Does the choice of interest rate data matter for the results of tests of the expectations hypothesis - some results for the UK

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Abstract

Using UK data for the period 1997:3 to 2005:5, this paper examines whether the expectations hypothesis is supported by recent UK data when the short-end of the term structure of interest rates is considered and whether the results of the tests of the expectations hypothesis are sensitive to the choice of data. The main results can be nicely summarized by considering five virtual researchers who test the expectations hypothesis using five different data sets for the 1997:3 to 2005:5 period for the 1 to 12-month maturity spectrum and who get quite different results.

The main conclusion to be drawn from the analysis in this paper is thus that robustness check may be very important when testing the expectations hypothesis using the 1 to 12-month maturity spectrum of the term structure. Furthermore, the results suggest that the specific data set used in tests of the expectations hypothesis may be a candidate explanation of a rejection of the expectations hypothesis – along with the possibility that a time-varying term premium and/or a structural break are responsible for the rejection.

1 Introduction

The expectations hypothesis which states that long interest rates are determined as an average of current and expected short rates is probably the most known theory of the term structure of interest rates. However, when testing the expectations hypothesis and other theories involving interest rates, researchers

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are faced with the problem of which interest rate data to use. The purpose of this paper is to examine the expectations hypothesis using recent UK data and to examine whether the main conclusions are sensitive to the choice of interest rate data used.

From a theoretical point of view, the correct interest rates to use are zero-coupon interest rates. In practice, however, such zero-coupon interest rates are only observable for very few maturities and often only for very short maturities. Researchers are therefore forced to either estimate zero-coupon interest rates or to rely on some kind of approximations to zero-coupon interest rates. When it is decided to use estimated zero-coupon interest rates the problem arises of how to estimate these interest rates.[1] In the current paper, this matter is, however, not addressed. When using UK data a natural choice of estimated zero-coupon interest rates is the data set supplied by the Bank of England.[2] This data set contains daily observations of estimated zero-coupon interest rates from 2nd of January 1979 to the present. One problem with this data set, however, is that estimated zero-coupon interest rates for maturities between 1 and 12 months are not generally available before 3rd of March 1997. When examining the short-end of the UK term structure of interest rates, it is therefore necessary only to focus on the period from March 1997 to the present or to splice short term interest rates into the Bank of England data set.[3] One choice of interest rates to splice into the Bank of England data set are UK Treasury Bill rates which are available on a daily basis for the 1 and 3-month maturities from 2nd of January 1975 and to the present from e.g. Datastream.[4] One practical problem using the Bank of England data set with or without Treasury Bill rate data is that these data are available on a daily frequency whereas empirical tests of many theories involving the term structure of interest rates "require" the use of monthly data. One is therefore forced to decide which daily observation should represent the monthly observation.

Two natural questions when using UK data are therefore: 1) Does the choice of daily observation to represent the monthly observation matter for tests of theories involving the term structure of interest rates? And, 2) Does the use of spliced Treasury Bill rates and zero-coupon interest rates from the Bank of England matter for tests of theories involving the term structure of interest rates?

This paper addresses these two questions by examining the expectations hypothesis on the short-end of the term structure of interest rates over the period March 1997 to May 2005 where both Bank of England interest rates and

[1] I.e. which method to use and which prices on zero-coupon and coupon bonds to use in the estimation of zero-coupon interest rates. See e.g. Anderson, Breedon, Deacon, Derry & Murphy (1996) and Bliss (1997) for a discussion and survey of different estimation methods.

[2] See Bank of England (2002) for a presentation of this data set and Anderson & Sleath (2001) for a discussion of the estimation method used in constructing the data set.

[3] A third possibility is of course to use the observed prices on zero-coupon and coupon bonds to estimate the whole term structure of interest rates. Anderson & Sleath (2001) discuss why this is not done by the Bank of England before 3rd of March 1997.

[4] See e.g. Cuthbertson & Nitzsche (2003) for a recent example of a study using Bank of England zero-coupon interest rates spliced with Treasury Bill rates.

Treasury Bill rates are available.[5] The paper demonstrates that even though the 1-month Bank of England and Treasury Bill rate and the 3-month Bank of England and Treasury Bill rate appear to be quite similar based on a graphical inspection and based on descriptive statistics, both the choice of daily observation to represent the monthly observation as well as the choice between using the data set provided by the Bank of England and using the spliced Treasury Bill rates and zero-coupon interest rates from the Bank of England (henceforth referred to as the mixed data set) matter for tests of the expectations hypothesis. Twelve different data sets are used in the empirical analysis. Using some data sets the expectations hypothesis is strongly supported for maturities up until 12 months whereas for other data sets the support for the expectations hypothesis for these maturities is very weak. In general, the expectations hypothesis is rejected for maturities above 12 months.

The main conclusion in this paper is thus that when testing the expectations hypothesis, it may be very important to test the robustness of the results using a different data set. Unfortunately, this may in practice often prove to be almost impossible. In addition, the results indicate that the specific data set used in tests of the expectations hypothesis may be a candidate explanation of a rejection of the expectations theory – along with the possibility that a time-varying term premium and/or a structural break is responsible for the rejection.

It is important to point out some limitations in the current paper which are all due to the availability of the data used: 1) The focus is only on tests of the expectations hypothesis using interest rate spreads where the long rate is equal to or below 24 months. And: 2) The analysis only focuses on the 1997:3 to 2005:5 period.

The conclusions in this paper suggest several interesting areas for further/future research:

- Does the choice of estimation method of zero-coupon interest rates matter for tests of the expectations hypothesis?
- Does the results in this paper also hold for other countries?[6]
- Does the results in this paper also hold for other theories involving interest rates – e.g. the Fisher equation or affine term structure models?

The paper is organized as follows. In section 2 the expectations hypothesis is presented and different econometric tests of the expectations hypothesis are discussed. Section 3 presents the data used and section 4 presents the empirical results. Section 5 concludes. Finally, the appendix contains detailed results.

[5] This choice of sample is thus dictated by the data. If one was only interested in testing the expectations hypothesis for this period, it would, of course, be natural to focus only on the Bank of England rates. The expectations hypothesis, however, ought to hold also if Treasury Bill rates were used instead of some of the Bank of England rates. As mentioned in the text, it is necessary to use the mixed Bank of England and Treasury Bill rate data set if one wants to test the expectations hypothesis on a longer sample.

[6] Using the Bliss (1997) US term structure data I am currently examining these first two points. The preliminary title of this work is: "The expectations hypothesis - does the choice of zero-coupon interest rate estimation method matter for the general conclusions?".

2 The expectations hypothesis

Denoting the continuously compounded 1-period holding return on an n-period zero-coupon bond as $r_{n,t+1}$, the log-local expectations hypothesis states that:

$$E_t\left[r_{n,t+1}\right] = y_{1,t} + tp_n \tag{1}$$

i.e. the expected 1-period holding return on an n-period zero-coupon bond equals the 1-period zero-coupon interest rate, $y_{1,t}$, plus a constant term premium, tp_n. Assuming rational expectations, it is easy to show that the log-local expectations hypothesis implies that:

$$y_{n,t} = \frac{1}{n}\sum_{i=0}^{n-1} E_t\left(y_{1,t+i}\right) + \frac{1}{n}\sum_{i=0}^{n-1} tp_i \tag{2}$$

i.e. the n-period zero-coupon interest rate equals the average of current and expected 1-period zero-coupon interest rates plus a constant term premium or put less formally: Long rates equal the average of the current and expected short rates.

Since interest rates are often found to be $I\left(1\right)$ variables, it is useful to rewrite equation (2) by subtracting $y_{1,t}$ from both sides, which yields:

$$s_{n,1,t} \equiv y_{n,t} - y_{1,t} = \frac{1}{n}\left[\sum_{i=1}^{n-1}\left(n-i\right)E_t\left[\Delta y_{1,t+i}\right]\right] + \frac{1}{n}\sum_{i=0}^{n-1} tp_i \tag{3}$$

The spread between the n-period and 1-period interest rate can thus be expressed as a weighted average of expected changes in the 1-period interest rate over the life of the n-period bond plus a time-invariant term premium. An interesting implication of equation (3) is that if interest rates are $I\left(1\right)$ variables and if term premia are $I\left(0\right)$, then yields of different maturities are cointegrated. Equation (3) is often referred to as the *expected-changes-in-short-rates* version of the expectations hypothesis.

Using the log-local expectations hypothesis combined with the assumption of rational expectations, it is also possible to show that:

$$E_t\left(y_{n-1,t+1} - y_{n,t}\right) = \frac{1}{n-1}s_{n,1,t} - \frac{1}{n-1}tp_n \tag{4}$$

i.e. the expected change from time t to time $t+1$ in yield to maturity of an n-period zero-coupon bond is proportional to the spread between the n and 1-period interest rates. For large n, equation (4) can also be interpreted as the expected change in the long interest rate. Equation (4) is often called the *expected-change-in-long-rates* version of the expectations hypothesis.

2.1 Testing the expectations hypothesis

Equation (3) and (4) form the basis of most tests of the expectations hypothesis.

Assuming rational expectations, the *expected-changes-in-short-rates* version, i.e. equation (3), and the *expected-change-in-long-rates* version, i.e. equation (4), can be rewritten as:

$$\frac{1}{n}\sum_{i=1}^{n-1}(n-i)\,\Delta y_{1,t+i} = s_{n,1,t} - \frac{1}{n}\sum_{i=0}^{n-1} tp_i + \frac{1}{n}\sum_{i=1}^{n-1}(n-i)\,\eta_{t+i} \tag{5}$$

and

$$y_{n-1,t+1} - y_{n,t} = -\frac{1}{n-1} tp_n + \frac{1}{n-1} s_{n,1,t} + \varepsilon_{t+1} \tag{6}$$

respectively. η_{t+i} and ε_{t+1} denote rational expectations errors and are thus uncorrelated with all time t information. Equation (5) and (6) can thus be rewritten in regression format as:

$$\frac{1}{n}\sum_{i=1}^{n-1}(n-i)\,\Delta y_{1,t+i} = \alpha^S_{n,1} + \beta^S_{n,1} s_{n,1,t} + \nu_{t+n-1} \tag{7}$$

and:

$$y_{n-1,t+1} - y_{n,t} = \alpha^L_{n,1} + \beta^L_{n,1}\left(\frac{s_{n,1,t}}{n-1}\right) + \varepsilon_{t+1} \tag{8}$$

and can be consistently estimated by OLS. Furthermore, the expectations hypothesis can be tested by simply testing the hypotheses:

$$\begin{aligned} H_0 &: \beta^S_{n,1} = 1 \\ H_0 &: \beta^L_{n,1} = 1 \end{aligned}$$

from the above regressions (7) and (8). When testing hypothesis about $\beta^S_{n,1}$ it is, however, necessary to take the MA$(n-2)$ component in the error term into account.[7]

2.2 Some existing results

Most studies of the expectations hypothesis have focussed on US data. Campbell & Shiller (1991) present an examination of the expectations hypothesis using monthly US data for the period 1952:1 to 1987:2. Campbell & Shiller (1991) examine both the short and the long-end of the term structure and find that the expectations hypothesis is rejected when the expected-change-in-long-rates version of the expectations hypothesis is examined. Using the expected-changes-in-short-rates version of the expectations hypothesis, the empirical results provide some support for the expectations hypothesis for the long-end of the maturity spectrum. The Campbell & Shiller (1991) results are quite representative of other studies of the expectations hypothesis using US data – see e.g. the discussion in Campbell, Lo & MacKinlay (1997). Several explanations for these mixed results have been proposed. One explanation is that the assumption

[7] See e.g. Engsted & Tanggaard (1995).

of a constant term premium is not correct and that equation (7) and (8) are therefore misspecified. Using US data, Tzavalis & Wickens (1997) show that taking account of a time-varying term premium using a single-factor approximation of the term premium somehow reconciles the expectations hypothesis with the data. Furthermore, Tzavalis (2003) shows how the term premia in the two versions of the expectations hypothesis are related and how the relationship between the term premia in these two versions of the expectations hypothesis can explain why the expected-changes-in-short-rates version is typically more supported by the data than the expected-change-in-long-rates version. Using US data, Tzavalis (2003) finds support for this explanation. Another explanation for the mixed results of tests of the expectations hypothesis is that the expectations hypothesis is not stable over time and that changes in the monetary policy regime may influence the relationship between short and long-term interest rates. Mankiw & Miron (1986) study the expectations hypothesis using US data from 1890 to 1979 and find that expectations hypothesis is better supported before than after the founding of the Federal Reserve System. According to Mankiw & Miron (1986), the founding of the Federal Reserve System resulted in a commitment to stabilize interest rates which induced an approximately random walk behaviour of the short term interest rate making changes in this less predictable and the expectations hypothesis perform more poorly. The dependence of the expectations hypothesis on the monetary policy regime has been more formally addressed by e.g. McCallum (1994, 2005), Rudebusch (1995), Fuhrer (1996) and Kugler (2002).

The expectations hypothesis has also been tested using data for other countries. Support is often found for the claim that the support for the expectations hypothesis depends on the monetary policy regime. It appears, however, that the expectations hypothesis is much more supported by European data – see e.g. Engsted & Tanggaard (1995), Gerlach & Smets and (1997*a*, 1997*b*). A recent example of a study of the expectations hypothesis using UK data is the study by Cuthbertson & Nitzsche (2003) who examine monthly UK data for the period 1976:1 to 1999:11 and $(m, 1)$ spreads for $m = 24, 36, ..., 120, 180, 240$ and 300 months. The 1-month interest rate is the 1-month Treasury Bill rate and the other interest rates are estimated zero-coupon interest rates from the Bank of England. For the expected-change-in-long-rates version of the expectations hypothesis, Cuthbertson & Nitzsche (2003) are not able to reject neither the null hypothesis $\beta^L_{n,1} = 0$ nor the null hypothesis $\beta^L_{n,1} = 1$ for $n = 24, 36, ..., 120$. For $n = 180, 240$ and 300, however, both the null hypothesis $\beta^L_{n,1} = 0$ and $\beta^L_{n,1} = 1$ are rejected. For the expected-changes-in-short-rates version of the expectations hypothesis, Cuthbertson & Nitzsche (2003) only consider $n = 24, 36, ..., 120$ due to the loss of data when testing this version of the expectations hypothesis. Cuthbertson & Nitzsche (2003) find that the null hypothesis $\beta^S_{n,1} = 0$ is rejected for all spreads and that the null hypothesis $\beta^S_{n,1} = 1$ is not rejected for most spreads. Using a modification of the Campbell & Shiller (1987, 1991) VAR approach, Cuthbertson & Nitzsche (2003) find that the rejection of the expectations hypothesis at these maturities cannot be attributed to a time-varying term premium.

3 Data

As mentioned in the introduction, the data used in this paper are estimated zero-coupon interest rates supplied by the Bank of England and the 1 and 3-month Treasury Bill rates available from Datastream.[8] All interest rates are available on a daily basis.

Since the interest rate with the lowest maturity is the 1-month interest rate, it is natural to focus on monthly data, i.e. it is chosen to convert the daily data set into a monthly data set. In the setting of the expectations hypothesis, the primary reason for focussing on monthly rather than daily interest rates is that the problem with overlapping data and hence the need for corrections to the variance-covariance matrix of the OLS estimator due to an MA component in the error term in equation (7) is "reduced".[9]

Apart from being dictated by the data,[10] an advantage of focusing on the period from March 1997 to May 2005 is that the issue of how to deal with (potential) structural breaks is of no major concern for this period since the period from March 1997 to the present can be considered as a single regime with an independent central bank pursuing inflation targeting.[11]

The sensitivity of the results with respect to the choice of daily observation used to represent the monthly observation is checked by testing the expectations hypothesis using different choices of daily observation to represent the monthly observation. Data sets are thus constructed where the 5th, the 10th, the 15th, the 20th, the 25th and the 30th each month are used to represent the monthly observation.[12]

An intuitive justification for splicing the 1- and 3-month Treasury Bill rates into the Bank of England data set when considering data prior to March 1997

[8] Mnemonic codes LDNTB1M and LDNTB3M, respectively. The Bank of England estimated zero-coupon interest rates are continuously compounded interest rates measured on an annual basis whereas the Datastream interest rates are measured as annually compounded interest rates. The Datastream interest rates are therefore transformed into continuously compounded rates measured on an annual basis.

[9] The problem with an MA component in the error term in the linear regression models typically used to test the expectations hypothesis can of course be avoided if the VAR approach suggested by Campbell & Shiller (1987, 1991) is used instead. However, when testing the expectations hypothesis with daily data and for the 12-month horizon using this approach, it is necessary to forecast interest rates approximatly 360 periods ahead which is not likely to produce reliable or usable results.

[10] As discussed in the introduction.

[11] Studying monetary policy rules, Adam, Cobham & Girardin (2005) find a structural break in the monetary policy reaction function at the time the Bank of England gained operational independence. The Bank of England gained operational independence in May 1997 but the use of the data for March and April 1997 ought not change the results.

[12] Due to missing observations, weekends, Bank Holidays etc. it is, of course, not possible always to use e.g. the 5th in each month to represent the monthly observation. When an observation for the chosen date is not available, the date closest to the date in question is used instead. In cases where an observation for e.g. the 5th is not available but observations for both the 4th and 6th are available, the observation corresponding to the 4th is used.

can be seen from the following graphs and the following descriptive statistics which are based on the period March 1997 to May 2005 where both set of interest rates are available. For simplicity, only the results based on the data set where the 15th of each month is used to represent the monthly observation are presented.[13]

Figure 1: Comparison of 1-month interest rates from the 15th

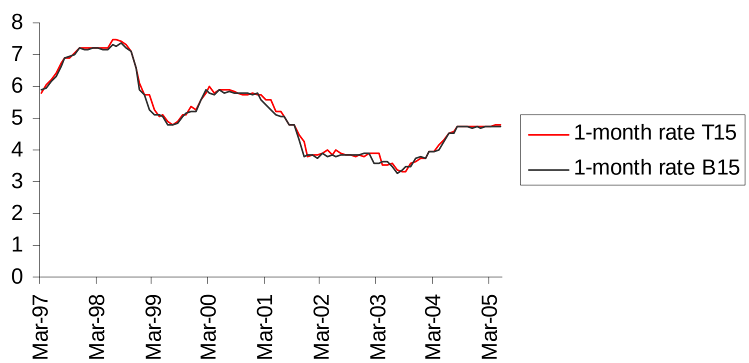
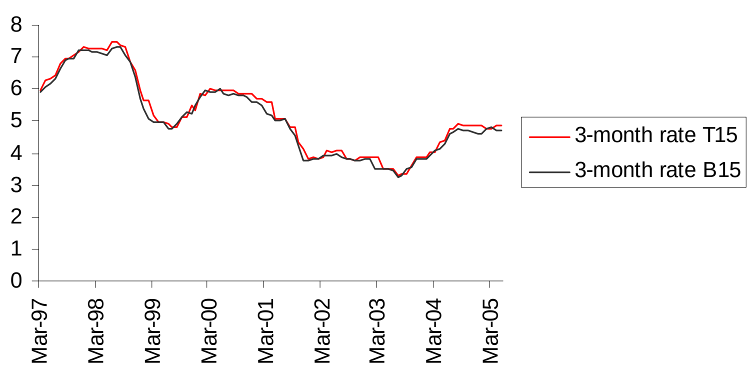


Figure 2: Comparison of 3-month interest rates from the 15th



[13] Similar graphs and descriptive statistics for the other data sets are available upon request. "1-month rate T15" is the 1-month Treasury Bill rate on the 15th each month and "1-month rate B15" is the 1-month Bank of England rate on the 15th each month.

Table 1: Descriptive statistics for 1 month BOE and TB interest rates

	mean	variance	ρ_1	ρ_2	ρ_3	ρ_4
$y_{1,t}$	5.11	1.43	0.99	0.97	0.94	0.91
$y_{tb,1,t}$	5.02	1.30	0.99	0.97	0.94	0.91
Correlation:	0.9958					

TB denotes Treasury-Bill rate, BOE Bank of England rate and ρ_i is the ith order autokorrelationcoefficient.

Table 2: Descriptive statistics for 3 month BOE and TB interest rates

	mean	variance	ρ_1	ρ_2	ρ_3	ρ_4
$y_{3,t}$	5.09	1.41	0.99	0.97	0.94	0.90
$y_{tb,3,t}$	5.06	1.30	0.99	0.97	0.94	0.90
Correlation:	0.9944					

TB denotes Treasury-Bill rate, BOE Bank of England rate and ρ_i is the ith order autokorrelationcoefficient.

Results of Phillips-Perron unit-root tests for the different data sets are only marginally sensitive to the choice of daily observation used to represent the monthly observation and in general show that interest rates are $I(1)$ but interest rate spreads are $I(0)$, i.e. interest rates of different maturities cointegrate as suggested by the expectations hypothesis.[14]

4 Results

4.1 Expected-changes-in-short-rates regression

As is clear from figure 3 and 4 there does not appear to be significant differences in the estimates of the $\beta_{n,1}^{S}$ coefficient depending on which date is chosen to represent the monthly observation.[15] This picture is clear for both the data set using the Bank of England rates and the mixed data set. As is clear from figure 5, however, the estimates based on the Bank of England data set and the estimates based on the mixed data set differ. The estimates of the $\beta_{n,1}^{S}$ coefficients are always higher in the regressions based on the Bank of England data set than in the regressions based on the mixed data set. Furthermore, in general the differences are quite high for the regressions with $n \lessapprox 6$. For $n \gtrapprox 8$, however, the differences are very small and for $n \gtrapprox 12$ almost not existing. Based solely on the point estimates from the expected-changes-in-short-rates regression using the Bank of England data set, it thus appears that the expectations hypothesis is supported by the data for $n \lessapprox 12$. From the expected-changes-in-short-rates regressions using the mixed data set this support appears less clear and the point estimates for $n = 2$ seem to deviate much from the other point estimates.

[14] The results of the unit root tests are not reported in the paper but are availabe upon request.

[15] Bi denotes Bank of England rates the ith each month. Ti denotes the mixed Bank of England and Treasury Bill rates the ith each month. Short-rate regression refer to equation (7).

Figure 3: Estimated β coeffcients in short-rate regressions

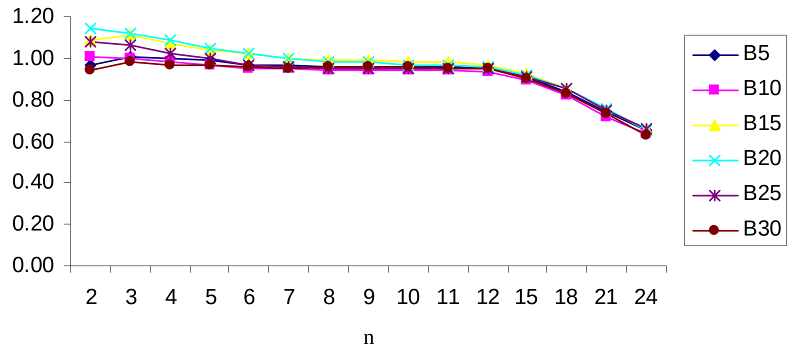


Figure 4: Estimated β coeffcients in short-rate regressions

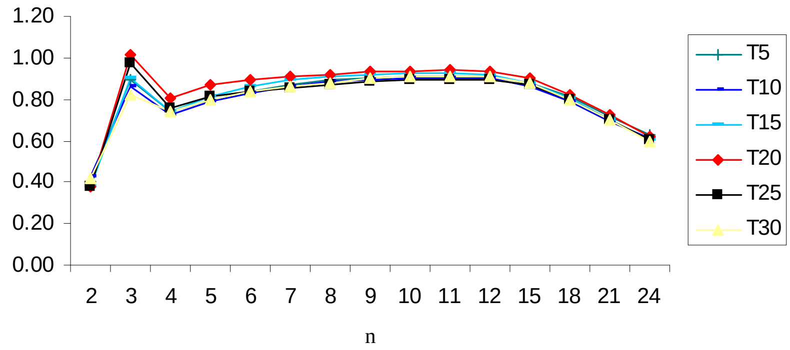
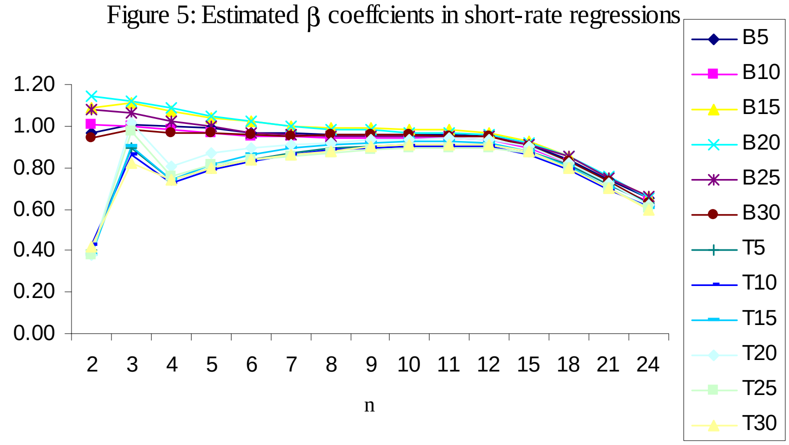


Figure 5: Estimated β coeffcients in short-rate regressions



These indications are strengthened when the results from statistical tests of the expectations hypothesis are considered. The following discussion is based on a 5% significance level and tables with the results are presented in the appendix.. The expectations hypothesis is said to be supported by the data if the null hypothesis $\beta^S_{n,1} = 0$ can be rejected and the null hypothesis $\beta^S_{n,1} = 1$ cannot be rejected.

For the Bank of England data set, the expectations hypothesis is only rejected for $n = 24$. The estimated standard errors are always relatively small – ranging between 0.10 and 0.20 – and follow an inverted U-shape with peak around n between 6 and 9. The R^2 values range between 0.31 to 0.58 and follow an inverted U-shape peaking at $n = 3$. Overall the results strongly support the expectations hypothesis for $n \leq 12$. For $n > 12$ the support is decreasing in n but for all n except 24 the expectations hypothesis is not rejected. In general, there does not appear to be much difference between the regressions using different daily observations to represent the monthly observation.

For the mixed data set, the results are not as clear cut as in the case with the Bank of England data set. The expectations hypothesis is always rejected for $n = 2$ and 24. With the exception of the regression where the 20th is used as the monthly observation, the expectations hypothesis is also rejected for $n = 4$. For the regressions where the 5th, 10th, 25th or 30th are used to represent the monthly observation, the expectations hypothesis is also rejected for $n = 21$. Furthermore, for the regression where the 10th, is used to represent the monthly observation, the expectations hypothesis is also rejected for $n = 5$. The choice of date to represent the monthly observation which provides the most support for the expectations hypothesis is thus the 20th and the choice of date to represent the monthly observation which provides the most evidence against the expectations hypothesis is thus the 10th. In general, the R^2 values follow an inverted U-shape with peak at $n = 4$ and values ranging between 0.29 and 0.61. The estimated standard errors are small – ranging between 0.04 and 0.20.

Whether tests of the expectations hypothesis formulated as the expected-change-in-future-short-rates are sensitive to the choice of daily observation to represent the monthly observation thus depends on whether the Bank of England data set or the mixed data set is used. For all choices of daily observation to represent the monthly observation, however, there appear to be some significant differences between the use the Bank of England and the mixed data set – both with respect to the size of the parameter estimates and with respect to the main conclusions regarding the validity of the expectations hypothesis.

4.2 Expected-change-in-long-rate regression

As is clear from figure 6 and 7 there appears to be some significant differences in the estimates of the $\beta^L_{n,1}$ coefficient depending on which date is chosen to represent the monthly observation.[16] This picture is clear for both the Bank of

[16] Long-rate regression refer to equation (8).

England data set and the mixed data set. Furthermore, as is clear from figure 8 the estimates of the $\beta^L_{n,1}$ coefficients are in general higher in the regressions based on the Bank of England data set than in the regressions based on the mixed data set. Furthermore, in general the point estimates of the $\beta^L_{n,1}$ coefficients from the regressions using the Bank of England data set are much closer to the theoretically correct value of 1. This picture is especially clear when the $n \geq 15$ cases are omitted. A very striking finding is the negative estimates of $\beta^L_{n,1}$ for $n = 2$ and 4 when the mixed data set is used. A good explanation of this finding is of course wanted but difficult to come up with. From the point estimates alone, it is thus difficult to evaluate the validity of the expected-change-in-long-rates version of the expectations hypothesis unambiguously. With the exception of $n = 2$ and 4 in the case with the mixed data set, the results, however, seem to provide at least some kind of support for the expectations hypothesis.

Figure 6: Estimated β coeffcients in long-rate regressions

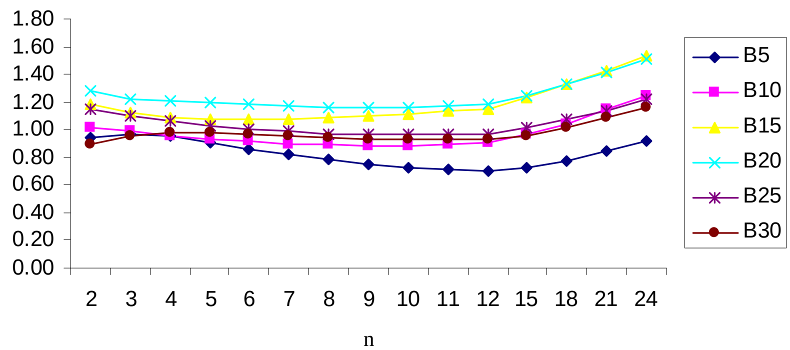


Figure 7: Estimated β coeffcients in long-rate regressions

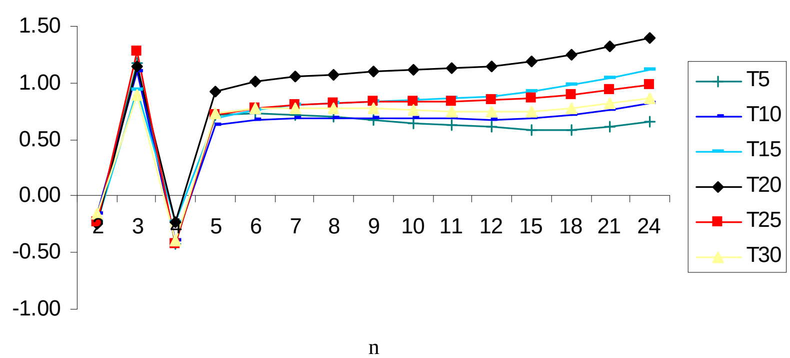
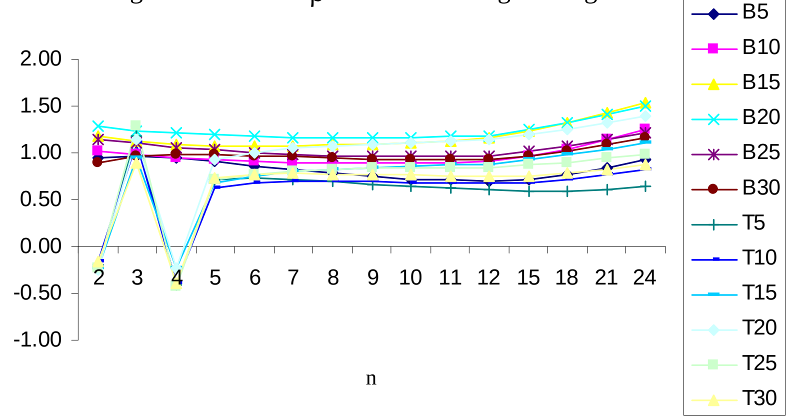


Figure 8: Estimated β coeffcients in long-rate regressions



The following discussion of the results of statistical tests of the expectations hypothesis is based on a 5% significance level and tables with the results are presented in the appendix. As in the case with the expected-changes-in-short-rates version of the expectations hypothesis, the expectations hypothesis is said to be supported by the data if the null hypothesis $\beta^L_{n,1} = 0$ can be rejected and the null hypothesis $\beta^L_{n,1} = 1$ cannot be rejected.

For the regressions using the Bank of England data set the expectations hypothesis is never rejected for $n = 2, 3, 4, 5$ and 6 and in general the expectations hypothesis is not rejected for $n \leq 8$. Furthermore, in the two cases where the observation corresponding to the 15th or the 20th represent the monthly observation, the expectations hypothesis is not rejected for $n \leq 12$ and never rejected using a 10% significance level. For all regressions the estimated standard errors are quite high, increasing in n, and are in general above 0.5 for $n > 10$. In addition, the R^2 values are decreasing in n and in general quite low – they never exceed 0.25 and are never above 0.10 for $n \geq 7$. Overall, the best results are obtained for the regression using the daily observation corresponding to the 20th as the monthly observation.

For the regressions using the mixed data set, the expectations hypothesis is always rejected for $n = 2$ and 4 and always supported for $n = 5$ and 6. In general the expectations hypothesis is also supported for $n = 3$ and 7. For all regressions except the regression where the daily observation corresponding to the 20th is used as the monthly observation, the expectations hypothesis is always rejected for $n \geq 9$. The best results are obtained when the daily observation corresponding to the 20th is used as the monthly observation since in this case the expectations hypothesis is only rejected for $n = 2$ and 4 and $n \geq 15$. The R^2 values are always very low and never exceed 0.10. Furthermore, the pattern in the R^2 values from the regressions based on the Bank of England data set is not found when the mixed data set is used – the R^2 values peak at $n = 5$ and in general follow an inverted U-shape. The estimated standard errors follow with the exception of the $n = 3$ case the same pattern as in the case when the Bank of England data set is used. The finding for the $n = 3$ case is peculiar!

The results from the expected-change-in-long rate regressions are thus sensitive to the choice of the daily observation used to represent the monthly observation as well as sensitive to the choice of data for the 1 and 3 month interest rates. Overall, the most support for the expectations hypothesis is found when the daily observation corresponding to the 20th is used to represent the monthly observation and when the Bank of England data set is used. The most evidence against the expectations hypothesis is found when the daily observation corresponding to the 5th is used to represent the monthly observation and when the mixed data set is used.

4.3 Summary

The above discussion describes a lot of results – two different tests using 12 different data sets, i.e. 24 regressions in total. The main conclusions can, however, be nicely summarized by considering the following five virtual researchers who want to test the expectations hypothesis using UK data for the 1997:3 to 2005:5 period and who focus on the short-end of the term structure in the form of the 1 to 12-month maturity spectrum.[17]

- Researcher A decides to use the estimated zero-coupon interest rates provided by Bank of England and decide to use the daily observation for the 5th in each month to represent the monthly observation.
- Researcher B decides to use the estimated zero-coupon interest rates provided by Bank of England and decide to use the daily observation for the 10th in each month to represent the monthly observation.
- Researcher C decides to use the estimated zero-coupon interest rates provided by Bank of England and decide to use the daily observation for the 20th in each month to represent the monthly observation.
- Researcher D decides to use the estimated zero-coupon interest rates provided by Bank of England but chooses to use the 1 and 3-month Treasury Bill rates provided by Datastream instead of the estimated 1 and 3-month zero-coupon interest rates provided by Bank of England. As discussed earlier, a reason for this choice may be the wish to be able to extend the period examined to include data back to 1979. Furthermore, researcher D decides to use the daily observation for the 10th in each month to represent the monthly observation.
- Researcher E decides to use the estimated zero-coupon interest rates provided by Bank of England but chooses as researcher D to use the 1 and

[17] For the 12 to 24-month maturity spectrum, the five researchers do in general not disagree about the main conclusions.

3-month Treasury Bill rates provided by Datastream. Furthermore, researcher E decides to use the daily observation for the 20th in each month to represent the monthly observation.

As is clear from the discussion above, the main conclusions from the five researches could be the following:

- Researcher A concludes: "As is standard in much of the literature, the results from the test of the expectations hypothesis are mixed. Using the expected-changes-in-short-rates version, the expectations hypothesis cannot be rejected. However, using the expected-change-in-long-rates version, the expectations hypothesis is rejected except when the 1 to 6-month maturity spectrum of the term structure is examined."

- Researcher B concludes: "As is standard in much of the literature, the results from the test of the expectations hypothesis are mixed. Using the expected-changes-in-short-rates version, the expectations hypothesis cannot be rejected. However, using the expected-change-in-long-rates version, the expectations hypothesis is rejected when the 9 to 12-month maturity spectrum of the term structure is examined."

- Researcher C concludes: "The expectations hypothesis is strongly supported by the data when using both the expected-changes-in-short-rates version and the expected-change-in-long-rate version."

- Researcher D concludes: "As is standard in much of the literature, the results from the test of the expectations hypothesis are mixed. Using the expected-changes-in-short-rates version, the expectations hypothesis is rejected for $n = 2, 4$ and 5 whereas when using the expected-change-in-long-rates version, the expectations hypothesis is rejected in all cases except when $n = 3, 5$ and 6. The general conclusion thus seems to be that the expectations hypothesis is not supported by the data."

- Researcher E concludes: "The expectations hypothesis is in general supported by the data. However, for $n = 2$ the expectations hypothesis is rejected using both the expected-changes-in-short-rates version and the expected-change-in-long-rates version. Using the former version, the expectations hypothesis is also rejected for $n = 4$."

5 Conclusion

This paper examines the expectations hypothesis for the short-end of the UK term structure of interest rates for the period 1997:3 to 2005:5 using twelve different data sets. The results in this paper demonstrate that tests of the expectations hypothesis are sensitive to the choice of data with respect to which short term interest rates are used (estimated zero-coupon interest rates vs Treasury

Bill rates) and to which daily observation is used to represent the monthly observation used in the empirical examination of the expectations hypothesis. For some data sets the expectations hypothesis appears to be strongly supported by the data for maturities up to 12 months whereas for other data sets the support is very weak. Furthermore, the general result found in the literature that the expected-changes-in-short-rates version of the expectations hypothesis is more supported by the data than the expected-change-in-long-rates is confirmed in this study.

When considering the short-end of the term structure, there thus appears to be some important information in the daily data which may be lost when the expectations hypothesis is tested using monthly data. The sensitivity of the *main conclusions* with respect to the chosen data set, however, apparently disappears when maturities above 12 months are used in the tests. The *point estimates* from the estimation of the test regressions, however, differ markedly for these maturities when the expected-change-in-long-rates version is considered but not when the expected-changes-in-short-rates version is considered. This result suggests that the expected-change-in-long-rates version of the expectations hypothesis is more sensitive to small differences in the data than the expected-changes-in-short-rates version of the expectations hypothesis.

The results **may** thus indicate that the sensitivity of the results to the data used is only relevant when the short-end of the term structure of interest rates is considered. If this is in fact true, it implies, hopefully, that the use of Treasury Bill rates instead of estimated zero-coupon interest rates apparently does not matter when the longer end of the term structure of interest rates is considered, i.e. the Bank of England data set can be spliced together with Treasury Bill rates such that analysis of the UK term structure of interest rates can be performed using data prior to 1997:3 once focus is not on the short-end of the term structure of interest rates.

The main conclusion to be drawn from the analysis in this paper is thus that when examining the short-end of the term structure of interest rates, it is important (if possible) to check the robustness of the results using other data. More specifically, the results suggest that the specific data set used in tests of the expectations hypothesis may be a candidate explanation when the expectations theory is rejected – along with the possibility that a time-varying term premium and/or a structural break is responsible for the rejection.

Appendix: Detailed results

BOE data denotes regressions based on Bank of England rates and BOE+TP data denotes regressions based on the mixed data set. Short-rate regression and long-rate regression refer to equation (7) and (8), respectively.

Table A1: Short-rate regression - 5th and BOE data

			p-value		
n	$\beta_{n,1}$	s.e.	$\beta_{n,1} = 0$	$\beta_{n,1} = 1$	R^2
2	0.97	0.10	0.00	0.76	0.47
3	1.01	0.12	0.00	0.94	0.55
4	1.00	0.16	0.00	1.00	0.53
5	0.99	0.19	0.00	0.94	0.51
6	0.97	0.20	0.00	0.89	0.49
7	0.97	0.20	0.00	0.87	0.48
8	0.96	0.20	0.00	0.83	0.47
9	0.96	0.19	0.00	0.82	0.47
10	0.96	0.18	0.00	0.82	0.47
11	0.96	0.18	0.00	0.81	0.47
12	0.95	0.18	0.00	0.79	0.47
15	0.91	0.18	0.00	0.62	0.44
18	0.84	0.17	0.00	0.35	0.41
21	0.74	0.16	0.00	0.10	0.36
24	0.65	0.13	0.00	0.01	0.33

Table A2: Short-rate regression - 10th and BOE data

			p-value		
n	$\beta_{n,1}$	s.e.	$\beta_{n,1} = 0$	$\beta_{n,1} = 1$	R^2
2	1.01	0.15	0.00	0.95	0.44
3	1.00	0.16	0.00	0.98	0.49
4	0.98	0.18	0.00	0.92	0.49
5	0.96	0.19	0.00	0.85	0.48
6	0.95	0.20	0.00	0.81	0.47
7	0.95	0.20	0.00	0.80	0.46
8	0.94	0.20	0.00	0.77	0.46
9	0.94	0.20	0.00	0.77	0.46
10	0.94	0.19	0.00	0.77	0.46
11	0.94	0.19	0.00	0.76	0.45
12	0.94	0.19	0.00	0.74	0.45
15	0.89	0.19	0.00	0.59	0.42
18	0.82	0.19	0.00	0.34	0.38
21	0.72	0.17	0.00	0.11	0.33
24	0.64	0.14	0.00	0.01	0.31

Table A3: Short-rate regression - 15th and BOE data

			p-value		
n	$\beta_{n,1}$	s.e.	$\beta_{n,1} = 0$	$\beta_{n,1} = 1$	R^2
2	1.09	0.14	0.00	0.51	0.45
3	1.11	0.16	0.00	0.50	0.53
4	1.07	0.17	0.00	0.70	0.52
5	1.04	0.19	0.00	0.84	0.50
6	1.02	0.19	0.00	0.93	0.49
7	1.00	0.20	0.00	0.99	0.47
8	0.99	0.19	0.00	0.96	0.47
9	0.99	0.19	0.00	0.94	0.46
10	0.98	0.18	0.00	0.92	0.46
11	0.98	0.18	0.00	0.91	0.46
12	0.97	0.18	0.00	0.88	0.45
15	0.93	0.18	0.00	0.69	0.42
18	0.85	0.18	0.00	0.41	0.39
21	0.75	0.17	0.00	0.14	0.34
24	0.66	0.14	0.00	0.02	0.32

Table A4: Short-rate regression - 20th and BOE data

			p-value		
n	$\beta_{n,1}$	s.e.	$\beta_{n,1} = 0$	$\beta_{n,1} = 1$	R^2
2	1.14	0.13	0.00	0.29	0.51
3	1.12	0.14	0.00	0.38	0.58
4	1.09	0.16	0.00	0.58	0.56
5	1.05	0.18	0.00	0.76	0.52
6	1.02	0.19	0.00	0.91	0.50
7	1.00	0.19	0.00	0.98	0.47
8	0.98	0.19	0.00	0.92	0.46
9	0.98	0.18	0.00	0.89	0.46
10	0.97	0.17	0.00	0.87	0.45
11	0.97	0.17	0.00	0.86	0.45
12	0.96	0.17	0.00	0.82	0.45
15	0.92	0.17	0.00	0.65	0.42
18	0.85	0.17	0.00	0.40	0.39
21	0.76	0.16	0.00	0.14	0.34
24	0.65	0.14	0.00	0.01	0.31

Table A5: Short-rate regression - 25th and BOE data

			p-value		
n	$\beta_{n,1}$	s.e.	$\beta_{n,1} = 0$	$\beta_{n,1} = 1$	R^2
2	1.08	0.13	0.00	0.54	0.50
3	1.06	0.14	0.00	0.66	0.58
4	1.02	0.16	0.00	0.90	0.55
5	1.00	0.18	0.00	1.00	0.52
6	0.97	0.19	0.00	0.89	0.49
7	0.96	0.19	0.00	0.82	0.48
8	0.95	0.19	0.00	0.80	0.47
9	0.95	0.19	0.00	0.79	0.47
10	0.95	0.18	0.00	0.78	0.47
11	0.95	0.17	0.00	0.77	0.47
12	0.95	0.17	0.00	0.75	0.46
15	0.91	0.17	0.00	0.61	0.43
18	0.85	0.17	0.00	0.37	0.41
21	0.75	0.16	0.00	0.13	0.36
24	0.66	0.14	0.00	0.01	0.33

Table A6: Short-rate regression - 30th and BOE data

			p-value		
n	$\beta_{n,1}$	s.e.	$\beta_{n,1} = 0$	$\beta_{n,1} = 1$	R^2
2	0.94	0.11	0.00	0.60	0.48
3	0.98	0.13	0.00	0.86	0.54
4	0.97	0.17	0.00	0.87	0.52
5	0.97	0.19	0.00	0.87	0.51
6	0.96	0.20	0.00	0.84	0.50
7	0.95	0.20	0.00	0.82	0.49
8	0.96	0.19	0.00	0.83	0.49
9	0.96	0.19	0.00	0.82	0.49
10	0.96	0.18	0.00	0.81	0.49
11	0.95	0.17	0.00	0.80	0.49
12	0.95	0.17	0.00	0.77	0.48
15	0.90	0.17	0.00	0.57	0.45
18	0.83	0.17	0.00	0.31	0.41
21	0.73	0.16	0.00	0.09	0.35
24	0.63	0.13	0.00	0.01	0.31

Table A7: Short-rate regression - 5th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1}=0$	p-value $\beta_{n,1}=1$	R^2
2	0.40	0.05	0.00	0.00	0.49
3	0.89	0.20	0.00	0.57	0.31
4	0.74	0.10	0.00	0.01	0.61
5	0.80	0.12	0.00	0.09	0.59
6	0.84	0.13	0.00	0.22	0.58
7	0.87	0.14	0.00	0.34	0.57
8	0.89	0.14	0.00	0.42	0.56
9	0.90	0.14	0.00	0.48	0.56
10	0.91	0.14	0.00	0.52	0.55
11	0.91	0.14	0.00	0.55	0.55
12	0.91	0.14	0.00	0.55	0.54
15	0.88	0.15	0.00	0.42	0.50
18	0.81	0.15	0.00	0.20	0.45
21	0.72	0.14	0.00	0.05	0.39
24	0.63	0.12	0.00	0.00	0.35

Table A8: Short-rate regression - 10th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1}=0$	p-value $\beta_{n,1}=1$	R^2
2	0.42	0.05	0.00	0.00	0.52
3	0.86	0.15	0.00	0.37	0.27
4	0.73	0.08	0.00	0.00	0.60
5	0.79	0.10	0.00	0.04	0.58
6	0.83	0.12	0.00	0.15	0.57
7	0.86	0.13	0.00	0.29	0.56
8	0.88	0.14	0.00	0.40	0.55
9	0.90	0.14	0.00	0.47	0.54
10	0.90	0.15	0.00	0.51	0.53
11	0.90	0.15	0.00	0.52	0.52
12	0.90	0.15	0.00	0.52	0.51
15	0.86	0.16	0.00	0.39	0.46
18	0.79	0.16	0.00	0.19	0.41
21	0.69	0.16	0.00	0.05	0.35
24	0.61	0.14	0.00	0.01	0.33

Table A9: Short-rate regression - 15th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1}=0$	p-value $\beta_{n,1}=1$	R^2
2	0.38	0.04	0.00	0.00	0.39
3	0.90	0.14	0.00	0.51	0.34
4	0.74	0.09	0.00	0.00	0.50
5	0.81	0.11	0.00	0.09	0.50
6	0.86	0.13	0.00	0.27	0.50
7	0.89	0.14	0.00	0.44	0.49
8	0.91	0.15	0.00	0.53	0.49
9	0.92	0.16	0.00	0.60	0.48
10	0.92	0.16	0.00	0.63	0.48
11	0.92	0.16	0.00	0.64	0.47
12	0.92	0.17	0.00	0.63	0.46
15	0.88	0.17	0.00	0.48	0.42
18	0.80	0.17	0.00	0.26	0.38
21	0.70	0.16	0.00	0.07	0.32
24	0.61	0.14	0.00	0.01	0.29

Table A10: Short-rate regression - 20th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1}=0$	p-value $\beta_{n,1}=1$	R^2
2	0.38	0.05	0.00	0.00	0.34
3	1.02	0.18	0.00	0.92	0.36
4	0.80	0.11	0.00	0.09	0.54
5	0.87	0.13	0.00	0.31	0.53
6	0.90	0.14	0.00	0.46	0.51
7	0.91	0.15	0.00	0.54	0.50
8	0.92	0.15	0.00	0.60	0.49
9	0.93	0.16	0.00	0.66	0.48
10	0.94	0.16	0.00	0.68	0.48
11	0.94	0.16	0.00	0.70	0.47
12	0.94	0.16	0.00	0.69	0.47
15	0.90	0.17	0.00	0.55	0.43
18	0.82	0.17	0.00	0.29	0.39
21	0.72	0.16	0.00	0.08	0.34
24	0.62	0.14	0.00	0.01	0.30

Table A11: Short-rate regression - 25th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1}=0$	p-value $\beta_{n,1}=1$	R^2
2	0.38	0.05	0.00	0.00	0.39
3	0.97	0.18	0.00	0.88	0.33
4	0.76	0.10	0.00	0.02	0.58
5	0.81	0.12	0.00	0.11	0.56
6	0.84	0.13	0.00	0.21	0.53
7	0.85	0.14	0.00	0.30	0.52
8	0.87	0.14	0.00	0.37	0.51
9	0.88	0.15	0.00	0.43	0.50
10	0.89	0.15	0.00	0.46	0.50
11	0.90	0.15	0.00	0.49	0.49
12	0.90	0.15	0.00	0.50	0.48
15	0.87	0.16	0.00	0.40	0.45
18	0.80	0.16	0.00	0.20	0.40
21	0.70	0.15	0.00	0.05	0.34
24	0.60	0.14	0.00	0.01	0.31

Table A12: Short-rate regression - 30th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1}=0$	p-value $\beta_{n,1}=1$	R^2
2	0.42	0.05	0.00	0.00	0.44
3	0.82	0.18	0.00	0.31	0.27
4	0.74	0.11	0.00	0.02	0.55
5	0.80	0.13	0.00	0.13	0.54
6	0.84	0.15	0.00	0.26	0.54
7	0.86	0.15	0.00	0.37	0.53
8	0.88	0.15	0.00	0.46	0.54
9	0.90	0.15	0.00	0.51	0.54
10	0.91	0.15	0.00	0.55	0.53
11	0.91	0.15	0.00	0.57	0.53
12	0.91	0.15	0.00	0.57	0.52
15	0.88	0.15	0.00	0.42	0.48
18	0.80	0.15	0.00	0.19	0.42
21	0.70	0.14	0.00	0.04	0.35
24	0.60	0.13	0.00	0.00	0.31

Table A13: Long-rate regression - 5th and BOE data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	0.94	0.21	0.00	0.77	0.17
3	0.97	0.26	0.00	0.91	0.13
4	0.95	0.30	0.00	0.87	0.09
5	0.91	0.35	0.01	0.79	0.07
6	0.86	0.39	0.03	0.73	0.05
7	0.82	0.43	0.06	0.67	0.04
8	0.78	0.47	0.10	0.63	0.03
9	0.75	0.50	0.14	0.61	0.02
10	0.72	0.54	0.19	0.61	0.02
11	0.71	0.58	0.22	0.62	0.02
12	0.70	0.62	0.26	0.63	0.01
15	0.72	0.72	0.32	0.70	0.01
18	0.77	0.82	0.35	0.78	0.01
21	0.84	0.91	0.36	0.86	0.01
24	0.92	0.99	0.36	0.93	0.01

Table A14: Long-rate regression - 10th and BOE data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	1.02	0.23	0.00	0.93	0.17
3	0.99	0.26	0.00	0.96	0.13
4	0.95	0.29	0.00	0.88	0.10
5	0.93	0.33	0.01	0.84	0.08
6	0.91	0.37	0.02	0.82	0.06
7	0.90	0.41	0.03	0.81	0.05
8	0.89	0.44	0.05	0.80	0.04
9	0.88	0.48	0.07	0.81	0.03
10	0.89	0.52	0.09	0.83	0.03
11	0.89	0.55	0.11	0.85	0.03
12	0.90	0.59	0.13	0.87	0.02
15	0.96	0.69	0.17	0.95	0.02
18	1.04	0.78	0.18	0.96	0.02
21	1.14	0.87	0.19	0.87	0.02
24	1.25	0.94	0.19	0.79	0.02

Table A15: Long-rate regression - 15th and BOE data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	1.18	0.25	0.00	0.46	0.19
3	1.12	0.27	0.00	0.65	0.15
4	1.09	0.30	0.00	0.77	0.12
5	1.07	0.33	0.00	0.82	0.10
6	1.07	0.37	0.00	0.84	0.08
7	1.07	0.40	0.01	0.85	0.07
8	1.08	0.44	0.01	0.85	0.06
9	1.09	0.47	0.02	0.84	0.05
10	1.11	0.50	0.03	0.83	0.05
11	1.13	0.54	0.04	0.81	0.04
12	1.15	0.57	0.05	0.79	0.04
15	1.23	0.66	0.07	0.73	0.03
18	1.33	0.75	0.08	0.66	0.03
21	1.43	0.83	0.09	0.61	0.03
24	1.53	0.90	0.09	0.56	0.03

Table A16: Long-rate regression - 20th and BOE data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	1.28	0.23	0.00	0.23	0.25
3	1.23	0.25	0.00	0.38	0.20
4	1.21	0.29	0.00	0.47	0.16
5	1.19	0.32	0.00	0.54	0.13
6	1.18	0.35	0.00	0.61	0.11
7	1.17	0.38	0.00	0.67	0.09
8	1.16	0.42	0.01	0.70	0.07
9	1.16	0.45	0.01	0.73	0.06
10	1.16	0.48	0.02	0.74	0.06
11	1.17	0.51	0.02	0.74	0.05
12	1.19	0.55	0.03	0.73	0.05
15	1.25	0.63	0.05	0.70	0.04
18	1.33	0.72	0.07	0.65	0.03
21	1.41	0.79	0.08	0.60	0.03
24	1.51	0.86	0.08	0.56	0.03

Table A17: Long-rate regression - 25th and BOE data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	1.15	0.22	0.00	0.49	0.22
3	1.10	0.25	0.00	0.68	0.17
4	1.06	0.29	0.00	0.84	0.12
5	1.03	0.33	0.00	0.93	0.09
6	1.00	0.36	0.01	0.99	0.07
7	0.99	0.40	0.01	0.97	0.06
8	0.97	0.43	0.03	0.95	0.05
9	0.97	0.46	0.04	0.94	0.04
10	0.97	0.50	0.06	0.95	0.04
11	0.97	0.53	0.07	0.95	0.03
12	0.97	0.56	0.09	0.96	0.03
15	1.01	0.66	0.13	0.98	0.02
18	1.07	0.75	0.15	0.92	0.02
21	1.14	0.83	0.17	0.86	0.02
24	1.22	0.91	0.18	0.81	0.02

Table A18: Long-rate regression - 30th and BOE data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	0.89	0.20	0.00	0.57	0.17
3	0.96	0.25	0.00	0.89	0.14
4	0.98	0.29	0.00	0.95	0.11
5	0.98	0.33	0.00	0.96	0.09
6	0.97	0.36	0.01	0.94	0.07
7	0.96	0.40	0.02	0.91	0.06
8	0.94	0.43	0.03	0.90	0.05
9	0.93	0.47	0.05	0.89	0.04
10	0.93	0.50	0.07	0.89	0.03
11	0.93	0.54	0.09	0.89	0.03
12	0.93	0.57	0.11	0.90	0.03
15	0.96	0.67	0.15	0.95	0.02
18	1.01	0.75	0.18	0.98	0.02
21	1.09	0.84	0.20	0.92	0.02
24	1.16	0.91	0.21	0.86	0.02

Table A19: Long-rate regression - 5th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	-0.20	0.08	0.02	0.00	0.06
3	1.17	0.50	0.02	0.73	0.05
4	-0.42	0.19	0.03	0.00	0.05
5	0.71	0.27	0.01	0.29	0.07
6	0.73	0.32	0.02	0.39	0.05
7	0.72	0.36	0.05	0.44	0.04
8	0.69	0.41	0.09	0.46	0.03
9	0.67	0.45	0.14	0.46	0.02
10	0.64	0.49	0.20	0.47	0.02
11	0.62	0.53	0.25	0.48	0.01
12	0.61	0.57	0.29	0.49	0.01
15	0.58	0.69	0.40	0.55	0.01
18	0.59	0.79	0.46	0.60	0.01
21	0.61	0.88	0.49	0.66	0.01
24	0.65	0.97	0.51	0.72	0.00

Table A20: Long-rate regression - 10th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	-0.15	0.08	0.07	0.00	0.03
3	1.10	0.52	0.04	0.85	0.05
4	-0.39	0.20	0.05	0.00	0.04
5	0.63	0.26	0.02	0.16	0.06
6	0.67	0.31	0.03	0.29	0.05
7	0.69	0.35	0.05	0.38	0.04
8	0.69	0.39	0.08	0.44	0.03
9	0.69	0.44	0.12	0.48	0.03
10	0.69	0.48	0.15	0.51	0.02
11	0.68	0.52	0.19	0.54	0.02
12	0.68	0.55	0.22	0.56	0.02
15	0.69	0.66	0.30	0.64	0.01
18	0.72	0.76	0.35	0.71	0.01
21	0.77	0.85	0.37	0.78	0.01
24	0.83	0.93	0.38	0.85	0.01

Table A21: Long-rate regression - 15th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	-0.24	0.10	0.02	0.00	0.06
3	0.94	0.44	0.04	0.90	0.05
4	-0.22	0.23	0.33	0.00	0.01
5	0.69	0.29	0.02	0.28	0.06
6	0.76	0.33	0.03	0.47	0.05
7	0.80	0.38	0.04	0.59	0.04
8	0.82	0.42	0.05	0.67	0.04
9	0.84	0.46	0.07	0.73	0.03
10	0.85	0.50	0.09	0.77	0.03
11	0.87	0.53	0.11	0.80	0.03
12	0.88	0.57	0.13	0.83	0.02
15	0.92	0.67	0.17	0.91	0.02
18	0.98	0.77	0.20	0.98	0.02
21	1.04	0.85	0.22	0.96	0.02
24	1.11	0.93	0.24	0.91	0.01

Table A22: Long-rate regression - 20th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	-0.24	0.11	0.02	0.00	0.05
3	1.15	0.48	0.02	0.76	0.06
4	-0.23	0.22	0.30	0.00	0.01
5	0.92	0.28	0.00	0.79	0.10
6	1.01	0.32	0.00	0.99	0.09
7	1.05	0.36	0.00	0.89	0.08
8	1.08	0.40	0.01	0.84	0.07
9	1.10	0.43	0.01	0.82	0.06
10	1.11	0.47	0.02	0.81	0.06
11	1.13	0.51	0.03	0.80	0.05
12	1.14	0.54	0.04	0.79	0.04
15	1.19	0.64	0.06	0.76	0.04
18	1.25	0.73	0.09	0.73	0.03
21	1.32	0.81	0.11	0.69	0.03
24	1.39	0.88	0.12	0.66	0.03

Table A23: Long-rate regression - 25th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	-0.24	0.10	0.02	0.00	0.06
3	1.28	0.50	0.01	0.57	0.06
4	-0.43	0.20	0.03	0.00	0.05
5	0.71	0.28	0.01	0.30	0.06
6	0.77	0.32	0.02	0.48	0.06
7	0.80	0.36	0.03	0.59	0.05
8	0.82	0.40	0.04	0.65	0.04
9	0.83	0.44	0.06	0.70	0.04
10	0.84	0.48	0.08	0.73	0.03
11	0.84	0.51	0.10	0.76	0.03
12	0.85	0.55	0.13	0.78	0.02
15	0.87	0.65	0.18	0.84	0.02
18	0.90	0.74	0.23	0.89	0.01
21	0.94	0.83	0.26	0.94	0.01
24	0.99	0.91	0.28	0.99	0.01

Table A24: Long-rate regression - 30th and BOE+TB data

n	$\beta_{n,1}$	s.e.	p-value $\beta_{n,1} = 0$	p-value $\beta_{n,1} = 1$	R^2
2	-0.16	0.10	0.11	0.00	0.03
3	0.90	0.47	0.06	0.83	0.04
4	-0.40	0.20	0.06	0.00	0.04
5	0.73	0.27	0.01	0.34	0.07
6	0.77	0.32	0.02	0.46	0.06
7	0.78	0.36	0.03	0.53	0.05
8	0.77	0.40	0.05	0.57	0.04
9	0.77	0.43	0.08	0.59	0.03
10	0.76	0.47	0.11	0.61	0.03
11	0.75	0.51	0.14	0.63	0.02
12	0.75	0.54	0.17	0.65	0.02
15	0.75	0.65	0.25	0.70	0.01
18	0.78	0.74	0.30	0.77	0.01
21	0.82	0.83	0.32	0.83	0.01
24	0.87	0.91	0.34	0.89	0.01

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