levels over a wide range, and
3. curvature at the short end.

The plan of the article is as follows. Section 1 describes the historical term structure database. Section 2 describes the Excel spreadsheet in detail. Section 3 describes how the movie can be used to make a classroom presentation. Section 4 concludes. The appendix details the graph inputs and formulas.

I. The Historical Term Structure Database

The movie is based on an historical term structure database of U.S. risk-free, zero-coupon yield curves covering the period 1/70 to the present. For the subperiod from 1/70 to 12/91, the database is based on the Bliss (1992) monthly estimates of the yield curve.[2] Bliss fits a parsimonious, nonlinear function first introduced by Nelson and Siegel (1987) that is capable of matching all of the empirically observed shapes of the yield curve. Bliss extends the Nelson-Siegel method to bring together "several desirable characteristics: accounting for the bid / asked spreads, fitting the term structure directly to bond prices, and use of an asymptotically flat approximating function." Bliss adds the Fama and Bliss (1987) smoothing technique "to 'smooth out' the raw spot rates by fitting an approximating function through them." Further details are available in Bliss (1992). The result is a monthly, estimated function that can be used to calculate term structure yields for any maturity. Term structure yields are calculated for the following set of maturities: 1, 3, 6, 12, 24, 36, 60, 120, 240, and 360 months.[3]

For the subperiod from 1/92 to the present, the database is based on monthly *Wall Street Journal* listings under the section titled "Treasury Bonds, Notes, and Bills." Yields are taken from the U.S. Treasury Bill or Treasury Strip which has the closest maturity date to each maturity in the set above.

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expected economic growth, and so on. There is a vast literature on dynamic models of the term structure. A few of the seminal articles are: Vasicek (1977), Brennan and Schwartz (1979), and Cox, Ingersoll, and Ross (1985).

[2] Zero-coupon bonds for maturities greater than a year (i.e., U.S. Treasury Strips) did not exist for most of this subperiod. Hence, the zero-coupon yield curve can not be observed directly and must be estimated indirectly from coupon bonds.

[3] For this calculation, a standardized month of 30.438 days is used.

II. The Excel Spreadsheet

We will now describe the Excel spreadsheet in detail. There are four components to the spreadsheet: (A) historical term structure database, (B) static features database, (C) graph controls and output, and (D) graph inputs and formulas. The first three components are described in this section and the last component is described in the appendix

A. Historical Term Structure Database

Exhibit 1 shows part of the range which contains the historical term structure database. Column **A** lists the exact date of each monthly observation and Column **B** shows the same date in “Month-Year” format. Row **1** lists the set of maturities in months and Row **2** lists the same maturities in years. The range **C3:L3** contains term structure yields observed in January 1970 for maturities of 1 month to 360 months (30 years) – as calculated from Bliss’ estimated term structure function for January 1970. The database continues with the range **C4:L4** covering February 1970, the range **C5:L5** covering March 1970, and so on, down to range **C309:L309** covering July 1996. Thus, the historical term structure database covers more than 26 years worth of data. The entire range of the database from **A1:L309** is given a range name, **History**.

B. Static Features Database

Exhibit 2 shows the range which contains the static features database. Column **N** lists one of the three static features: shape, level, or curvature. For each feature, Column **O** lists the different types that are empirically observed. For example, shape may be upward, downward, flat, or hump. Rows **1** and **2** list the same set of maturities by month and by year, respectively, as in the historical database. The range **P3:Y3** contains term structure yields for November 1987, which is a good example of an upward-sloping yield curve. The range **P4:Y4** contains term structure yields for November 1980, which is a good example of a downward-sloping yield curve. Similarly, the rest of the static features database contains term structure yields for dates which have been chosen as good examples of that feature type. The entire range of the static features database from **N1:Y10** is given a range name, **Features**.

C. Graph Controls and Outputs

Our animation is a single graph within which a rapid sequence of monthly yield curves are displayed to create the illusion of dynamic term structure "movie." Just as any movie is a series of still frames, our animation is a series of monthly snapshots from the rows of the historical term structure database or the rows of the static features database. As we rapidly change the graph input from row to row, the graph output shifts from location to location and the animation comes to life.

The animation is run by two controls. The first control is a simple Check Box with the label "History." When the History Check Box IS checked, then a row from the historical term structure database is graphed. When the History Check Box is NOT checked, then a row from the static features database is graphed.

Exhibit 3 shows the Graph Controls and Outputs. 3A shows what the graph output looks like when the History Check Box IS checked (see blow-up of the History Check Box). The yield curve is a single curve drawn on an XY (scatter) graph. We plot yield on the y-axis and fix the scale from 0% to 16%. We plot time-to-maturity in years on the x-axis and fix the scale from 0 years to 30 years. These scales are sufficient to span all yields and all maturities in both databases. Cell **AO1** displays the date of the historical term structure, so we can see 3A is displaying the yield curve for August 1970.

3B shows what the graph output looks like when the History Check Box is NOT checked. Cells **AN1** and **AO1** show that this a graph of the static feature "Curvature" for a "Lot" of curvature. Indeed, we can see that the yield curve climbs steeply from 6% at one month maturity up to 11.5% at five years maturity and stays essentially flat out to thirty years maturity.

The second control is a combination up-arrow and down-arrow. Microsoft gives this control the somewhat odd name of a "Spinner." 3C shows a blow-up version of a Spinner. If you start from the graph in 3A and use the mouse to click on the up-arrow, then graph will display the yield curve for Sept-70. Another click will display Oct-70. Another click gives Nov-70. And so on. If you click on the down-arrow, it will step backward to Oct-70. Another click on the down-arrow step back to Sept-70. And so on. The instructor can move through the historical data at any desired pace by clicking slowly, rapidly, or holding down the mouse button to create a "movie" with calendar dates flying by like an H.G. Wells time machine. The instructor has complete control and can choose at any moment to speed-up, slow-down, stop, or reverse. On a 486 or better computer, the graph redraw is essentially instantaneous. Indeed on a Pentium 90, if you hold down the mouse button, the graph will run through all 26 years (307 months) in 30 seconds!

Where do these two controls come from? The two most recent versions of Microsoft Excel[4] include a toolbar for creating controls to make electronic forms. Unfortunately, Lotus 1-2-3 version 5 does *not* offer similar controls. To access this toolbar from Excel's main menu, click on "View" and then "Toolbars...". Then a dialog box will appear with check boxes for 14 different toolbars. Check the check box for the "Forms" toolbar and click on OK. A Forms toolbar will appear with many different kinds of controls. If you hover the mouse arrow over each of the icons on the toolbar, then a "tooltip" will appear which explains what each icon does. One of the icons is for a Check Box and another icon yields a Spinner. All you have to do to create a spinner is to click on the spinner icon and then highlight an area on the spreadsheet where you want to place the spinner button (the up-arrow and down-arrow combination).

The spinner works by controlling an index value in a cell on the spreadsheet. To specify the settings for the spinner, simply select the spinner button[5] and then double-click on it. A dialog box will appear. Click on the control tab and you will be able to set the minimum value of the index value, the

[4] Namely, version 5.0 for Windows 3.1 and version 7.0 for Windows 95.

[5] One way to select the spinner is to: (1) hover the mouse arrow over the spinner, (2) click on the *right* mouse button, (3) move the mouse arrow slightly, but still keep it over the spinner, and (4) click on the *left* mouse button.

maximum value, and the incremental change (when the spinner is clicked). Enter a cell location in the Cell Link entry line. For example, the spinner placed in cell **AP1** is linked to cell **AB6**. The value in cell **AB6** determines what **row** from the databases to display on the graph. When **AB6** is equal to **10** and the History Check Box IS checked, then the graph displays row **10** of the historical term structure database. When the spinner up-arrow is clicked, **AB6** increments to **11** and the graph displays row **11** of the historical term structure database. Further details on how the spinner, check box, and databases are connected to the graph input are described in the appendix.

III. Classroom Presentation

In this section, we will discuss how this spreadsheet-based animation can be used to make a classroom presentation. We assume that the instructor has already described the types of securities issued by the Treasury, explained yield-to-maturity calculations, and defined the yield curve. A typical classroom presentation would start by explaining to students what features to look for in the term structure. First we show them the static features and then list the dynamic features on the board or on a handout. This way they know what to look for. Then we switch to the historical term structures and show them the dynamic features. Alternatively, the instructor can begin the discussion by running through the historical movie, asking students to note any interesting patterns they observe in the process. We spice up the term structure movie by adding a running narrative about what historical events were influencing the term structure, such as changes in monetary regimes, changes in Fed chairmanship, changes in Presidential leadership, etc.

A. Static Features

Exhibit 4 shows how one particular static feature, shape, can be explained. With the History Check Box NOT checked, the graph displays rows from the Static Features Database. 4A, 4B, 4C, and 4D show good examples of yield curves that are upward-sloping, downward-sloping, flat, and hump-shaped, respectively. Clicking on the spinner up-arrow moves forward from 4A to 4B to 4C to 4D and then moves to the rest of the rows in the features database. Clicking on the spinner down-arrow moves backwards. The instructor would state that the term structure can take on a variety of shapes: “upward, (click) downward, (click) flat, (click) hump.” Next the static features of level and curvature would be explained in a similar manner.

B. Dynamic Feature #1: Short rates are more volatile than long rates

Exhibit 5 shows that yields on short-term bonds are more volatile than yields on long-term bonds. For example, 5A through 5D show an eighteen month period from October 1987 to April 1989. During this period, the yields on 10 year, 20 year, and 30 year bonds are nearly constant around 9%. During the same period, the yields on one month bonds fluctuation from 4.5% to 8.5%. As a visual analogy, we describe the short-end of the term structure as the “tail” and the long-end as the “body” and the tail wags far more than body.

A thought-provoking question about this feature to pose to the class is: if short rates are more volatile than long rates, does this mean that short-term bonds have greater interest rate risk than long-term bonds? Of course, the answer is no. A small change at the long-end will have a much greater impact on price than a larger change at the short-end.

Another thought-provoking question is: why are short rates more volatile than long rates? A common explanation for the curvature at the short-end of the term structure is cash management by corporations. Corporations use short-maturity bonds to designate funds for near-term liabilities and to make the payments. Greater demand for short-term bonds pushes their price up and their yield down. Random fluctuations in the demand for cash management is a likely explanation for more volatile short-term yields.

C. Dynamic Feature #2: Big jumps due to Carter’s credit controls

Exhibit 6 shows the dynamic impact that President Carter's sudden imposition of credit controls and subsequent relaxation of credit controls had on the term structure. Specifically, on March 14, 1980, President Carter authorized the Federal Reserve to impose credit restraint measures under the Credit Control Act. The measures were designed to reign in the growth of credit, particularly consumer credit, as an inflation-fighting device. Among other actions, the Fed imposed a 15%, non-interest bearing reserve requirement on lenders who allowed certain types of credit accounts to grow beyond target ranges. Less than three weeks later, the Fed eased these restrictions amidst signs that the economy was slipping into recession.

The spreadsheet clearly illustrates this turbulent period in credit markets. The largest single month-to-month change in the yield curve in our sample took place between March and April of 1980. It was during March that the prime rate topped 20% for the first time in history, rising several percentage points in a matter of weeks. Other short-term rates rose quickly during March as well. The credit controls precipitated a huge, short-term drop in the quantity of credit and a corresponding decline in industrial production, retail sales and other indicators. The effects of the controls on output were so stark that the controls were lifted soon after they were imposed. As the Fed backed off, short-term interest rates fell sharply. This event, by now unfamiliar to most undergraduate students, provides a dramatic illustration of the potential consequences of government intervention in financial markets.

D. Dynamic Feature #3: Low levels are less volatile than high levels

Exhibit 7 shows that low levels of the yield curve generate less volatility in yields (at all maturities) than high levels of the yield curve. As a rough generalization, the yield curve level was low in the 70's and 90's and high in the 80's. Exhibit 7 uses as an example the year 1972 when the level was low. 7A, 7B, 7C, and 7D show March, June, September, and December of 1972, respectively. It is readily apparent 1972 was a boring year – that is, a low volatility year. The short-end of the yield curve stayed in a narrow range from 3% to 5% and the long-end stayed in a very narrow range from 6.3% to 6.5%. By contrast, Exhibit 6 covers the first four months of 1980 when the level was high. It shows the short-end of the yield curve moving up 3.5% and then down 5% and the long-end moving up 1% in the span of only four months. Admittedly, the first four months of 1980 are an extreme example. This is one of the most volatile periods in the entire 26-year history. However, it is very obvious even to the casual observer of the term structure animation, that high volatility is associated with high levels and low volatility is associated with low levels.[6] The animation easily conveys a dynamic feature that is hard to convey on a static blackboard (or even a static journal article).

E. Dynamic Feature #4: Downward slope is a noisy predictor of a recession

One of the most important innovations in our understanding of asset pricing over the last decade is the idea that there is long-run "predictability" in the expected returns of both stocks and bonds. Fama and French (1989) document that the slope of the yield curve does a good job of forecasting the business cycle, as measured by National Bureau of Economic Research dates for business cycle peaks and troughs. Specifically, a negative slope forecasts a recession and a steep positive slope forecasts an expansion.

Exhibit 8 shows the yield curve on the first date during a boom period that a significant portion of the yield slopes downward. In these cases, the yield curve is typically hump-shaped and the downward-sloped portion spans a range of maturities on the short-end. In all four cases, a recession began 6 to 15 months later.[7] Remarkably, there where no false signals of a coming recession (type I errors) and no recessions that failed to be forecasted in advance (type II errors). Interestingly, a recent yield curve (July 95) is slightly downward-sloped. This forecasts a recession sometime during in 1996.

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[6] Chan, Karolyi, Longstaff, and Sanders (1992) empirically estimate a stochastic process for the short-end of the yield curve that allows volatility to be a function of level. Their data covers the period from June 1964 to December 1989. They find that the dependence of volatility on level is highly significant and is much larger in magnitude than is suggested by the Cox, Ingersoll, Ross (1985) model.

[7] The four dates shown where the yield curve is downward-sloped are May 73, Oct 78, Oct 80, and July 89. The official NBER dates for business cycle peaks (starting dates of a recession) are Nov 73, Jan 80, July 81, and July 90. See the Web address **gopher://128.103.119.20/00/.cycles.txt**

F. Other Dynamic Features

During the classroom presentation, it is often useful to highlight some of the major economic and political events that were happening concurrently with the yield curve being shown. This helps provide some context for what time-period is being discussed at a particular moment in time. Exhibit 9 provides a chronology of major economic and political events over the past 26 years. The instructor may wish to highlight 5-10 of them during the animation.

There are a variety of additional features of the term structure illustrated by the movie that may warrant discussion, depending on the course level and background of the students. For instance, if students are familiar with the historical inflation record from 1970 to the present (generally rising during the early 1980s and falling thereafter), they will see that the level of the term structure closely follows this pattern. This naturally leads to a discussion of inflation as one of the fundamental forces driving the level of nominal interest rates over time.

IV. Conclusion

We have used the Check Box and Spinner controls from the Forms toolbar to construct a simple spreadsheet-based animation that can be used to teach dynamic features of the term structure. This is a big advantage because these dynamic features are very hard to teach by other means. But there is no reason to limit use of spreadsheet-based animation to the term structure. Many dynamic features of stock, derivatives, exchange rates, etc. could be advantageously demonstrated with a spreadsheet-based animation. Further, the Forms toolbar offers many additional controls, such as Option Button, List Box, Edit Box, Group Box, Drop-down Box, etc., which can be used to drive a wide variety of spreadsheet-based classroom presentations.

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Appendix

Exhibit 10 details the graph inputs and formulas, which are the heart of the novel programming in this spreadsheet. 10A shows graph input when the toggle switch **Hist** has a value of **FALSE**. When **Hist** is **FALSE**, the graph output is static features, and when **Hist** is **TRUE**, the graph output is historical term structures. Looking at the 10A spreadsheet, we see that the cell **AD6** has a range name **Hist** and the current value is **FALSE**. Thus, the corresponding graph output in 3A is a static feature. Specifically, 3A show a graph of the yield curve which has a *lot* of *curvature* at short maturities.

Returning to 10A, we see that the cell **AB6** has a range name **Row** and the current value is **10**. This is an instruction to look in Row 10 of the **History** database to get the graph input. Cells **AA3** and **AB3** display 8/31/70 and Aug-70 from Row 10 of the **History** database. Simultaneously, **Row** equals **10** means look in Row 10 of the **Features** database. Cells **AA4** and **AB4** display "Curvature =" and "Lot" from Row 10 of the **Features** database. Rows **1** and **2** list the same set of maturities by month and by year, respectively, as in the historical database and static features database. The range **AC3:AL3** contains the value **-10.00%** which will not show up on the graph. Because **Hist** is **FALSE**, we are *not* interested in the historical data and an arbitrary negative value removes this data series from the graph. The range **AC4:AL4** contains the term structure yields for a good example of a *lot* of *curvature* at short maturities. Because **Hist** is **FALSE**, we *are* interested in the static features and this data series is displayed on the graph.

10C shows the simple formulas which generate the graph input. The basic idea is to use the horizontal lookup function **=HLOOKUP( )**. There are three arguments that go into a horizontal lookup function: (1) column heading, (2) database name, and (3) what row. For example, the three arguments in the **=HLOOKUP( )** formula in cell **AB3** are: (1) **AB1** which contains the column heading ("**Column 2**"), (2) **History** which is the range name of the database to look in, and (3) **Row** which is the range name for what row to look in ("**10**"). When we look under the column heading "**Column 2**" in **Row 10** of the **History** database, we find a cell with a value of "Aug-70" and that also appears in cell **AB3**. The **=HLOOKUP( )** formula in cell **AB4** works the same way, except it looks in the **Features** database. The formula in cell **AC3** is similar, but now we add an "IF" function **=IF( )**. The first argument of the IF function **=IF( )** as whether **Hist** is equal to **TRUE**. If this is so, then the value returned by the horizontal lookup function **=HLOOKUP( )** as before which will show up on the graph. If not, then we get the value **-**

10.00% which will not show up on the graph. The formula in cell **AC4** works the same way, except that it tests whether **Hist** is equal to **FALSE**.

The result of the IF function **=IF( )** can easily be seen by comparing 10A to 10B. In 10A when the History Check Box is NOT checked and **Hist** is equal to **FALSE**, then the history range **AC3:AL3** has values of **-10.00%** and the static feature range **AC4:AL4** has yields for a good example of a *lot* of *curvature* at short maturities. In 10B when the History Check Box IS checked and **Hist** is equal to **TRUE**, then the history range **AC3:AL3** has yields for Aug-70 and the static feature range **AC4:AL4** has values of **-10.00%**. This provides a simple way to toggle the graph back and forth between static features and historical term structures.

Exhibit 1. Historical Term Structure Data

Time to Maturity (Months in Row 1 and Years in Row 2)

	A	B	C	D	E	F	G	H	I	J	K	L
1	Column 1	Column 2	1	3	6	12	24	36	60	120	240	360
2	Date	Mon-Yr	0.083333	0.25	0.5	1	2	3	5	10	20	30
3	1/30/70	Jan-70	7.72%	8.00%	8.03%	7.98%	7.95%	7.94%	7.94%	7.93%	7.93%	7.93%
4	2/27/70	Feb-70	6.22%	6.99%	6.97%	6.96%	7.02%	7.04%	7.07%	7.08%	7.09%	7.09%
5	3/31/70	Mar-70	6.33%	6.44%	6.53%	6.67%	6.85%	6.95%	7.04%	7.11%	7.14%	7.15%
6	4/30/70	Apr-70	6.47%	7.03%	7.35%	7.50%	7.60%	7.67%	7.75%	7.81%	7.84%	7.85%
7	5/29/70	May-70	6.21%	7.03%	7.28%	7.45%	7.58%	7.63%	7.66%	7.69%	7.70%	7.71%
8	6/30/70	Jun-70	6.14%	6.47%	6.81%	7.17%	7.43%	7.53%	7.60%	7.66%	7.69%	7.70%
9	7/31/70	Jul-70	6.32%	6.38%	6.55%	6.87%	7.19%	7.32%	7.42%	7.49%	7.53%	7.54%
10	8/31/70	Aug-70	6.21%	6.38%	6.57%	6.83%	7.08%	7.18%	7.31%	7.53%	7.74%	7.83%
11	9/30/70	Sep-70	5.32%	6.03%	6.49%	6.63%	6.64%	6.77%	7.05%	7.42%	7.65%	7.73%
12	10/30/70	Oct-70	5.22%	5.91%	6.23%	6.33%	6.50%	6.69%	6.94%	7.17%	7.29%	7.33%
13	11/30/70	Nov-70	4.86%	5.05%	5.11%	5.10%	5.29%	5.59%	6.05%	6.49%	6.72%	6.80%
14	12/31/70	Dec-70	4.62%	4.91%	4.95%	5.03%	5.40%	5.69%	5.99%	6.22%	6.34%	6.38%

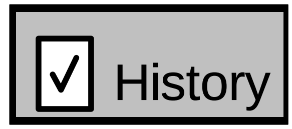
Exhibit 2. Static Features Term Structure Data

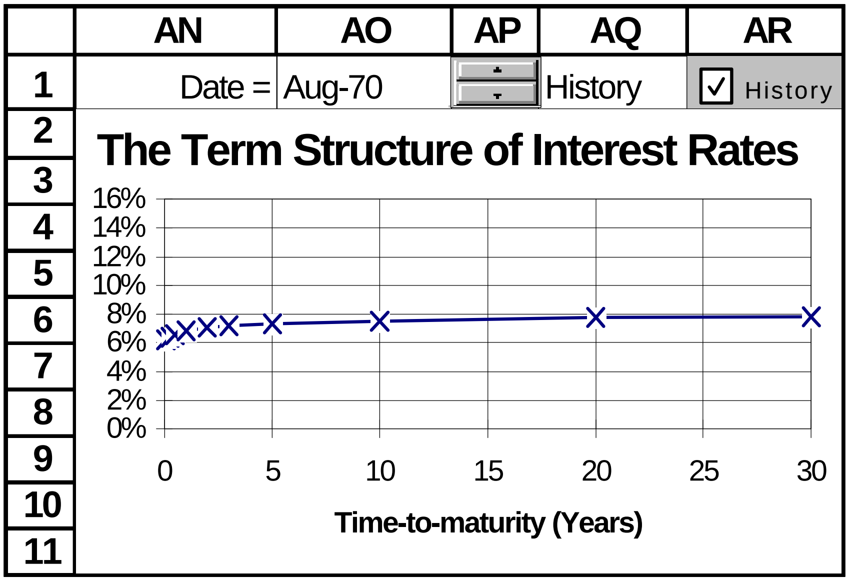
Time to Maturity (Months in Row 1 and Years in Row 2)

	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Column 1	Column 2	1	3	6	12	24	36	60	120	240	360
2	Feature	Type	0.083333	0.25	0.5	1	2	3	5	10	20	30
3	Shape =	Upward	3.63%	5.36%	6.43%	7.09%	7.64%	8.04%	8.54%	8.99%	9.22%	9.29%
4	Shape =	Downward	14.83%	14.60%	14.65%	14.17%	13.22%	12.75%	12.36%	12.07%	11.92%	11.87%
5	Shape =	Flat	8.21%	8.13%	8.07%	8.01%	7.98%	7.97%	7.97%	7.96%	7.96%	7.96%
6	Shape =	Hump	8.82%	9.48%	9.99%	10.18%	9.76%	9.40%	9.04%	8.77%	8.63%	8.59%
7	Level =	Low	4.04%	4.20%	4.23%	4.26%	4.68%	5.18%	5.83%	6.41%	6.70%	6.79%
8	Level =	High	14.83%	14.60%	14.65%	14.17%	13.22%	12.75%	12.36%	12.07%	11.92%	11.87%
9	Curvature =	Little	4.93%	5.24%	5.44%	5.62%	5.86%	6.01%	6.15%	6.26%	6.31%	6.33%
10	Curvature =	Lot	6.66%	7.86%	9.05%	10.29%	11.16%	11.43%	11.55%	11.50%	11.44%	11.42%

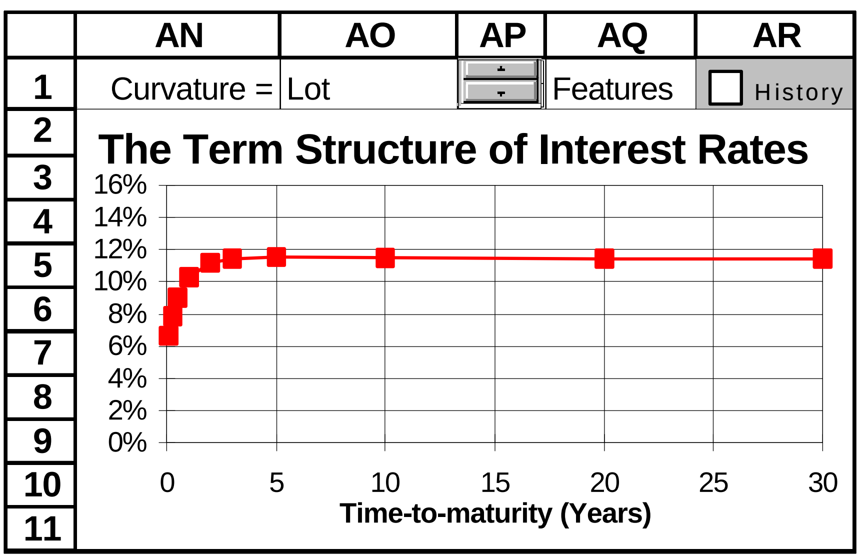
Exhibit 3. Graph Controls and Outputs

3A. Graph Output when the History Check Box IS checked





3B. Graph Output when the History Check Box is NOT checked



3C. Blow-up of a "Spinner"

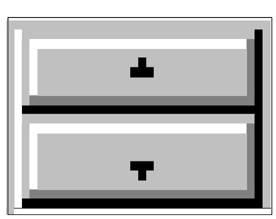
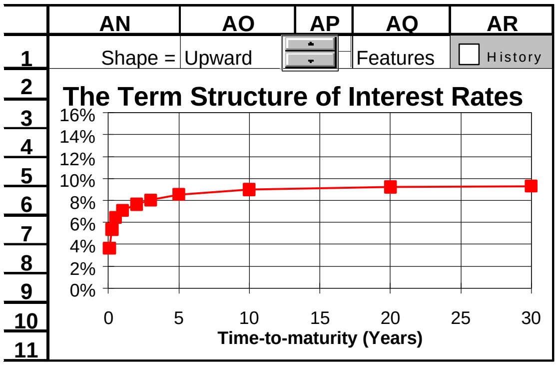
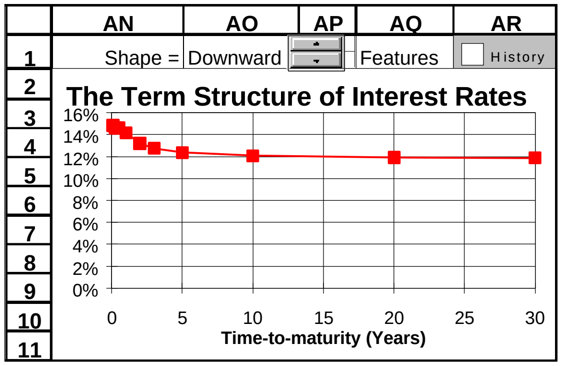


Exhibit 4. Static Features of the Term Structure

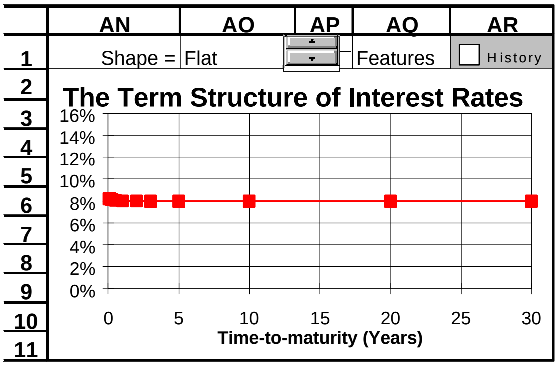
4A.



4B.



4C.



4D.

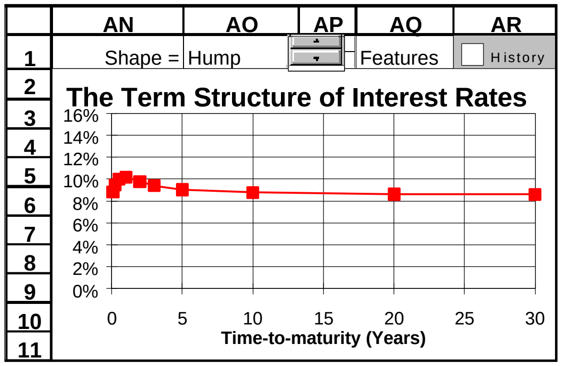
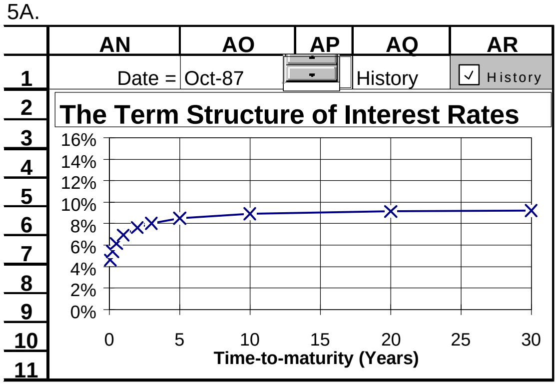
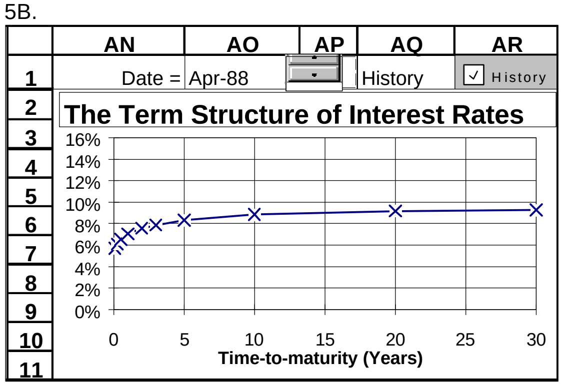


Exhibit 5. Dynamic feature #1: Short rates are more volatile than long rates

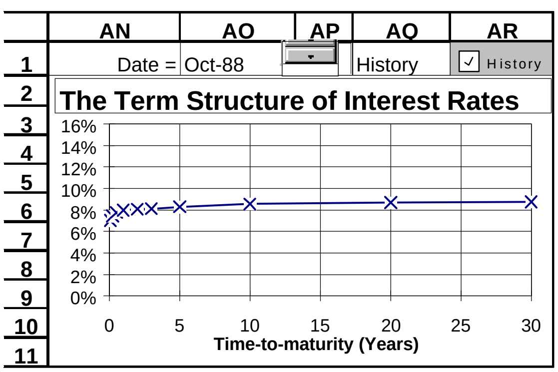
5A.



5B.



5C.



5D.

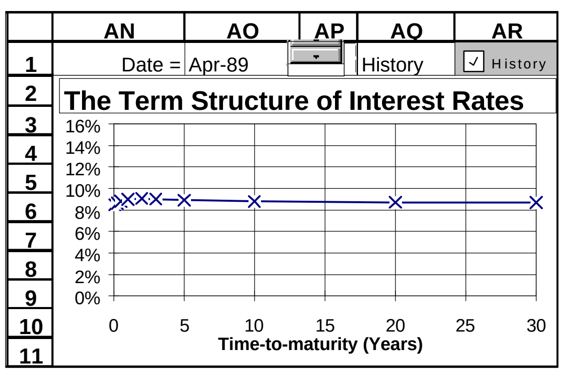
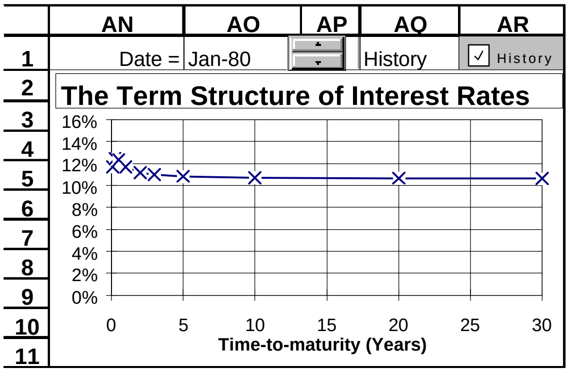
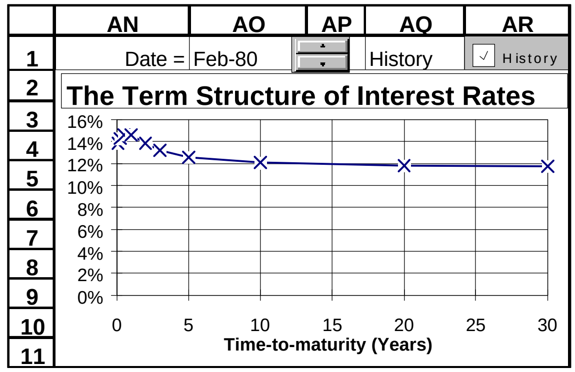


Exhibit 6. Dynamic feature #2: Big jumps when President Carter imposed and removed credit controls

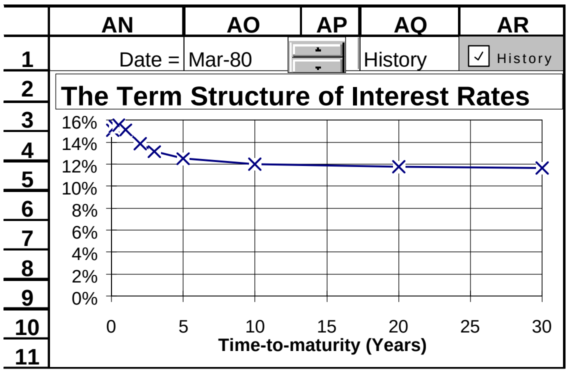
6A.



6B.



6C.



6D.

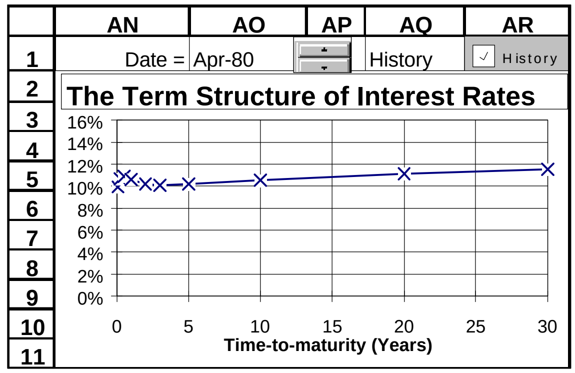
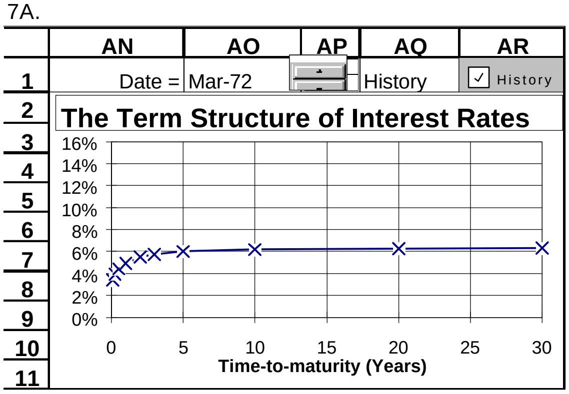
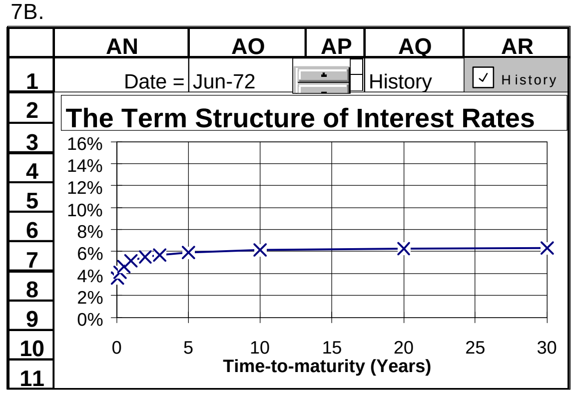


Exhibit 7. Dynamic feature #3: Low levels are less volatile than high levels -- boring 1972

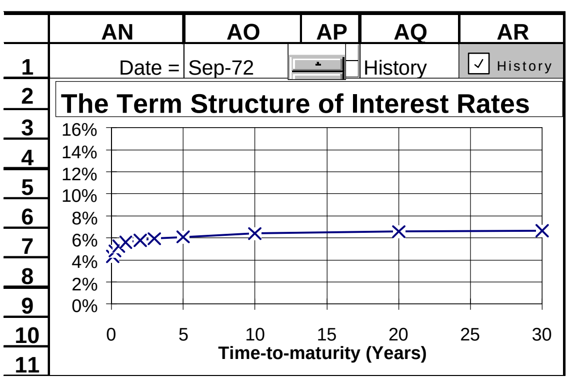
7A.



7B.



7C.



7D.

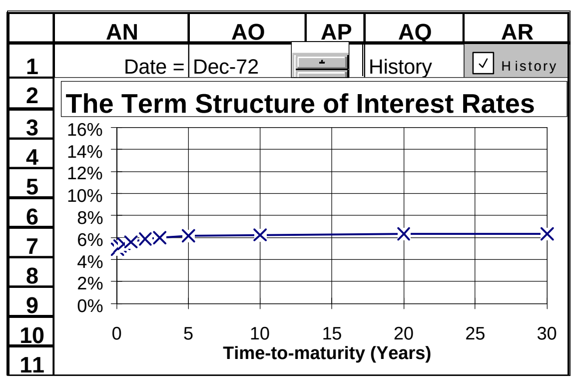
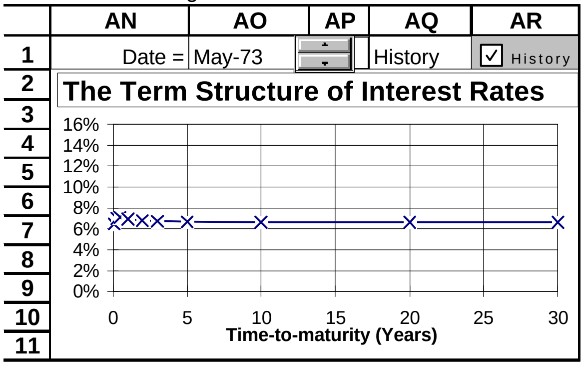
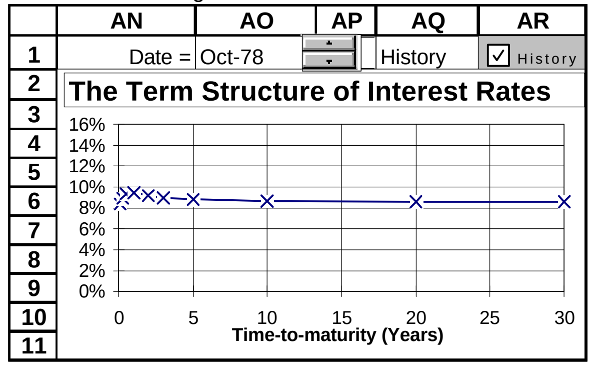


Exhibit 8. Dynamic feature #4: Downward slope is a noisy predictor of a recession

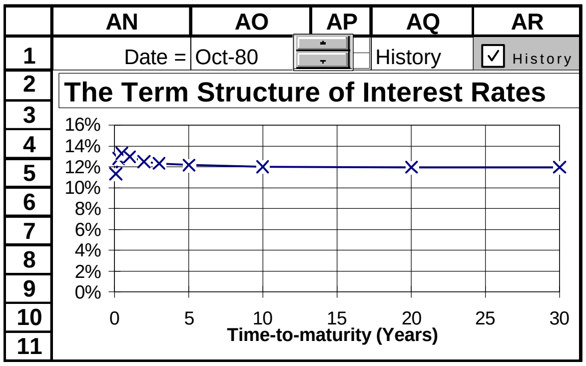
8A. Recession begins 6 months later.



8B. Recession begins 15 months later.



8C. Recession begins 9 months later.



8D. Recession begins 12 months later.

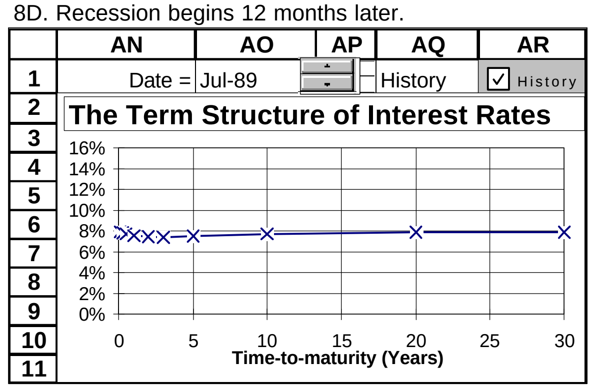


Exhibit 9. Chronology of Major Economic and Political Events

Date	Event
January 1973	Nixon's second term begins.
November 1973	Business cycle peak. Recession begins.
April 1974	First oil crisis. Oil prices rise 61% in 4 months.
August 1974	Richard Nixon resigns and Ford presidency begins.
March 1975	Business cycle trough.
January 1977	Carter presidency begins.
October 1979	Volcker appointed Fed Chairman. Announces shift in policy from interest-rate targeting to money supply targeting.
December 1979	Second oil crisis. Oil prices up 87% from December 1978.
January 1980	Business cycle peak. Recession begins. Reagan takes office.
March 1980	Carter Administration imposes credit controls.
April 1980	Credit controls relaxed.
July 1980	Business cycle trough.
April 1981	Oil prices peak at $36.49/barrel.
July 1981	Business cycle peak. Recession begins.
June 1982	Fed shifts policy away from narrow money supply targeting.
November 1982	Business cycle trough.
January 1984	Reagan's second term begins.
August 1987	Greenspan replaces Volcker as Fed Chairman
October 1987	Stock market crashes.
January 1989	Bush inaugurated.
July 1990	Business cycle peak. Recession begins.
August 1990	Iraq invades Kuwait.
March 1991	Business cycle trough.
January 1993	Clinton presidency begins.

Exhibit 10. Graph Input Values and Formulas

10A. Graph Input Values when the History Check Box is NOT Checked

Time to Maturity (Months in Row 1 and Years in Row 2)

	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	Column 1	Column 2	1	3	6	12	24	36	60	120	240	360
2			0.083333	0.25	0.5	1	2	3	5	10	20	30
3	8/31/70	Aug-70	-10.000%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%
4	Curvature =	Lot	6.661%	7.86%	9.05%	10.29%	11.16%	11.43%	11.55%	11.50%	11.44%	11.42%
5												
6	Row =	10	Hist =	FALSE								

10B. Graph Input Values when the History Check Box IS Checked

Time to Maturity (Months in Row 1 and Years in Row 2)

	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	Column 1	Column 2	1	3	6	12	24	36	60	120	240	360
2			0.083333	0.25	0.5	1	2	3	5	10	20	30
3	8/31/70	Aug-70	6.214%	6.38%	6.57%	6.83%	7.08%	7.18%	7.31%	7.53%	7.74%	7.83%
4	Curvature =	Lot	-10.000%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%	-10.00%
5												
6	Row =	10	Hist =	TRUE								

10C. Formulas for Graph Input

	AB	AC	AD
1	Column 2	1	3
2		=AC1/12	=AD1/12
3	=HLOOKUP(AB1,History,Row)	=IF(Hist=TRUE,HLOOKUP(AC1,History,Row),-0.1)	=IF(Hist=TRUE,HLOOKUP(AD1,History,Row),-0.1)
4	=HLOOKUP(AB1,Features,Row)	=IF(Hist=FALSE,HLOOKUP(AC1,Features,Row),-0.1)	=IF(Hist=FALSE,HLOOKUP(AD1,Features,Row),-0.1)
5			
6	10	Hist =	TRUE