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The Empirics of UK Gilts' Yields

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Disclaimer: The authors' institutional affiliations are provided solely for identification purposes. Views expressed are solely those of the authors. The standard disclaimers apply. **The data set is available for replication:** The data set used in the empirical part of this paper is available upon request to bona fide researchers for the replication and verification of the results.

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ABSTRACT

This paper analyzes the nominal yields of UK gilt-edged securities (“gilts”) based on a Keynesian perspective, which holds that the short-term interest rate is the primary driver of the long-term interest rate. Quarterly data are used to model gilts’ nominal yields. These models bring to light the complex dynamics relating the nominal yields on gilts to the short-term interest rate, inflation, the growth of industrial production, and the government debt ratio. The results show that the short-term interest rate has a crucial influence on the nominal yields on gilts, even after controlling for various factors. Contrary to widely held views, a higher government debt ratio does not lead to higher nominal yields.

KEYWORDS: UK Gilt-Edged Securities; Government Bonds; Long-Term Interest Rates; Nominal Bond Yields; Government Debt

JEL CLASSIFICATIONS: E43; E50; E58; E60; G10; G12

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1. INTRODUCTION

Understanding the dynamics of government bond yields is an important macroeconomic and policy issue. The effects of the central bank's policy rate and overall monetary policy, inflation, economic activity, and government indebtedness on government bond yields are crucial issues for economic theory and public policy debate.

John Maynard Keynes (1930) was emphatic about the vital influence of the short-term interest rate on the long-term interest rate. He maintained that since the short-term interest rate invariably moves in lockstep with the central bank's policy rate, the central bank's actions have an inordinate effect on government bond yields. Keynes's (1930, [1936] 2007) approach to interest rate dynamics can be contrasted to the dominant approach, which is inspired by the loanable funds theory. The loanable funds theory holds that the long-term interest rate is determined by the demand for and supply of funds. Hence, in the loanable funds theory, the interest rate is the "price" of funds.

This paper tests whether Keynes's view that the short-term interest rate is the major driver of the long-term interest rate holds for gilt-edged government securities ("gilts") in the United Kingdom, after controlling for other variables. It also examines the effects of inflation, economic activity (as measured by the growth of industrial production), and the government debt ratio on gilts' nominal yields. These are serious questions with far-reaching consequences not only for investors in government securities and financial assets, but also for central bankers, treasury officials, policymakers, portfolio managers, multinational corporations, financial institutions, small business owners, consumers, savers, borrowers, lenders, and taxpayers. The findings of this papers can elucidate various macroeconomic theoretical and policy debates concerning government bond yields, monetary policy, fiscal policy, the monetary transmission mechanism, the fiscal theory of price, debt deflation, modern money theory, and the sustainability of government debt and private sector leverage. These issues have become even more pertinent since the global financial crisis, the debt crisis in the eurozone's periphery, and recent actions by major central banks in response to the financial market turbulence and economic dislocations caused by the outbreak of COVID-19.

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The paper is structured as follows. Section II presents the evolution of macroeconomic fundamentals and the evolution of nominal yields on long-term gilts in the United Kingdom. Section III briefly narrates the institutional features of the market for gilts and gives an overview of government debt management in the United Kingdom. Section IV describes the data. Section V presents the models in the paper and reports the empirical findings. Section VI discusses the implications and relevance of the findings for economic policy, economic theory in the context of the recent literature, and the scholarly debate on the issues. Section VII concludes.

2. MACROECONOMIC FUNDAMENTALS AND THE EVOLUTION OF GILTS' YIELDS

Long-term interest rates on gilts have steadily declined since the early 1990s. Figure 1 shows the evolution of the long-term interest rate on gilts of various maturity tenors. There has been a fairly steady decline in the long-term interest rate. A noticeable decline occurred in the early 1990s with the fall in inflation. There was also a marked declined during global financial crisis. The long-term interest rate on gilts has remained low for the past decade.

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Figure 1: The Evolution of Gilts' Nominal Yields, 1990–2018

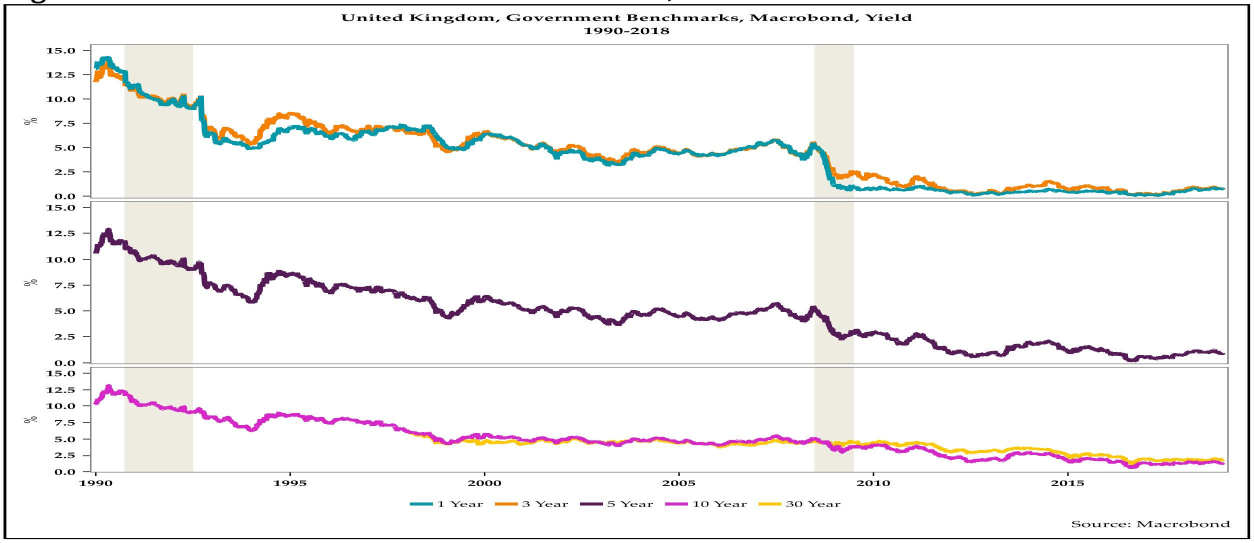
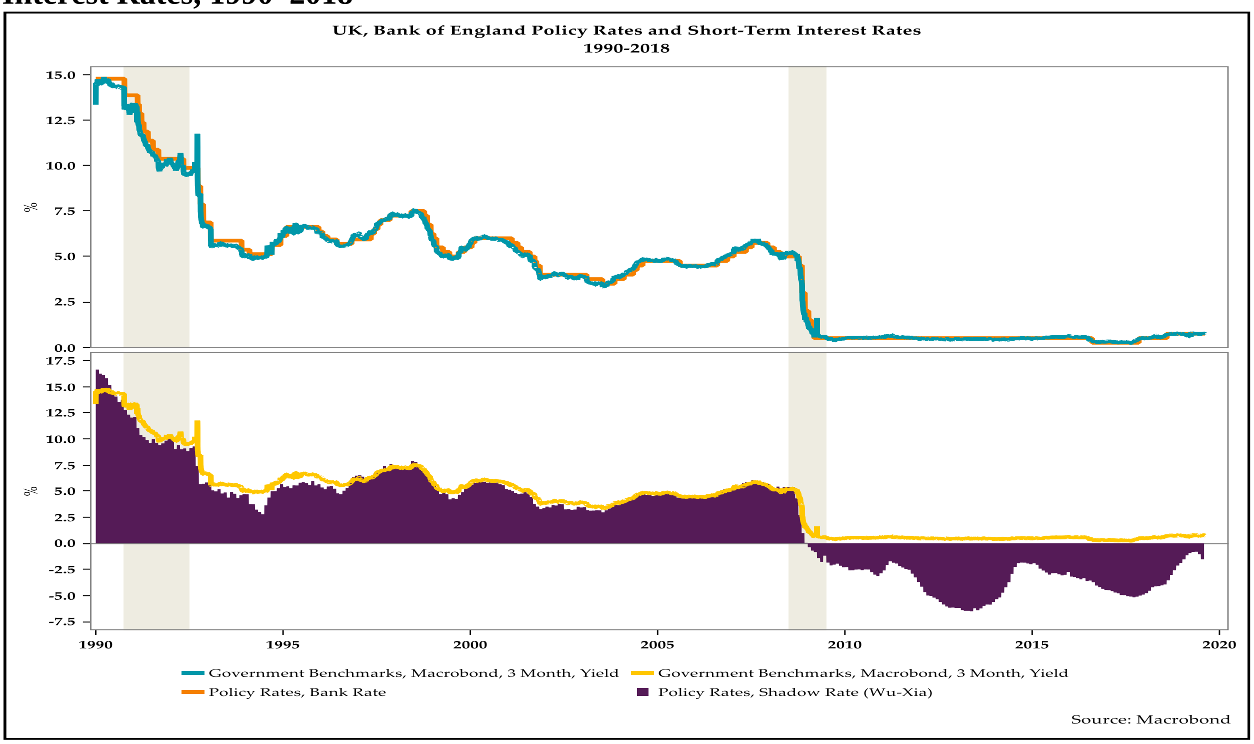


Figure 2 displays the evolution of the Bank of England's (BOE) policy rates and short-term interest rates in the United Kingdom. It is quite clear that the short-term interest rate moves in tandem with the BOE's policy rate.

Figure 2: The Evolution of the Bank of England's (BOE) Policy Rates and Short-Term Interest Rates, 1990–2018



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Figures 3–24 are scatterplots. These scatterplots reveal two crucial patterns. First, the yields of gilts of various maturity tenors are strongly correlated with the yields of 3-month Treasury bills. Second, the year-over-year percentage point changes in the yields of gilts of various maturity tenors are positively corelated with the year-over-year percentage point changes in the yields of 3-month Treasury bills.

A closer examination of these scatterplots divulges several other stylized facts. First, the correlations between the yields of gilts of various maturity tenors and 3-month Treasury bills are much stronger than the correlations between the year-over-year percentage point changes in the yields of the same securities. Second, the correlations for both the levels of the yields and the year-over-year percentage point changes of the yields tend to gradually decline with the rise in the maturity tenors of gilts.

Figure 3: Scatterplot of the Yields of 2-Year Gilts and 3-Month Treasury Bills, 1990–2018

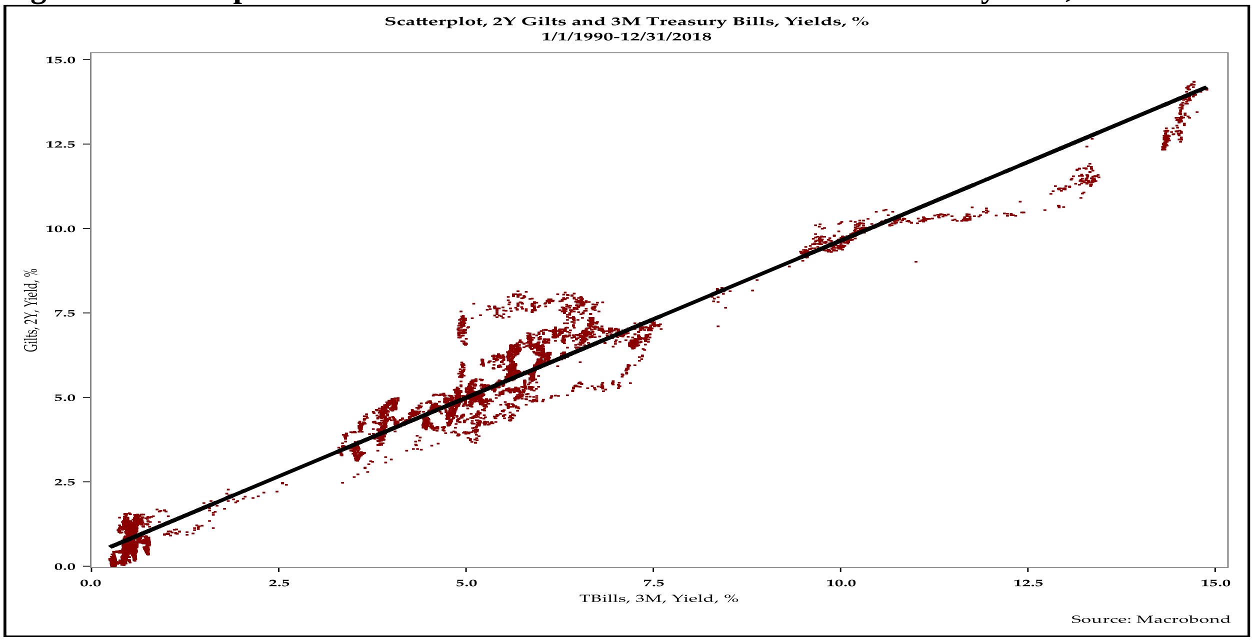

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Figure 4: Scatterplot of Year-over-Year Percentage Point Changes in the Yields of 2-Year Gilts and 3-Month Treasury Bills, 1990–2018

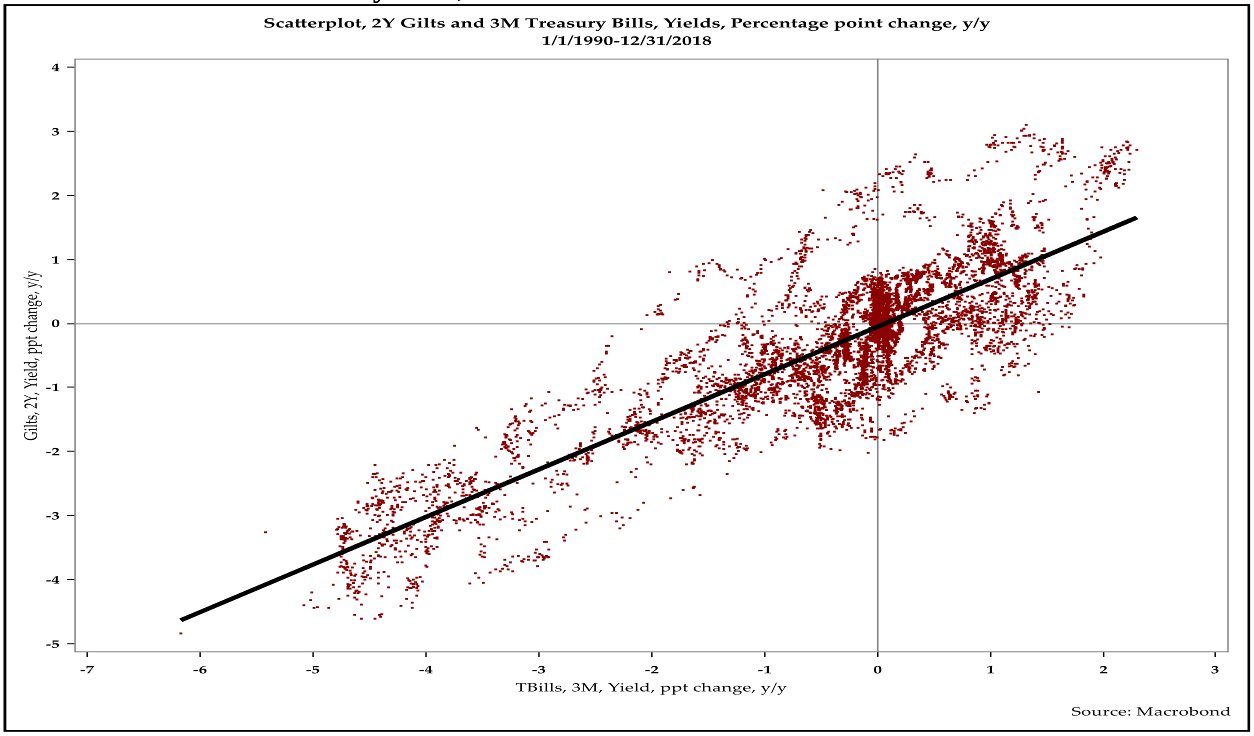

Figure 5: Scatterplot of the Yields of 3-Year Gilts and 3-Month Treasury Bills, 1990–2018

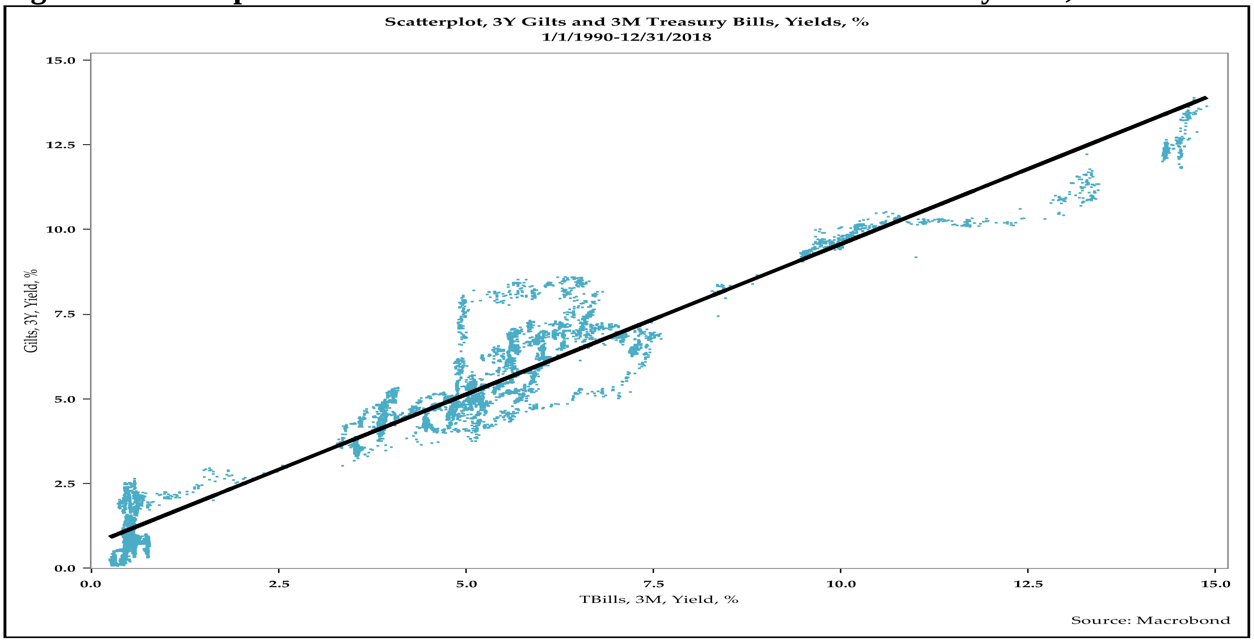

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Figure 6: Scatterplot of the Year-Over-Year Percentage Point Changes in the Yields of 3-Year Gilts and 3-Month Treasury Bills, 1990–2018

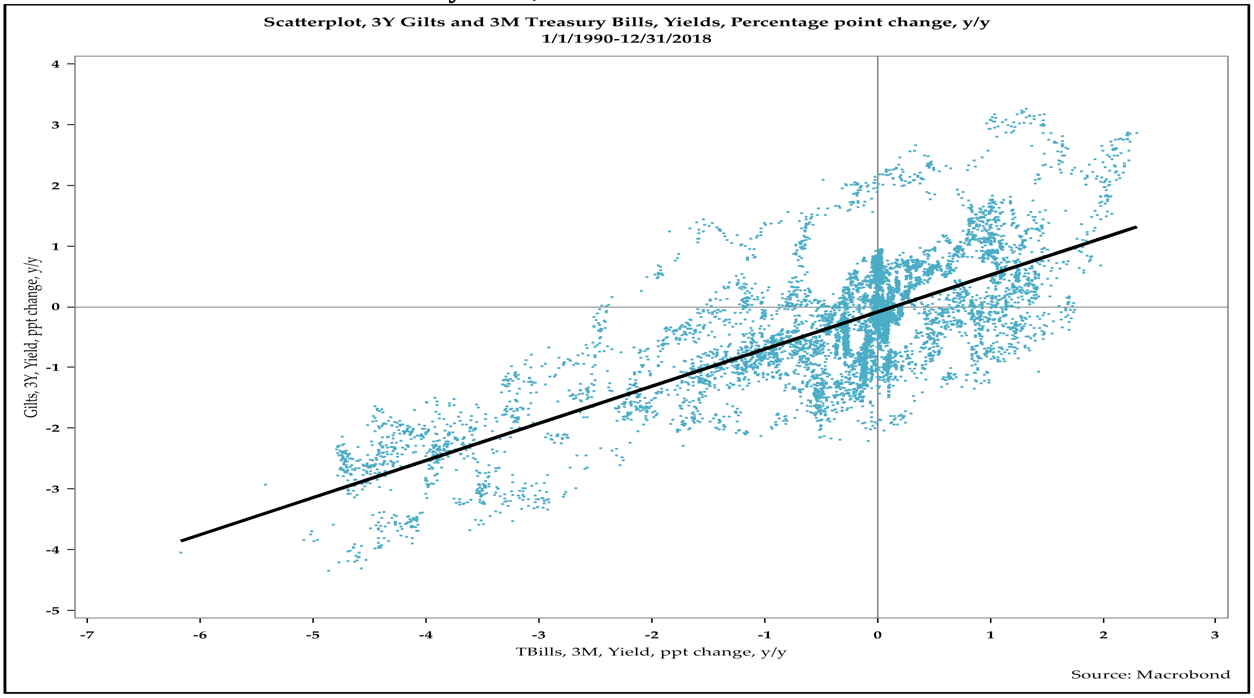

Figure 7: Scatterplot of the Yields of 4-year Gilts and 3-Month Treasury Bills, 1990–2018

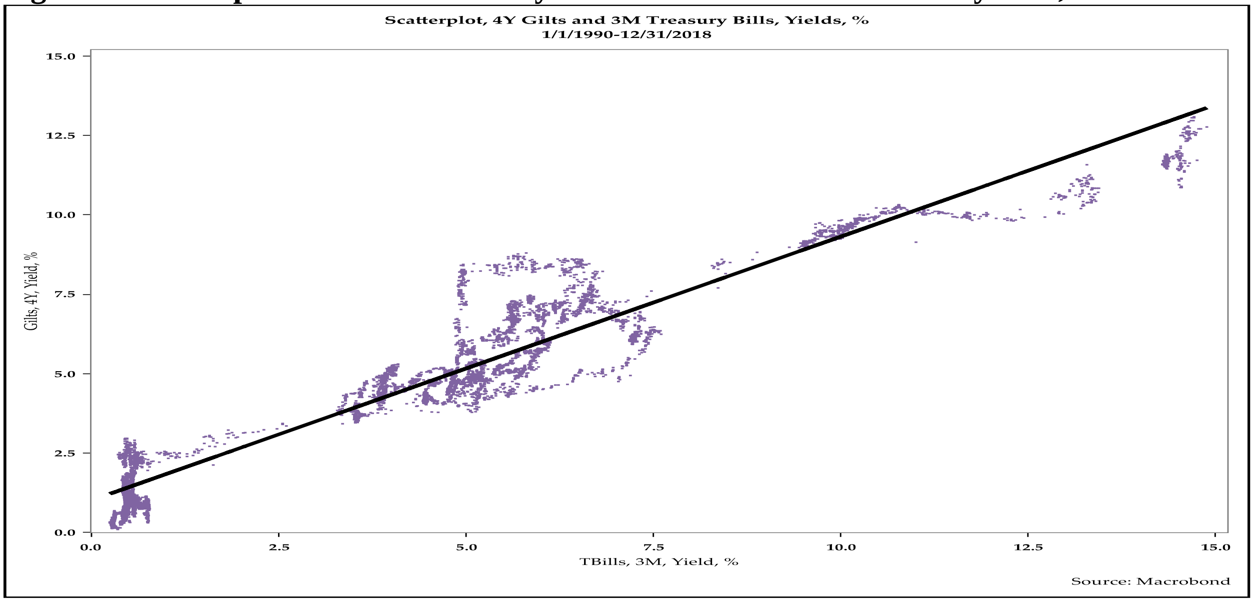

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Figure 8: Scatterplot of the Year-Over-Year Percentage Point Changes in The Yields of 4-Year Gilts and 3-Month Treasury Bills, 1990–2018

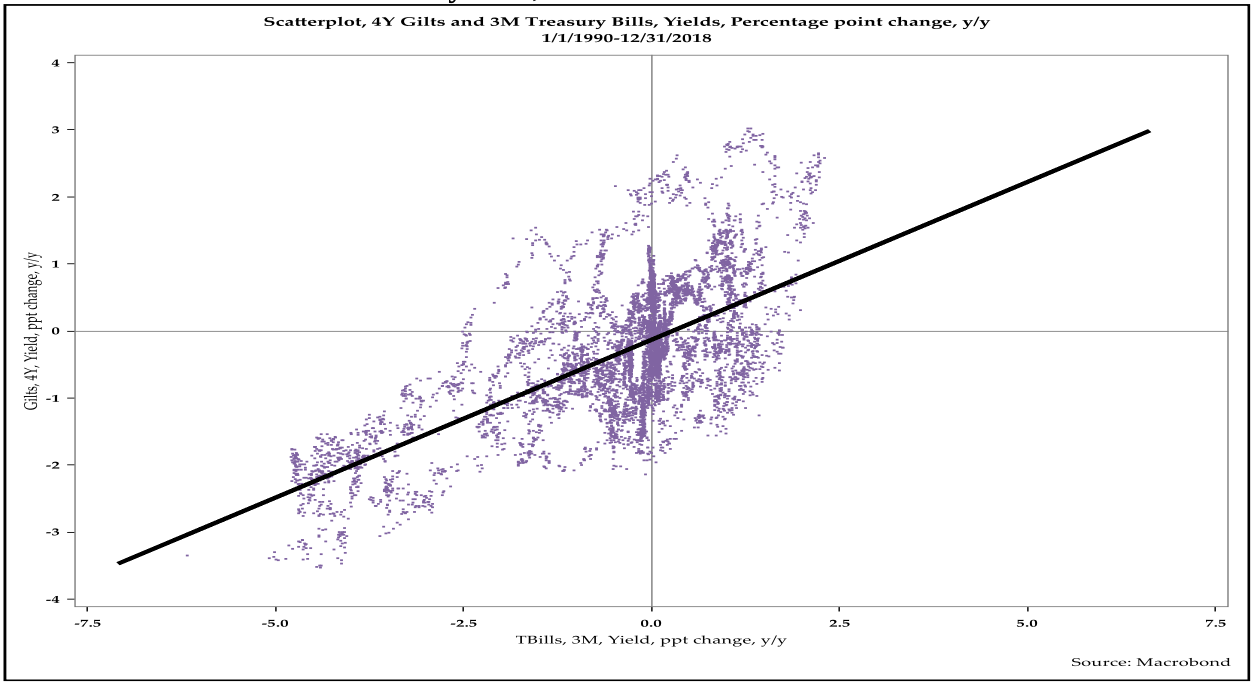

Figure 9: Scatterplot of the Yields of 5-year Gilts and 3-month Treasury Bills, 1990–2018

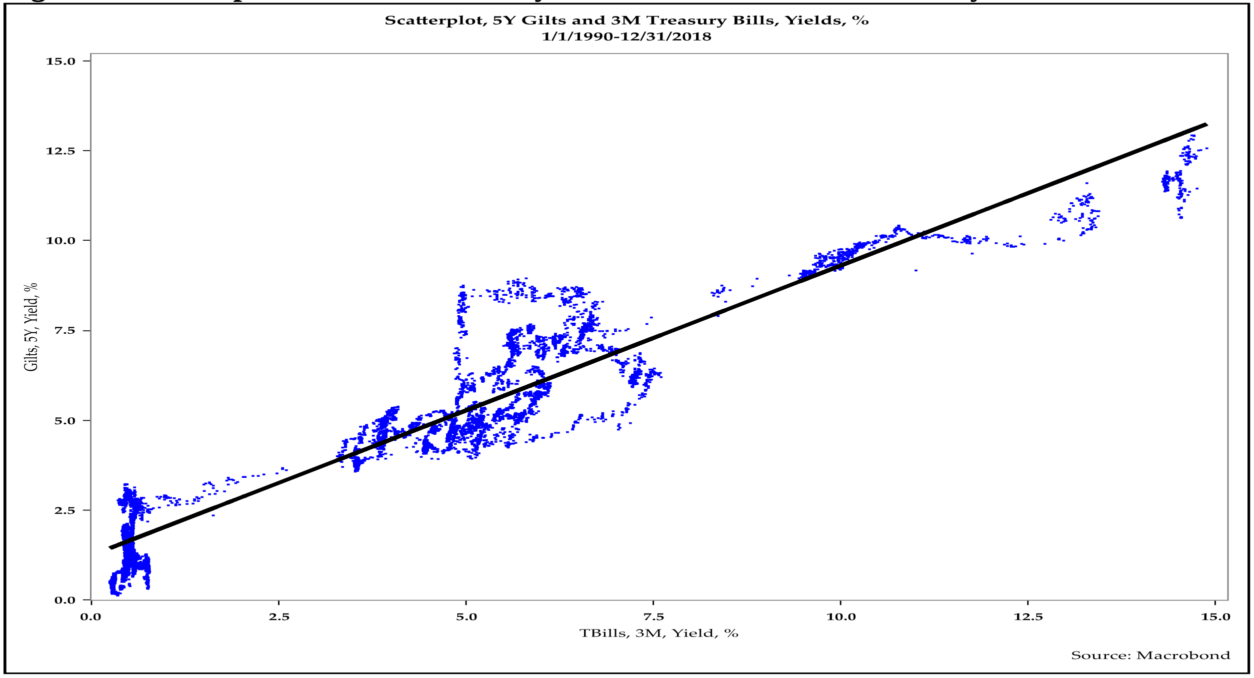

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Figure 10: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 5-year Gilts and 3-Month Treasury Bills, 1990–2018

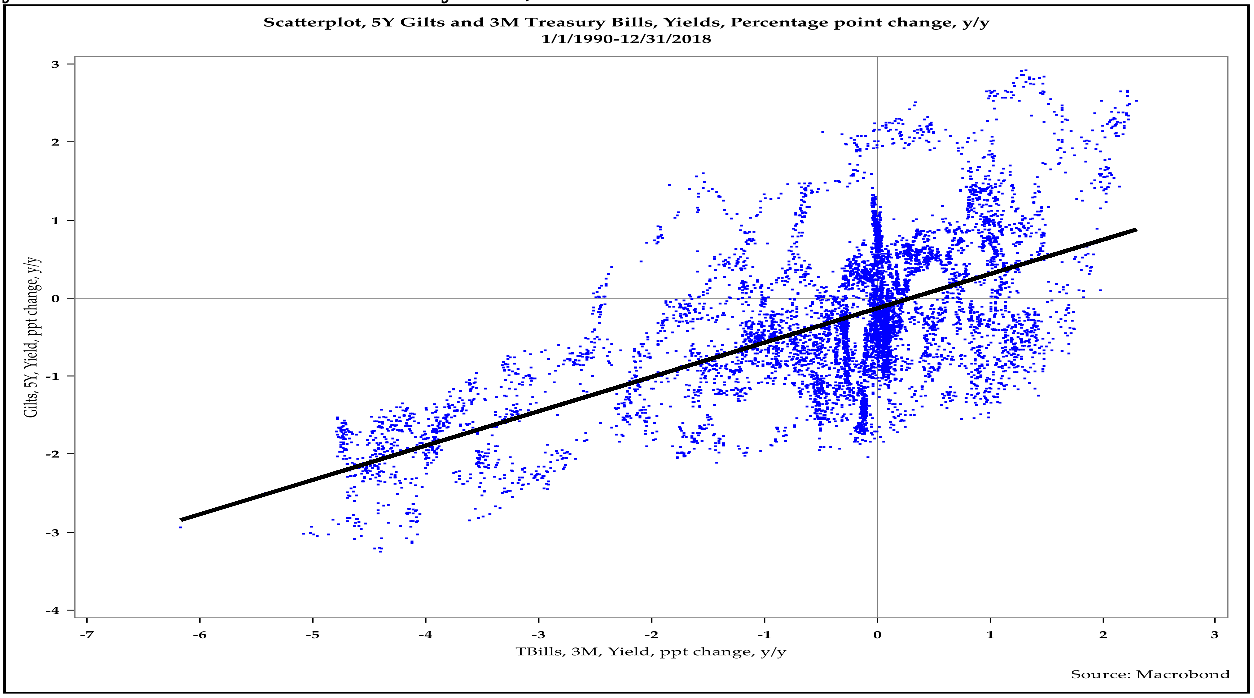

Figure 11: Scatterplot of the Yields of 6-Year Gilts and 3-Month Treasury Bills, 1990–2018

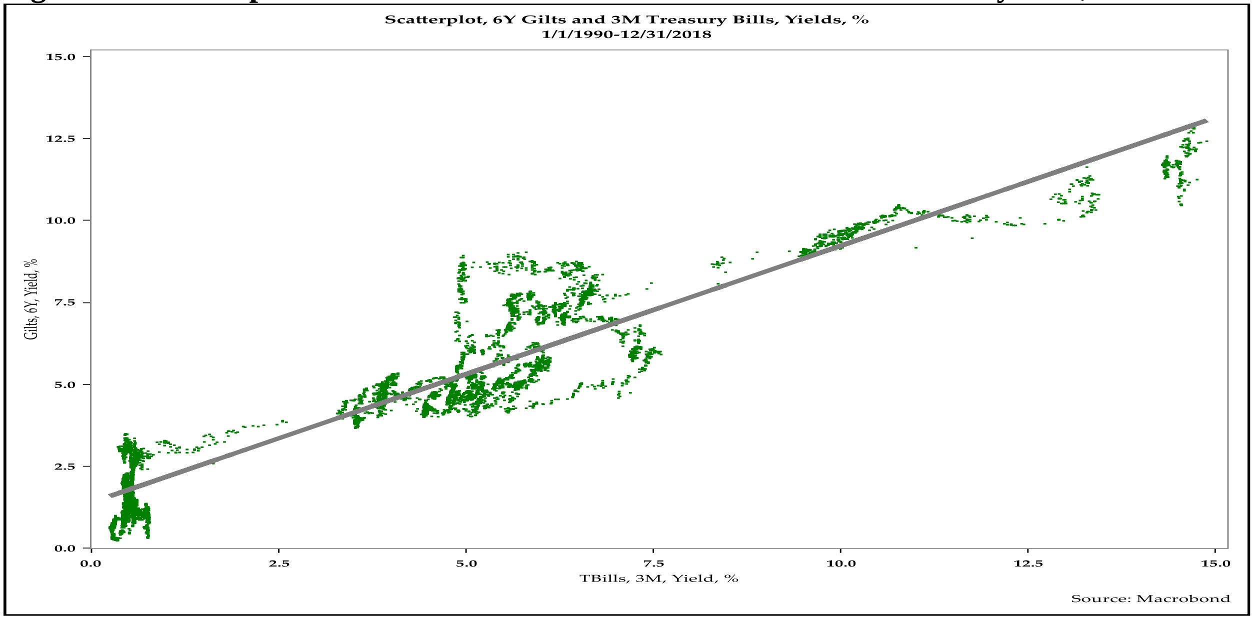

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Figure 12: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 6-Year Gilts and 3-Month Treasury Bills, 1990–2018

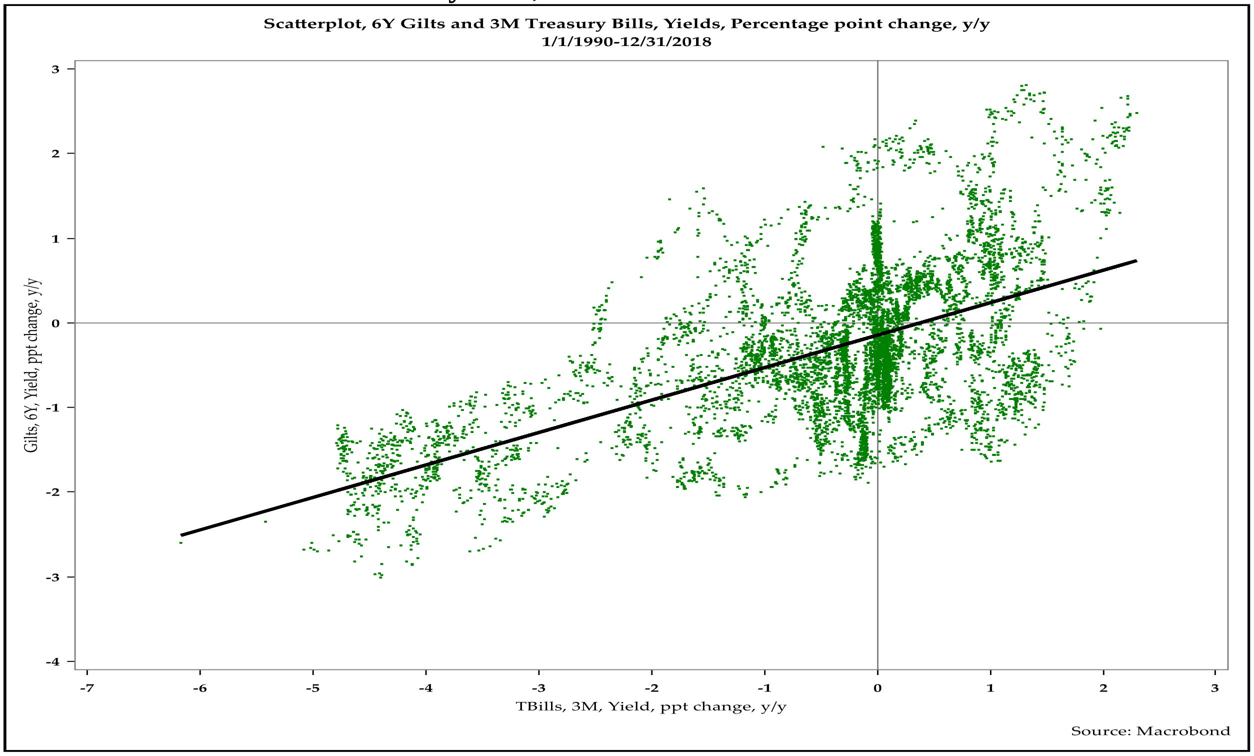

Figure 13: Scatterplot of the Yields of 7-Year Gilts And 3-Month Treasury Bills, 1990–2018

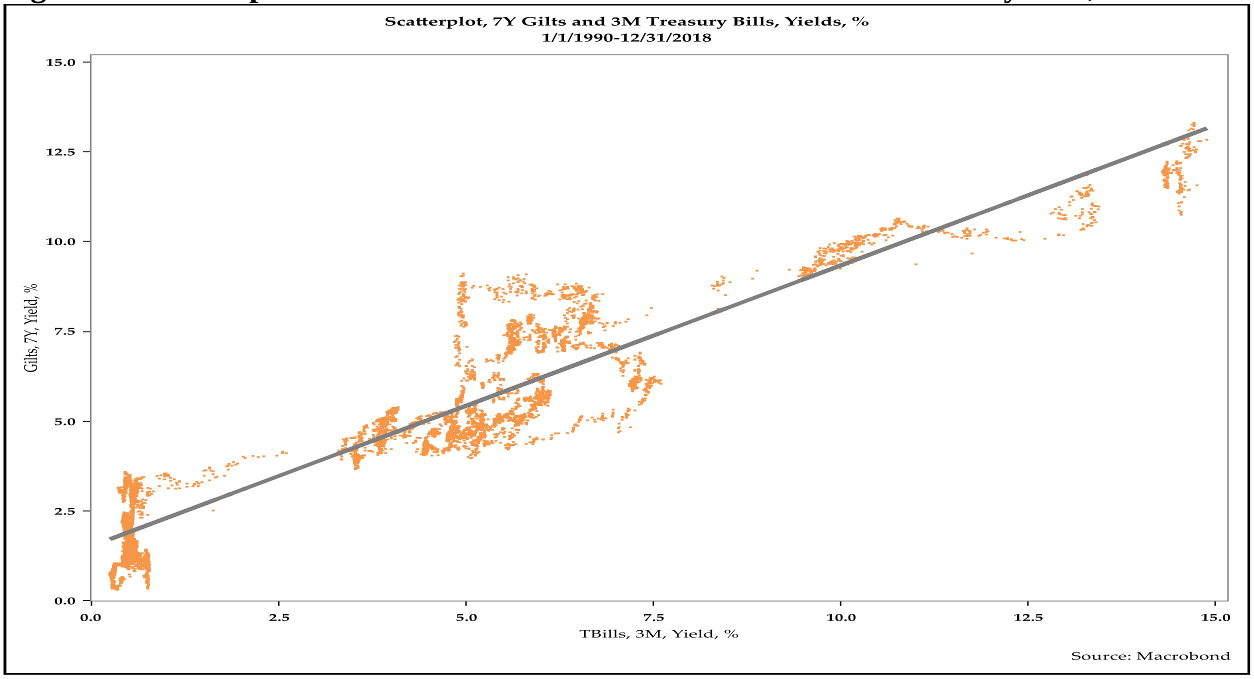

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Figure 14: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 7-Year Gilts and 3-Month Treasury Bills, 1990–2018

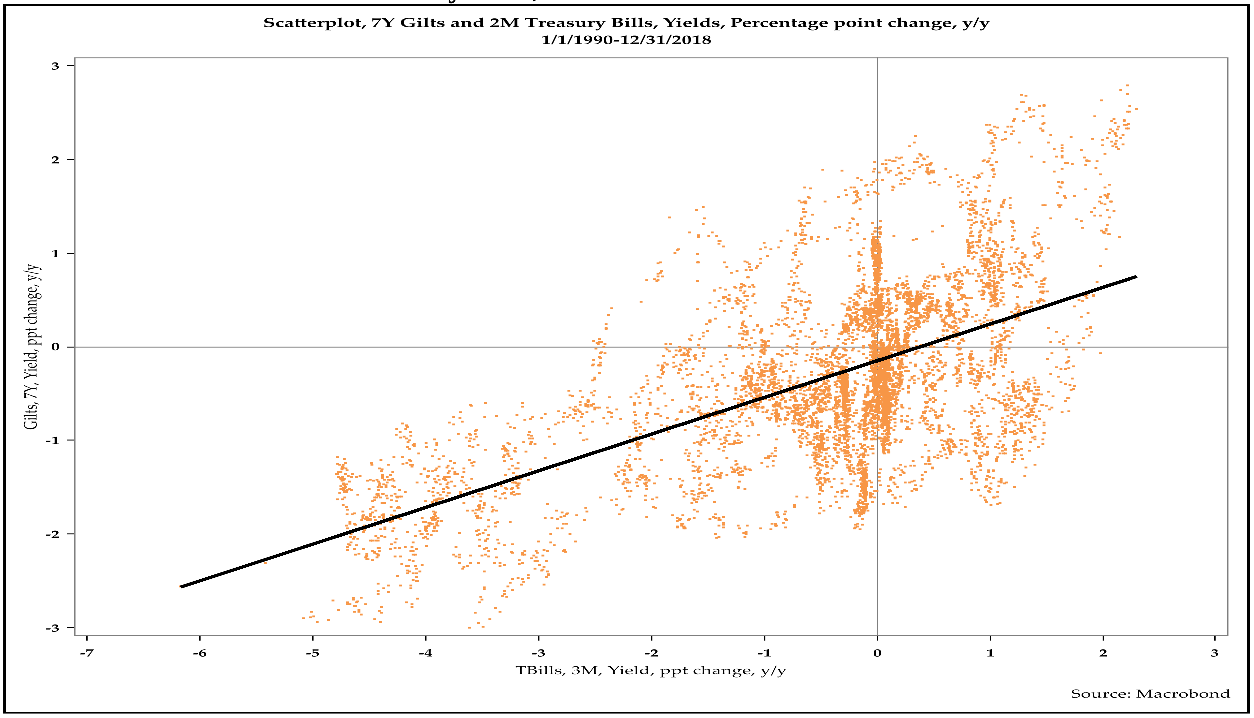

Figure 15: Scatterplot of the Yields of 8-Year Gilts and 3-Month Treasury Bills, 1990–2018

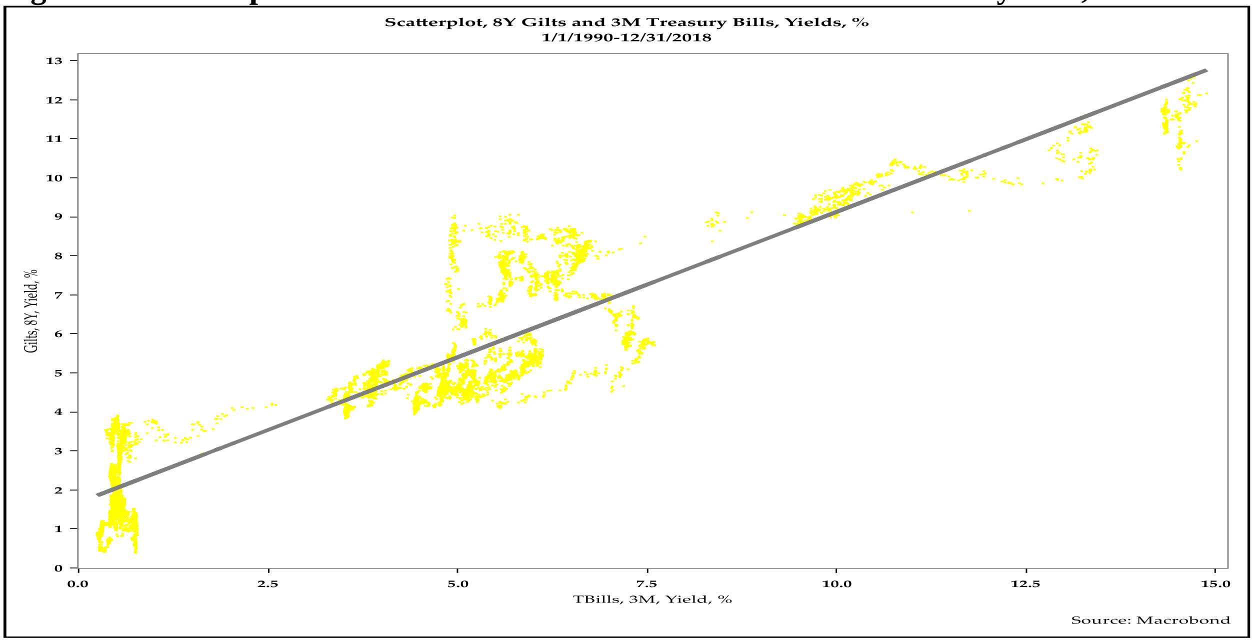

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Figure 16: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 8-Year Gilts and 3-Month Treasury Bills, 1990–2018

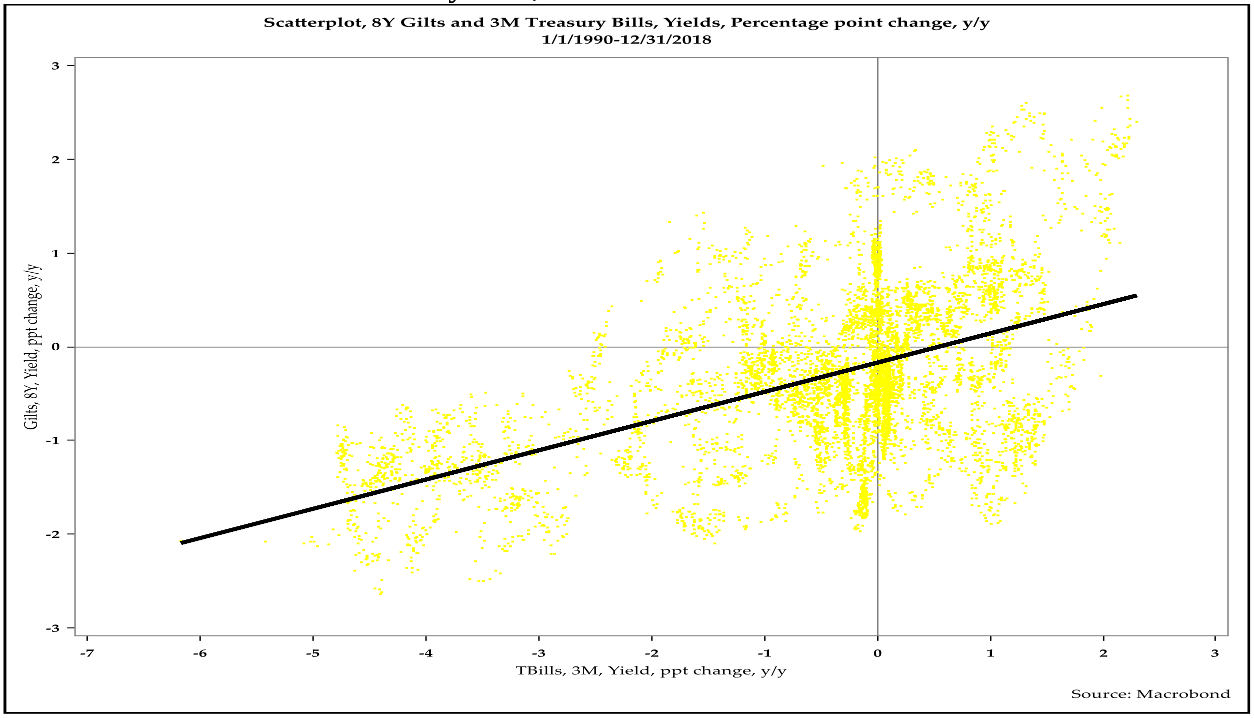

Figure 17: Scatterplot of the Yields of 9-Year Gilts and 3-Month Treasury Bills, 1990–2018

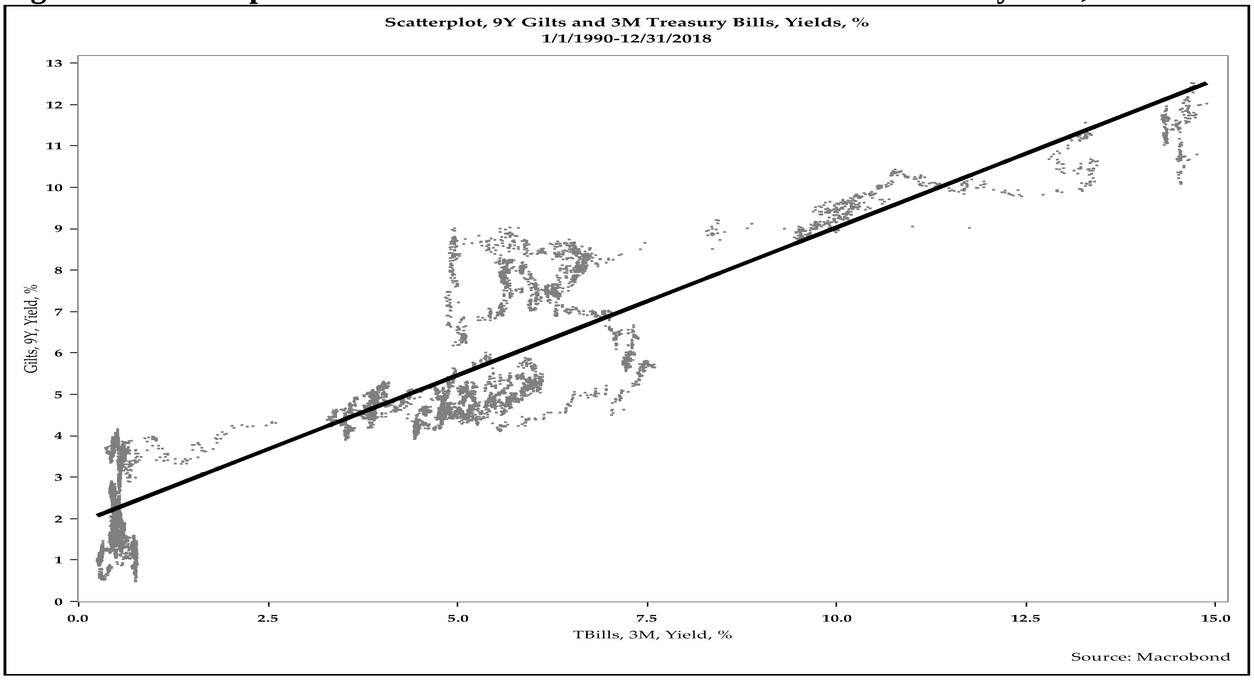

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Figure 18: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 9-Year Gilts and 3-Month Treasury Bills, 1990–2018

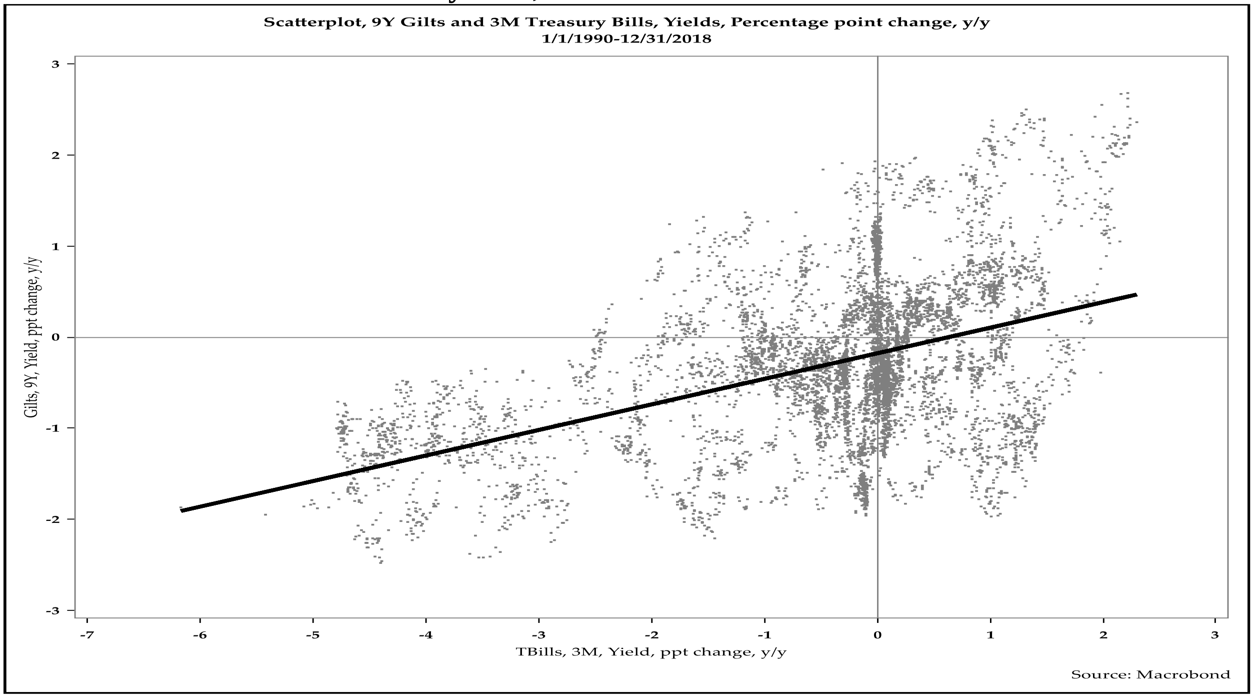

Figure 19: Scatterplot of the Yields of 10-Year Gilts and 3-Month Treasury Bills, 1990–2018

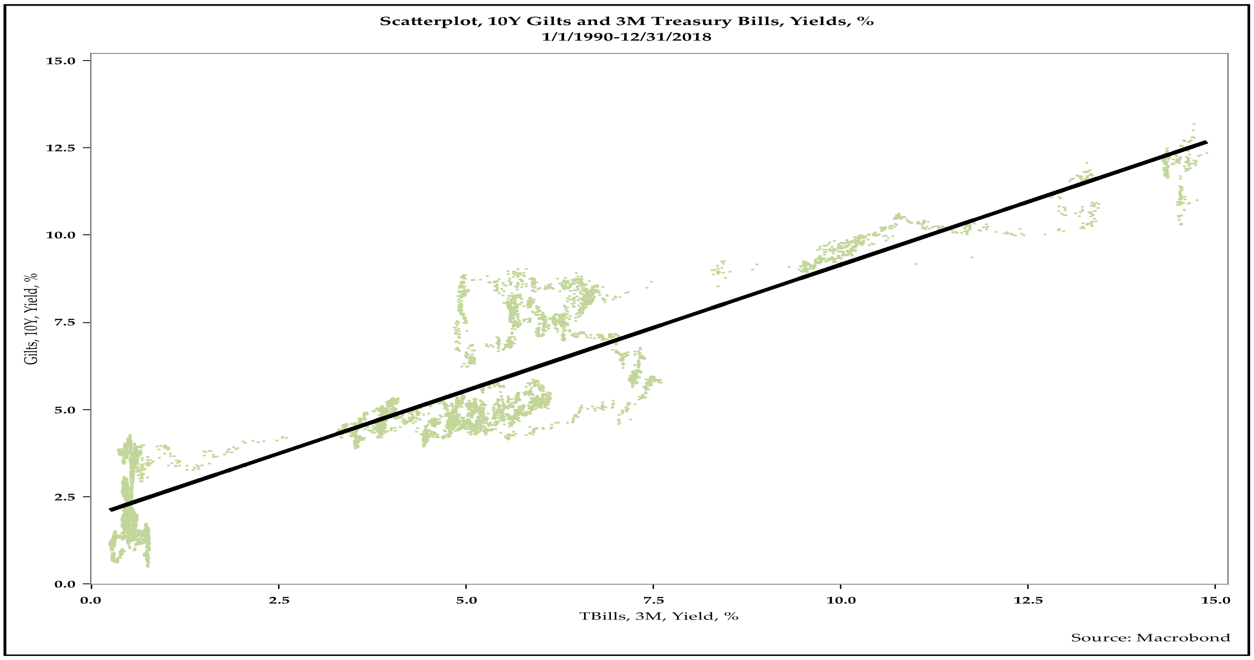

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Figure 20: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 10-Year Gilts and 3-Month Treasury Bills, 1990–2018

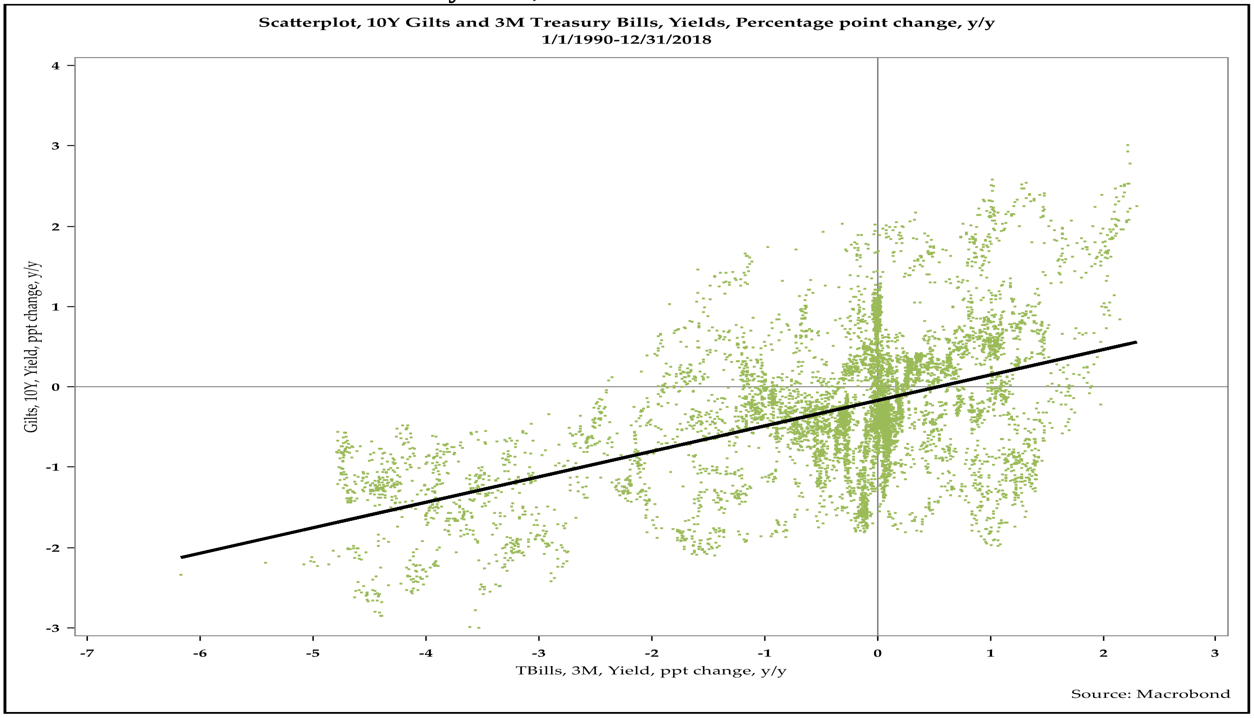

Figure 21: Scatterplot of the Yields of 20-Year Gilts and 3-Month Treasury Bills, 1990–2018

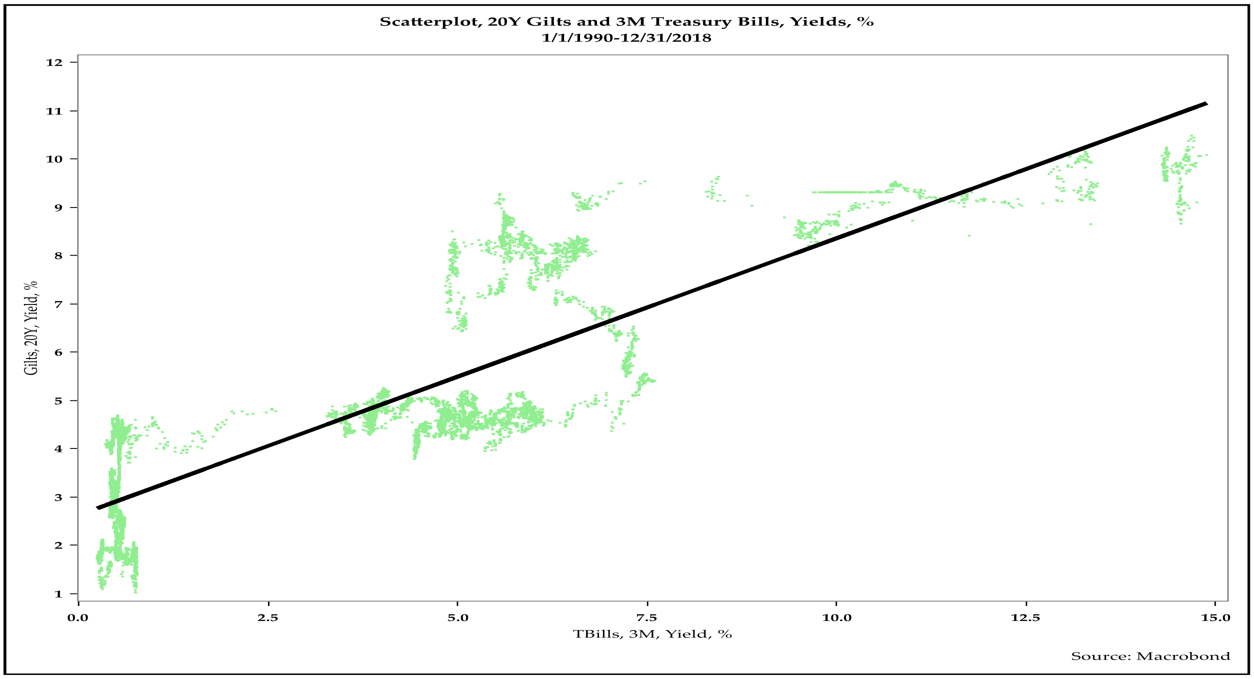

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Figure 22: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 20-Year Gilts and 3-Month Treasury Bills, 1990–2018

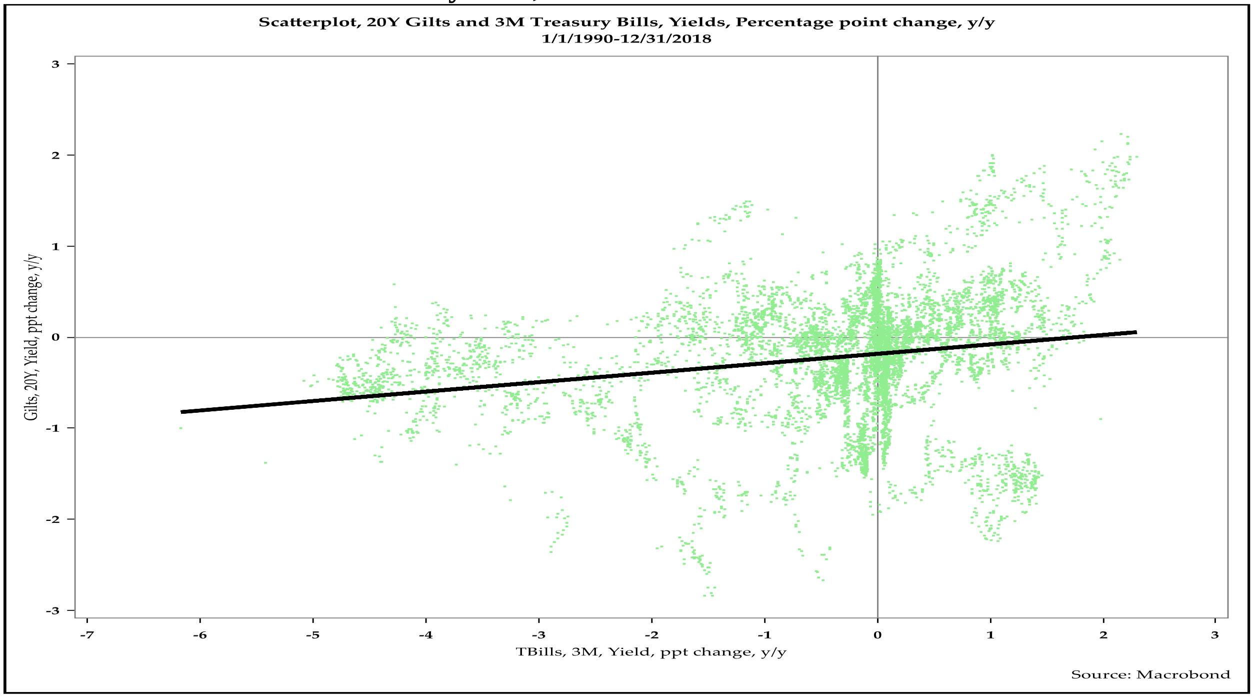

Figure 23: Scatterplot of the Yields of 30-Year Gilts And 3-Month Treasury Bills, 1998-2018

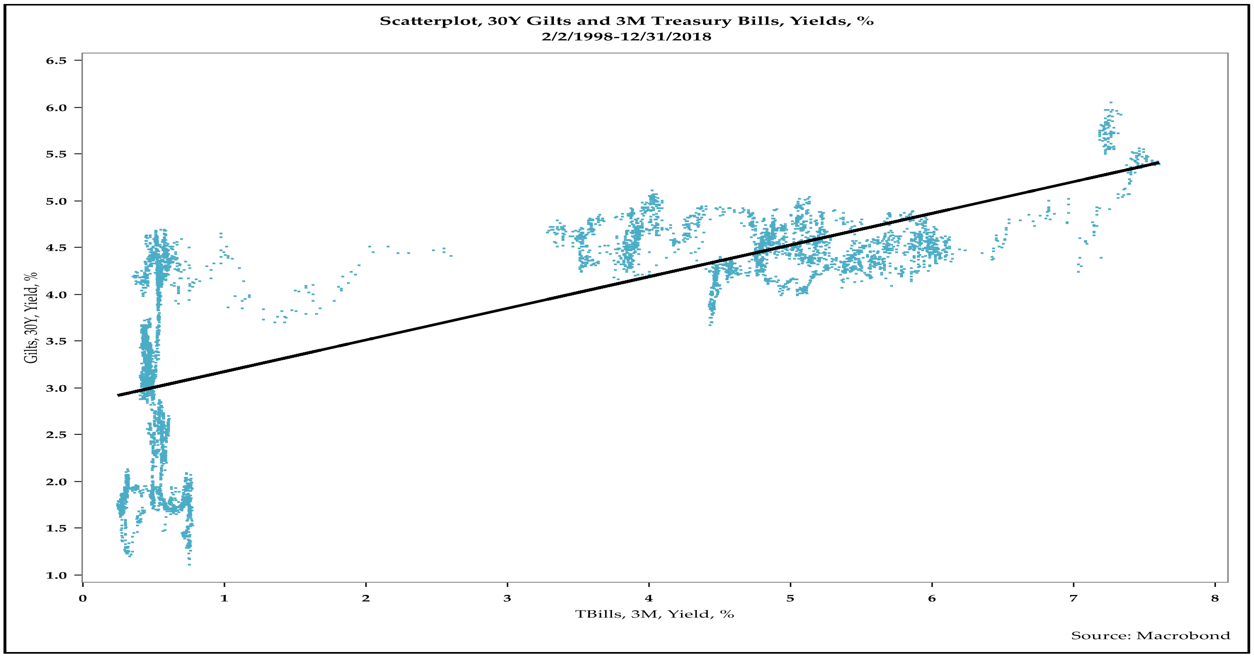

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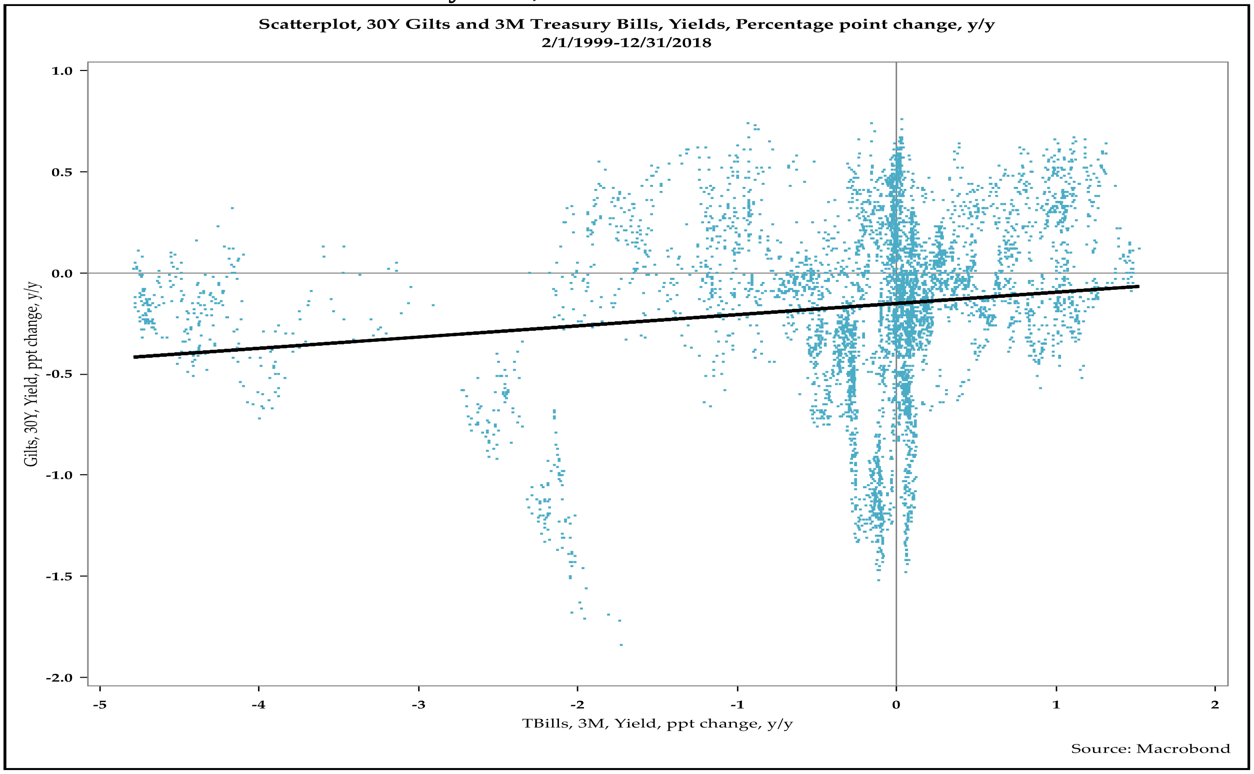
Figure 24: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 30-Year Gilts and 3-Month Treasury Bills, 1999-2018



Figures 25 and 26 show the evolution of 10-year gilts' yields and various measures of inflation. These figures display several things. First, usually nominal yields on gilts are higher than the pace of observed inflation. However, this pattern has not held since the end of the global financial crisis. Second, nominal yields on gilts have tended to decline largely in line with the decline in various measures of inflation.

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Figure 25: The Evolution of 10-Year Gilts' Yields and Total and Core Consumer Price Index (CPI) Inflation In the United Kingdom, 1990–2018

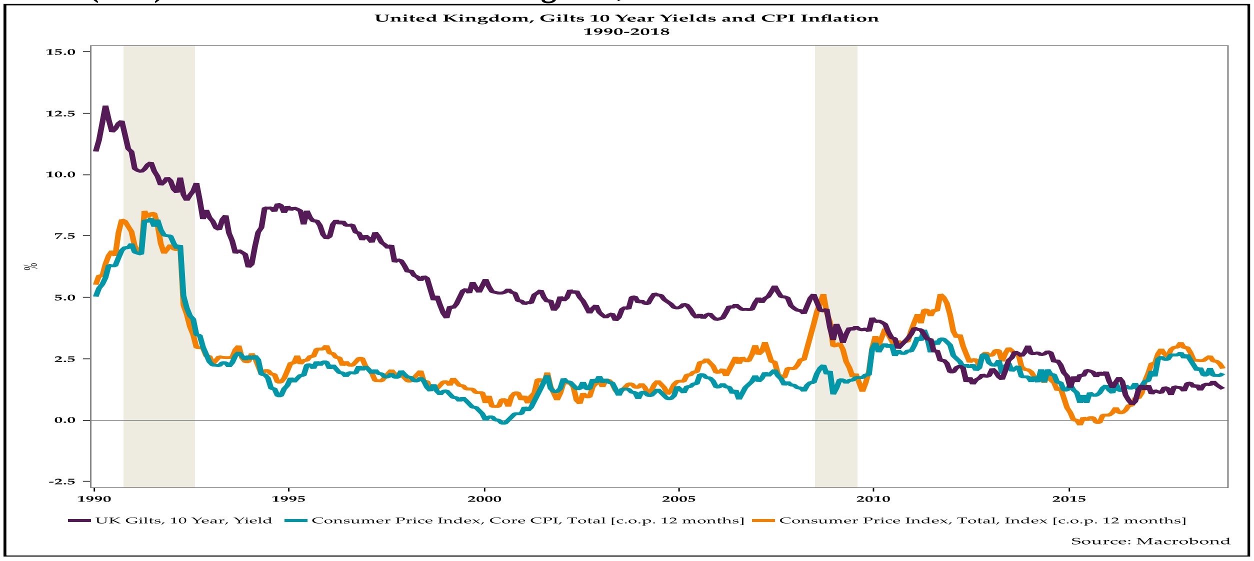
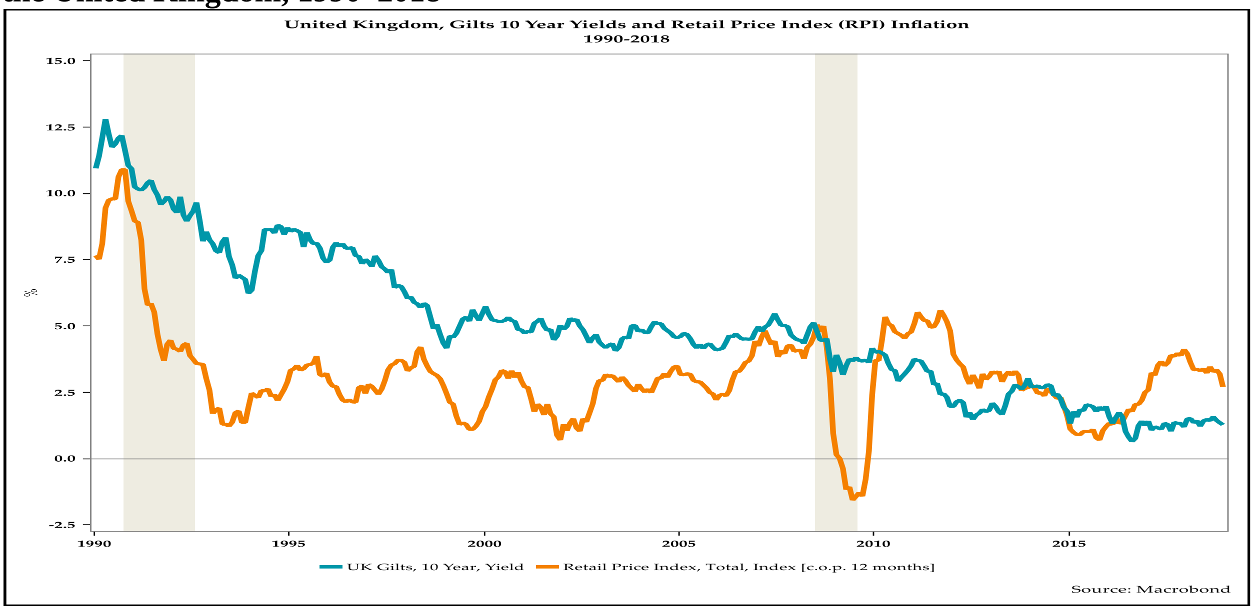


Figure 26: The Evolution 10-Year Gilts' Yields and Retail Price Index (RPI) Inflation in the United Kingdom, 1990–2018



Figures 27a and 27b display the relationship between economic activity, as measured by real GDP growth and industrial production. These variables have positive correlations. Figure 27a shows the relation between the year-over-year growth in industrial production and real GDP, while figure 27b shows the same relations between the quarter-over-quarter growth in the same two variables. Both correlations are positive, but it is markedly stronger for the year-over-year growth than for the quarter-over-quarter growth.

Figure 27a: The Evolution of Year-over-Year Change in Industrial Production and Economic Activity in the United Kingdom, 1990–2018

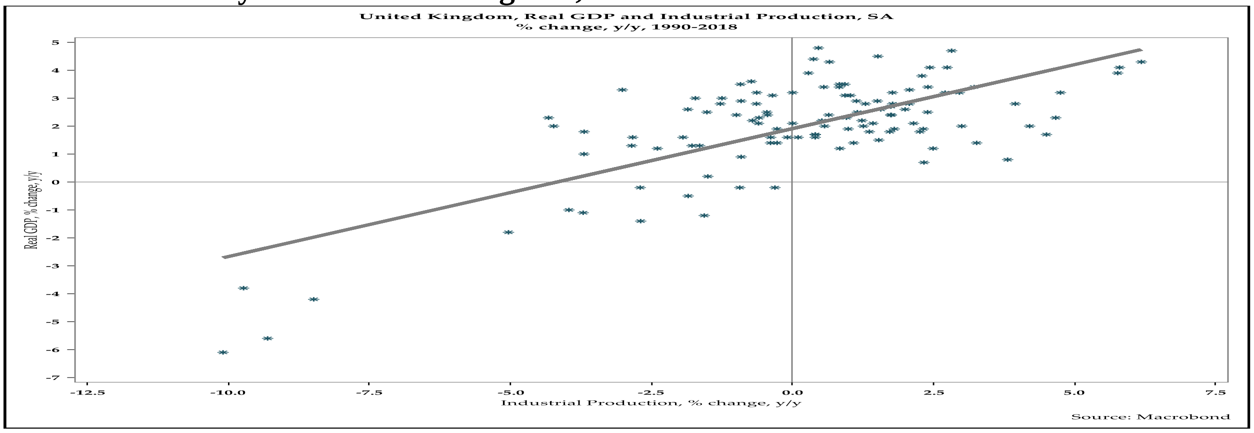


Figure 27b: The Evolution of Quarter-over-Quarter Change in Industrial Production and Economic Activity in the United Kingdom, 1990–2018

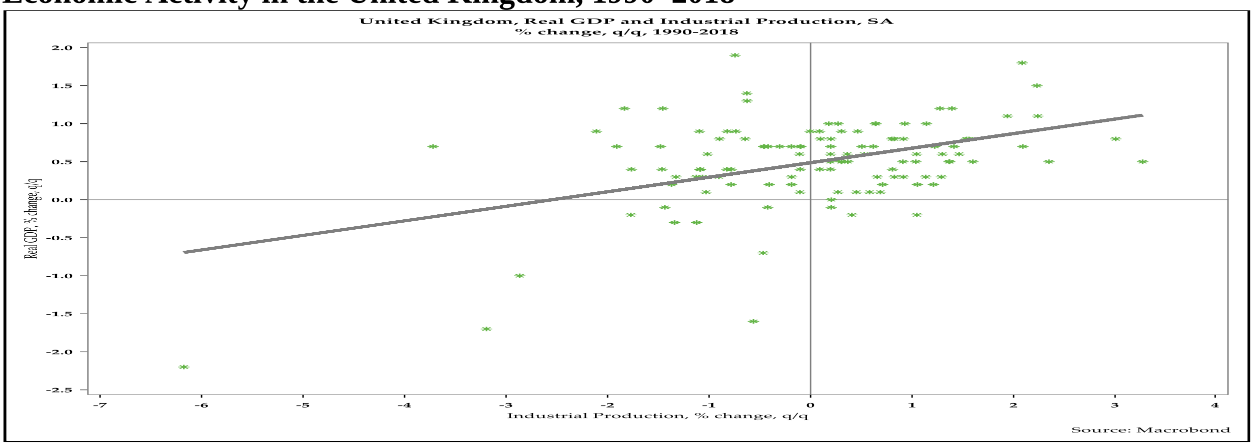


Figure 28 presents that evolution of key fiscal ratios, such as net debt, gross debt, net lending/borrowing, and primary net lending/borrowing as a share of nominal GDP (nGDP) in the United Kingdom. Usually for most years the United Kingdom incurs a fiscal deficit. The debt ratios rose markedly amid the global financial crisis due to increased fiscal deficits. Since then the debt ratios have remained high, even though fiscal deficit ratios have gradually declined.

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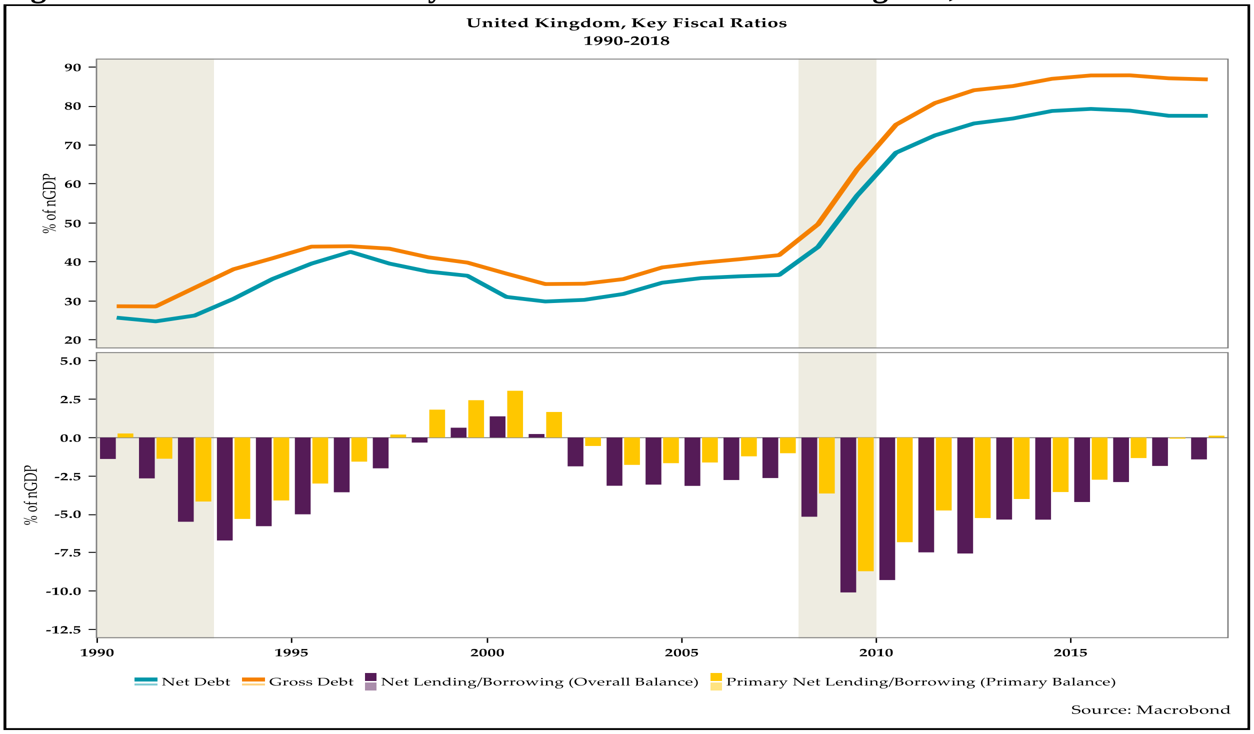
Figure 28: The Evolution of Key Fiscal Ratios in the United Kingdom, 1990–2018



3. INSTITUTIONAL OVERVIEW

Gilts are government bonds issued by the UK government through its Debt Management Office (DMO). Gilts are issued in order to finance the central government's net cash requirements and to refinance maturing debt. There are many different types of gilts. Gilts vary by maturity tenures and many other features. Most gilts provide nominal interest and capital payments, while others are indexed to inflation, as measured by the retail price index (RPI) and consumer price index (CPI). Some gilts are strippable, which means that the interest payments and redemption payments can be separately traded. Conventional gilts remain the largest part of outstanding UK government bonds. All gilts are denominated in pound sterling.

Gilts are actively traded among primary dealers, known as gilt-edged market makers (GEMMs), such as Goldman Sachs, HSBC, JP Morgan, Royal Bank of Scotland, and so forth. There is an active secondary market for gilts, while gilts can also be purchased directly from the DMO at auctions and through competitive and noncompetitive bids. Gilts are by held by investors in both

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the United Kingdom and abroad. With the exception of bearer bonds, entry in the official register confers title to gilts.

The United Kingdom exercises full monetary sovereignty, as it issues its own currency. It collects taxes in the same currency. It has a freely floating currency, as well as its own central bank and treasury.

4. DATA DESCRIPTION

This paper uses time series macroeconomic and financial data, covering from 1990 to 2018. Quarterly data on various key macroeconomic and financial variables, such as long-term interest rates, short-term interest rates, inflation, industrial production, and debt ratios, are used.

Long-term interest rates are gathered from the nominal yields of gilts of 2-, 3-, 4-, 5-, 7-, 8-, 9-, 10-, 15-, 20-, and 30-year maturity tenors. Short-term interest rates are obtained from the discount rate on UK Treasury bills of 3 months.

Table 1 provides a summary of the data used the paper. The first column displays the label for each variable. The second column lists the variables' description and the time range for the data. The third column shows the original frequency. It indicates whether the variables have been converted to a lower frequency. The last column provides both the primary and secondary sources for the data.

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Table 1. Summary of the Data

Variables	Data Description, Date Range	Frequency	Sources
Short-term interest rates			
QTB3M	Treasury bills, 3-month, yield, % Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
Long-term interest rates			
QGILTS2Y	Gilt-edged securities, 2-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS3Y	Gilt-edged securities, 3-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS4Y	Gilt-edged securities, 4-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS5Y	Gilt-edged securities, 5-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS6Y	Gilt-edged securities, 6-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS7Y	Gilt-edged securities, 7-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS8Y	Gilt-edged securities, 8-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS9Y	Gilt-edged securities, 9-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS10Y	Gilt-edged securities, 10-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS20Y	Gilt-edged securities, 20-year, yield, %, Jan 1, 1990–Dec 31, 2018	Daily; converted to quarterly	Macrobond
QGILTS30Y	Gilt-edged securities, 30-year, yield, %, Feb 1, 1998–Dec 31, 2018	Daily; converted to quarterly	Macrobond
Inflation			
QCPI	Consumer price index, total, index, % change, y/y, Jan 1990–Dec 2018	Monthly; converted to quarterly	UK Office of National Statistics (ONS); Macrobond
QCCPI	Core consumer price index, core CPI, total, % change, y/y, Jan 1997–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond

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Variables	Data Description, Date Range	Frequency	Sources
QCCPIXESF	Consumer price index, core CPI, excluding energy & seasonal food, % change, y/y, Jan 1997–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond
QCCPIXEUF	Consumer price index, core CPI, excluding energy & unprocessed food, % change, y/y, Jan 1997–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond
QCCPIXE	Consumer price index, core CPI, excluding energy, % change, y/y, Jan 1997–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond
QRPI	Retail price index, total, index, % change, y/y, Jan 1990–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond
QRPIXF	Retail price index, all items excluding food, index, % change, y/y, Jan 1990–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond
Economic Activity			
QIP	Industrial production, total, constant prices, seasonally adjusted, index, % change, y/y, Jan 1990–Dec 2018	Monthly; converted to quarterly	ONS; Macrobond
Fiscal Indicator			
QDEBT	Debt ratio, gross general government debt to nGDP, %, Seasonally adjusted, 1990Q1–2018Q3	Quarterly	ONS; Macrobond

5. EMPIRICAL MODELS AND FINDINGS

5.1 Model Specification

The vector error correction (VEC) approach to economic modeling, as developed by Johansen (1988, 1991, 1995), is appropriate for addressing the main question raised in this paper since the variables are cointegrated, as will be shown later. Johansen's model has cointegration relations built into the model specification. It restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships. Another advantage of this specification is that it allows for modeling short-run adjustment dynamics.

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The dynamic relations among the variables are examined using a vector autoregression (VAR) model. The VAR model here is adapted to the VEC representation and is as given below:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{p-t} \Delta Z_{t-p+1} + \alpha\beta' Z_{t-p} + \nu + e_t \qquad \ldots \qquad (1)$$

where

$Z_t =$ (long-term interest rate, short-term interest rate)′ (model 1),

$Z_t =$ (long-term interest rate, short-term interest rate, inflation)′ (model 2),

$Z_t =$ (long-term interest rate, short-term interest rate, inflation, industrial production)′ (model 3).

$Z_t =$ (long-term interest rate, short-term interest rate, inflation, government debt ratio)′ (model 4).

Here, $\alpha\beta' Y_{t-p}$ is the error correction component; α is an ($n \times r$) matrix that explains the long-run disequilibrium; β is an ($n \times r$) matrix of cointegrating vectors that explains the long-run relationship; $\Gamma_j \Delta Z_{t-j}$ is the VAR component in first differences; Γ_j is an ($n \times n$) matrix that stands for the short-term adjustment coefficients among variables with *p-1* number of lags; ν is a deterministic shift vector; and the model residuals e_t is white noise.

5.2 Model Estimation

In the model estimation section, unit root tests for each series are conducted. Next, tests are carried out to detect the number of cointegrating vectors in the system, given that one cannot reject the null hypothesis of nonstationary variables. Finally, appropriate models in the framework of a multivariate VEC are estimated.

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5.2.1 Unit Root Tests

Various types of unit root tests are conducted in order to determine the univariate properties of the following variables: nominal yields of UK Treasury bills of a 3-month tenor; yields of Treasury securities of 5- and 10-year tenors; CPI and RPI excluding food; the growth in the seasonally adjusted measure of the index of industrial production; and gross general government debt as a percentage of nGDP.[1]

The results are presented in tables 2a and 2b. It is evident from table 2a that the long-term rate, short-term rate, and government debt ratio are nonstationary in their levels, while inflation and industrial production are stationary in their levels. Table 2b displays the same tests for the first difference of the variables. It shows that for the first difference of all the variables, the null hypothesis of a unit root is significantly rejected.

[1] The results of the unit root tests on the nominal yields of UK government bonds of other tenors (2-, 3-, 4-, 6-, 7-, 8-, 9-, 20-, 30-years) are consistent with the nominal yields of UK government bonds of 5- and 9-year tenors. Those results are provided in appendix tables A1 and A2.

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Table 2a. Unit Root Tests (Level)

Variable		Tests		P-value	Obs.
QGILTS5Y	Trend	ADF	-3.891	0.013	114
		PP	-3.962	0.010	114
	No trend	ADF	-2.452	0.128	114
		PP	-2.478	0.121	114
	No trend, No constant	ADF	-3.077		114
		PP	-3.188		114
QGILTS10Y	Trend	ADF	-3.508	0.039	114
		PP	-3.509	0.038	114
	No trend	ADF	-2.424	0.135	114
		PP	-2.466	0.124	114
	No trend, No constant	ADF	-3.120		114
		PP	-3.275		114
QTB3M	Trend	ADF	-3.229	0.079	114
		PP	-3.361	0.057	114
	No trend	ADF	-3.471	0.009	114
		PP	-3.067	0.029	114
	No trend, No constant	ADF	-4.193		114
		PP	-3.450		114
QCPI	Trend	ADF	-9.178	0.000	114
		PP	-9.351	0.000	114
	No trend	ADF	-8.962	0.000	114
		PP	-9.123	0.000	114
	No trend, No constant	ADF	-5.914		114
		PP	-5.942		114
QRPIXF	Trend	ADF	-8.01467	0.000	114
		PP	-7.79856	0.000	114
	No trend	ADF	-8.00068	0.000	114
		PP	-7.78282	0.000	114
	No trend, No constant	ADF	-5.09571		114
		PP	-4.82547		114
QIP	Trend	ADF	-11.268	0.000	114
		PP	-11.284	0.000	114
	No trend	ADF	-11.283	0.000	114
		PP	-11.301	0.000	114
	No trend, No constant	ADF	-11.326		114
		PP	-11.339		114
QDEBT	Trend	ADF	-1.06	0.936	114
		PP	-1.32	0.883	114
	No trend	ADF	0.58	0.987	114
		PP	0.10	0.971	114
	No trend, No constant	ADF	3.41		114
		PP	2.22		114

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Table 2b. Unit Root Tests (First Difference)

Variable		Tests	Statistic	P-value	Obs.
ΔQGILTS5Y	Trend	ADF	-9.733	0.000	113
		PP	-9.712	0.000	113
	No trend	ADF	-9.690	0.000	113
		PP	-9.663	0.000	113
	No trend, No constant	ADF	-9.471		113
		PP	-9.429		113
ΔQGILTS10Y	Trend	ADF	-9.588	0.000	113
		PP	-9.538	0.000	113
	No trend	ADF	-9.510	0.000	113
		PP	-9.450	0.000	113
	No trend, No constant	ADF	-9.226		113
		PP	-9.163		113
ΔTB3M	Trend	ADF	-6.502	0.000	113
		PP	-6.378	0.000	113
	No trend	ADF	-6.346	0.000	113
		PP	-6.228	0.000	113
	No trend, No constant	ADF	-6.168		113
		PP	-6.057		113
ΔQCPI	Trend	ADF	-18.2029	0.000	113
		PP	-27.7034	0.000	113
	No trend	ADF	-18.2346	0.000	113
		PP	-27.2516	0.000	113
	No trend, No constant	ADF	-18.3047		113
		PP	-27.2429		113
ΔQRPIXF	Trend	ADF	-14.07	0.000	113
		PP	-16.996	0.000	113
	No trend	ADF	-14.0646	0.000	113
		PP	-16.8417	0.000	113
	No trend, No constant	ADF	-14.1138		113
		PP	-16.8806		113
ΔQIP	Trend	ADF	-21.728	0.000	113
		PP	-29.130	0.000	113
	No trend	ADF	-21.826	0.000	113
		PP	-29.295	0.000	113
	No trend, No constant	ADF	-21.923		113
		PP	-29.454		113
ΔQDEBT	Trend	ADF	-8.27087	0.000	113
		PP	-8.73021	0.000	113
	No trend	ADF	-8.23302	0.000	113
		PP	-8.68203	0.000	113
	No trend, No constant	ADF	-7.62341		113
		PP	-8.10265		113

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5.2.2 Cointegration Test

Initially Johansen and Juselius's (1990) cointegration method is applied to determine whether there is a stable, long-run relationship between the key variables (the short-term interest rate, inflation, industrial production, and the debt ratio) and the long-term interest rate.

To analyze the cointegration relationships between the variables, eight VAR models are defined. They are:

- (QGILTS5Y, QTB3M)
- (QGILTS5Y, QTB3M, QCPI)
- (QGILTS5Y, QTB3M, QRPIXF)
- (QGILTS5Y, QTB3M, QIP)
- (QGILTS5Y, QTB3M, QDEBT)
- (QGILTS5Y, QTB3M, QCPI, QIP)
- (QGILTS5Y, QTB3M, QRPIXF, QIP)
- (QGILTS5Y, QTB3M, QCPI, QDEBT)
- (QGILTS5Y, QTB3M, QRPIXF, QDEBT)

Table 3 presents test statistics for determining whether there is a long-run relationship between the variables in any of those models. However, the results based on VARs are generally found to be sensitive to the lag length used and the ordering of the variables. Lag lengths were chosen based on Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC) before determining the number of cointegrating vectors.

The Johansen cointegration test compares both trace and likelihood eigenvalue statistics to their critical values. The null hypothesis is that there is no significant difference between the log likelihood of the unconstrained model with the cointegrating equations and the log likelihood of the constrained model that does not include the cointegrating equations. The test starts from the model with no cointegration and proceeds to the model with two cointegrating vectors, accepting the first null hypothesis cannot be rejected. For instance, in the case of (QGILTS5Y, QTB3M), the trace statistic at r=0 of 20.755 exceeds its critical value of 20.04. Therefore, the null hypothesis of no cointegrating equations can be rejected. The trace statistic at r=1 of 4.4355 is

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less than the critical value of 6.65 at the 10 percent level of significance. Therefore, the null hypothesis that there is one cointegrating vector in the system cannot be rejected. The maximum eigenvalue test provides more conclusive evidence regarding the exact number of cointegrating vectors in the system. According to table 3, these findings suggest that there is no cointegrating equation in some of those models. However, since standard cointegration techniques could be biased toward accepting the null hypothesis of no cointegration in the presence of structural breaks, further analysis is required. The scope for potential structural breaks is explored, based on Gregory and Hansen’s (1996) cointegration test.

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Table 3: Multivariable Cointegration Tests

Trace Test			Maximum Eigenvalue Test		
Null Hypo.	**Test Statistic**	**1% Critical Value**	**Null Hypo.**	**Test Statistic**	**1% Critical Value**
(QGILTS5Y, QTB3M); AIC lag-order=2					
r=0	20.755	20.04	r=0	16.3195*	18.63
r#1	4.4355*	6.65	r#1	4.4355	6.65
(QGILTS5Y, QTB3M, QCPI); AIC lag-order=4					
r=0	29.3444*	35.65	r=0	18.8865*	25.52
r#1	10.4579	20.04	r#1	8.1718	18.63
r#2	2.2861	6.65	r#2	2.2861	6.65
(QGILTS5Y, QTB3M, QRPIXF); AIC lag-order=5					
r=0	43.2731	35.65	r=0	27.9912	25.52
r#1	15.2818*	20.04	r#1	13.0318*	18.63
r#2	2.25	6.65	r#2	2.25	6.65
(QGILTS5Y, QTB3M, QIP); AIC lag-order=3					
r=0	54.6696	35.65	r=0	29.7165	25.52
r#1	24.9531	20.04	r#1	20.8084	18.63
r#2	4.1447*	6.65	r#2	4.1447*	6.65
(QGILTS5Y, QTB3M, QDEBT); AIC lag-order=6					
r=0	27.2083*	35.65	r=0	18.1245*	25.52
r#1	9.0839	20.04	r#1	8.3829	18.63
r#2	0.7009	6.65	r#2	0.7009	6.65
(QGILTS5Y, QTB3M, QCPI, QIP); AIC lag-order=4					
r=0	56.4369	54.46	r=0	28.0833*	32.24
r#1	28.3536*	35.65	r#1	18.5357	25.52
r#2	9.8179	20.04	r#2	7.9101	18.63
r#3	1.9078	6.65	r#3	1.9078	6.65
(QGILTS5Y, QTB3M, QRPIXF, QIP); AIC lag-order=5					
r=0	70.2984	54.46	r=0	32.723	32.24
r#1	37.5754	35.65	r#1	23.0184*	25.52
r#2	14.5570*	20.04	r#2	13.1492	18.63
r#3	1.40	6.65	r#3	1.3978	6.65
(QGILTS5Y, QTB3M, QCPI, QDEBT); AIC lag-order=11					
r=0	62.0342	54.46	r=0	36.038	32.24
r#1	25.9962*	35.65	r#1	18.3072*	25.52
r#2	7.6889	20.04	r#2	7.45	18.63
r#3	0.2389	6.65	r#3	0.2389	6.65
(QGILTS5Y, QTB3M, QRPIXF, QDEBT); AIC lag-order=5					
r=0	65.0425	54.46	r=0	41.9413	32.24
r#1	23.1011*	35.65	r#1	16.2056*	25.52
r#2	6.8956	20.04	r#2	6.0819	18.63
r#3	0.8137	6.65	r#3	0.8137	6.65

Note 1: r denotes the number of cointegrated vectors.
Note 2: Lag lengths were chosen by AIC.
Note 3: * denotes significance at the 10 percent level.

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5.2.3 Testing for Structural Breaks

Gregory and Hansen's (1996) cointegration test extends Engle and Granger's (1987) procedure by allowing a structural break in either the intercept or the intercept and the cointegrating coefficient. The advantage of the Gregory-Hansen test is that it allows for a one-time, endogenously determined structural break in the cointegrating vector.

Three different models of (QGILTS5Y, QTB3M), (QGILTS5Y, QTB3M, QCPI), and (QGILTS5Y, QTB3M, QCPI, QDEBT) are tested for structural breaks. These models are:

(i) *Model C* allows for cointegration with a change in intercept only;
(ii) *Model C/T* includes a time trend into shift; and
(iii) *Model C/S* takes into consideration the simultaneous presence of both a mean and slope break.

Each of the models has a dummy variable that is determined endogenously to allow for a structural break. The dummy is zero before a breakpoint and one afterwards. The null hypothesis in all three models is that the residuals are nonstationary. In contrast, the alternative hypothesis is that the residuals are stationary with one structural break at an unknown time. Three different unit root tests (ADF test with ADF statistic; PP test with Z_t, Z_a statistics) on the residuals obtained from those models are used to choose the breakpoints that are associated with the smallest values of the unit root statistics. Asymptotic critical values of these unit root tests are available in Gregory and Hansen (1996).

Table 4 shows that the null hypothesis of no cointegration is rejected by most models. This implies that a structural change is indeed present in the long-run cointegration equation. Thus, these findings support the conjecture that there is a bias toward the null hypothesis of no cointegration arising from Johansen cointegration tests when there is a structural break. Hence, it would be prudent to identify such structural breaks and construct suitable models that allow for structural breaks.

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Table 4: Gregory and Hansen Cointegration Tests for Regime Shifts

	(QGILTS5Y, QTB3M)		(QGILTS5Y, QTB3M, QCPI)		(QGILTS5Y, QTB3M, QCPI, QDEBT)	
	Test Stat.	**Breakpoint**	**Test Stat.**	**Breakpoint**	**Test Stat.**	**Breakpoint**
ADF						
Model C	-4.35*	1996q1	-4.31	1996q4	-5.52**	1997q4
Model C/T	-5.38**	1996q4	-5.53**	1996q2	-5.94**	1997q1
Model C/S	-5.75**	1996q1	-6.26**	1996q2	-6.53**	1996q2
Z_t						
Model C	-4.24	1996q4	-4.41	1996q4	-5.95***	1997q3
Model C/T	-5.64***	1996q4	-5.70**	1996q4	-6.20***	1997q3
Model C/S	-5.93**	1996q4	-6.14**	1996q2	-6.21*	1997q3
Z_a						
Model C	-28.49	1996q4	-31.55	1996q4	-49.22*	1997q3
Model C/T	-45.64*	1996q4	-44.39	1996q4	-51.35	1997q3
Model C/S	-48.26	1996q4	-48.08	1996q2	-50.58	1997q3

Note 1: *, **, and *** imply significance at 10 percent, 5 percent, and 1 percent levels, respectively.
Note 2: The model specifications are denoted by C-level shift, C/T- level shift with a trend, C/T-regime trend.
Note 3: Critical values are taken from Gregory and Hansen (1996).
Note 4: The results of models with QGILTS10Y and QRPIXF are similar and are available upon request.

In model (QGILTS5Y, QTB3M, QCPI, QDEBT), the modified Chow break test proposed by Shehata (2011) is applied on those break dates (1996q2, 1997q1, 1997q3, 1997q4) separately.[2]

This methodology provides three types of regressions, including:

(1) independent variable (X) with a dummy,
(2) X with each X multiplied with a dummy, and
(3) X with both a dummy and each X multiplied with a dummy.

The dummy is zero before a breakpoint and one afterwards. According to table 5, for all types of regression, the Chow test statistics are quite large and with p-values near zero. Thus, the Chow

[2] The results of models with QRPIXF are similar and are available upon request.

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break test results imply rejecting the null hypothesis of no structural breaks for all dates specified.

Thus, after incorporating these structural breaks in the model, there is evidence of cointegration in models with the long-term interest rate, the short-term interest rate, inflation rate, the growth of industrial production, and the government debt ratio.

Table 5: Chow Test and Structural Change Regressions

	(QGILTS5Y, QTB3M, QCPI, QDEBT)								
	DUM1996q2			DUM1997q1			DUM1997q3		
	Chow test_1	Chow test_2	Chow test_3	Chow test_1	Chow test_2	Chow test_3	Chow test_1	Chow test_2	Chow test_3
QTB3M	0.480*** (0.0371)	0.497*** (0.0396)	0.512*** (0.0592)	0.450*** (0.0331)	0.488*** (0.0352)	0.494*** (0.0513)	0.434*** (0.0334)	0.482*** (0.0360)	0.459*** (0.0511)
QCPI	0.000551 (0.000987	0.00141 (0.00144)	0.00136 (0.00145)	0.00113 (0.000864	0.00170 (0.00126)	0.00169 (0.00127)	0.00118 (0.000858	0.00165 (0.00128)	0.00170 (0.00129)
QDEBT	-0.0357*** (0.00500)	0.0293** (0.0129)	0.0384 (0.0297)	-0.0370*** (0.00441)	0.0162 (0.0109)	0.0195 (0.0236)	-0.0384*** (0.00439)	-0.000404 (0.0109)	-0.0127 (0.0218)
CONSTANT	5.907*** (0.450)	3.506*** (0.493)	3.081** (1.349)	6.133*** (0.393)	3.942*** (0.439)	3.778*** (1.116)	6.239*** (0.394)	4.476*** (0.457)	5.095*** (1.058)
DUM	-1.860*** (0.188)		0.491 (1.450)	-2.012*** (0.160)		0.194 (1.214)	-2.021*** (0.159)		-0.762 (1.174)
DUM*QTB3M		0.0512 (0.0517)	0.0299 (0.0818)		-0.0115 (0.0462)	-0.0205 (0.0729)		-0.0713 (0.0477)	-0.0332 (0.0757)
DUM*QCPI		-0.000774 (0.00198)	-0.000742 (0.00199)		-0.000500 (0.00176)	-0.000498 (0.00176)		-0.000917 (0.00179)	-0.00092 (0.00180)
DUM*QDEBT		-0.0594*** (0.00907)	-0.0692** (0.0304)		-0.0515*** (0.00743)	-0.0552** (0.0243)		-0.0408*** (0.00725)	-0.0269 (0.0227)
Obs.	115	115	115	115	115	115	115	115	115
Adj R2	0.9525	0.9556	0.9552	0.9632	0.9648	0.9644	0.9637	0.9635	0.9633
Chow test statistics	97.4636	37.9107	28.2285	157.787	57.1596	42.4893	161.3375	53.8686	40.29
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note 1: *, **, and *** imply significance at the 10 percent, 5 percent, and 1 percent levels, respectively.
Note 2: Chow test types: (1) Y=X+DUM; (2) Y=X+DX; (3) Y=X+DUM+DX, where: DUM=Dummy variable (0, 1), takes (0) in first period, and (1) in second period. DX=Cross product of each Xi times in DUM.
Note 3: The results of models with dum1997q4 are similar with model with dum1997q3 and are available upon request.

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5.2.4 Vector Error Correction Model

Table 6 presents the estimation of the four models from the model specification section:

$Z_t =$ (long-term interest rate, short-term interest rate)′ (model 1),

$Z_t =$ (long-term interest rate, short-term interest rate, inflation)′ (model 2),

$Z_t =$ (long-term interest rate, short-term interest rate, inflation, growth rates)′ (model 3),

$Z_t =$ (long-term interest, short-term interest rate, inflation, government debt ratio)′ (model 4).[3]

In model 1, the long-term interest rate is regressed only on the short-term interest rate. The coefficient is highly significant and it suggests that an increase in the short-term interest rate by 1 percentage point increases the long-term interest rate by 80 basis points. The addition of the other variables, one by one, leaves the coefficient on the short-term interest rate always highly significant, but its size changes across different models (from 0.800 to 0.783). Table 6a displays results from these models using 5-year government bonds, whereas table 6b displays results using 10-year government bonds. The results are similar in sign, size, and statistical significance.

Several diagnostic tests are performed to check for misspecifications, like serial correlation or nonnormality. First, the Breusch-Godfrey Lagrange Multiplier test of serial correlation in the residuals shows that for all models the null hypothesis that there is no serial correlation cannot be rejected. Since in cointegration analysis the data has been corrected for unit roots, serial correlation as such is not a serious problem.

Second, the skewness statistic is computed to test the null hypothesis that the residuals are normally distributed. At the 1 percent level, the null hypotheses are rejected for all models since all the p-values are less than 0.01. Thus, the results of the skewness test do not suggest that the residuals are normally distributed in these four models. However, such findings regarding nonnormality of residuals are not at all unusually for macro-financial models of asset prices and interest rates.

[3] Model 1´, model 2´, and model 3´ use QGILTS10Y instead of QGILTS5Y.

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Table 6a: Johansen VEC Model

	Model 1	Model 2-1	Model 2-2	Model 3	Model 4-1	Model 4-2
Long-run relationship	**GILTS5Y_Q**					
QTB3M	-0.800*** (0.0645)	-0.864*** (0.0883)	-0.824*** (0.0754)	-0.831*** (0.164)	-0.561*** (0.121)	-0.783*** (0.0967)
QCPI		-0.00990 (0.00652)			0.0326*** (0.00543)	
QRPIXF			0.0308*** (0.00605)			0.0198*** (0.00330)
QIP				0.0355*** (0.00642)		
QDEBT					0.0328*** (0.0123)	0.0134 (0.00983)
CONSTANT	-3.198	-2.469	-3.706	-3.699	-7.238	-3.943
Error correction terms						
Eq. QGILTS5Y	-0.0275 (0.0659)	0.0467 (0.0554)	-0.104* (0.0538)	0.0542*** (0.0194)	-0.418*** (0.112)	-0.178** (0.0894)
Eq. QGILTS10Y						
Eq. QTB3M	0.183*** (0.0563)	0.174*** (0.0475)	0.0214 (0.0492)	0.0496*** (0.0177)	-0.400*** (0.0983)	0.0494 (0.0828)
Eq. QCPI		10.03 (6.319)			-43.58*** (10.21)	
Eq. QRPIXF			-17.73*** (6.670)			-33.70*** (11.21)
Eq.QIP				-17.56*** (5.106)		
Eq. QDEBT					0.426* (0.222)	-0.288 (0.199)
Diagnostics						
Obs.	113	111	110	112	104	110
Lags	2	4	5	3	11	5
AIC	2.334	13.204	13.034	14.954	15.758	16.016
Log Likelihood	-118.885	-691.801	-666.858	-805.447	-632.415	-789.903
Serial Correlation test	4.811	10.788	5.161	13.293	16.538	15.18
P-value	0.3070	0.291	0.82	0.15	0.416	0.511
Skewness test	118.896	133.952	88.096	97.884	23.993	88.362
P-value	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000

Note 1: *, **, *** imply significance at 10 percent, 5 percent, 1 percent level, respectively.
Note 2: Test statistics and p-values are presented in respective rows.
Note 3: The results of all other long-term interest rates with dummy variables are available upon request.

`

Table 6b: Johansen VEC Model

	Model 1'	Model 2-1'	Model 2-2'	Model 3'	Model 4-1'	Model 4-2'
Long-run relationship	**GILTS10Y_Q**					
QTB3M	-0.647*** (0.0696)	-0.808 (0.511)	-5.877** (2.544)	1.926 (2.046)	-0.435* (0.250)	-0.776*** (0.151)
QCPI		0.203*** (0.0275)			0.0535*** (0.0106)	
QRPIXF			1.394*** (0.140)			0.0264*** (0.00497)
QIP				0.537*** (0.0651)		
QDEBT					0.0325 (0.0253)	-9.71e-05 (0.0154)
CONSTANT	-4.226	-17.89	-90.46	-49.48	0.886	8.588
Error correction terms						
Eq. QGILTS5Y						
Eq. QGILTS10Y	-0.0659 (0.0576)	-0.0137*** (0.00425)	-0.00164*** (0.000539)	0.00190* (0.000969)	-0.133** (0.0522)	-0.123** (0.0501)
Eq. QTB3M	0.157*** (0.0577)	-0.00988** (0.00450)	-0.00141** (0.000563)	0.000425 (0.00102)	-0.181*** (0.0549)	0.00511 (0.0566)
Eq. QCPI		-4.480*** (0.607)			-23.56*** (5.555)	
Eq. QRPIXF			-0.773*** (0.0791)			-26.93*** (7.529)
Eq.QIP				-2.028*** (0.283)		
Eq. QDEBT					0.259** (0.119)	-0.162 (0.133)
Diagnostics						
Obs.	113	113	113	113	104	110
Lags	2	2	2	2	11	5
AIC	2.23	13.328	13.166	14.816	15.689	15.92
Log Likelihood	-115.017	-733.026	-726.864	-817.09	-636.853	-796.622
Serial Correlation test	3.703	9.317	5.167	18.328	18.188	14.64
P-value	0.435	0.409	0.819	0.032	0.313	0.551
Skewness test	116.382	188.936	116.763	114.652	35.833	147.495
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note 1: *, **, *** imply significance at 10 percent, 5 percent, and 1 percent level, respectively.
Note 2: Test statistics and p-values are presented in respective rows.
Note 3: The results of all other long-term interest rates with dummy variables are available upon request.

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5.2.5 Interpretation of VEC Model Results

Based on the postestimation statistics, model 4 with QCPI in table 6a is treated here as a baseline model for further and more detailed examination. After normalizing on the long-term interest rate, the cointegrating vectors associated with the largest eigenvalues yield the following cointegrating relationship.[4]

$$QGILTS5Y = 7.238 + 0.561\, QTB3M - 0.0326\, QCPI - 0.0328\, QDEBT \qquad (2)$$

The results of equation (2) show that there is a significant long-run relationship between the short-term interest rate, inflation, the government debt ratio, and the long-term interest rate after incorporating structural breaks into the cointegrating vector. There is a significant positive relationship between the short-term interest rate and the long-term interest rate. A 1 percentage point increase in the short-term interest rate causes a 56.1 basis point increase in the long-term interest rate.

The error correction terms presented in the middle panel of table 6a are derived from the long-run cointegration relationship. The significance of error correction terms indicates the long-term causal relationship. Model 3 with QIP has a negative and highly significant coefficient of error correction term for one of the four equations: Eq. QIP. This implies that there is a long-run cointegration equation with QIP as the "dependent variable." The error correction terms for the other two equations are positive. Thus, the cointegration relation only enters significantly in the growth rates equation. When examining the adjustment coefficients in model 4 with QCPI, it appears that three (Eq. QGILTS5Y, Eq. QTB3M, and Eq. QCPI) of the four adjustment coefficients have negative and significant signs, indicating an adjustment process of the short-run disequilibrium in the cointegration system toward the long-run equilibrium. In contrast, the estimated error correction term in the equations of QDEBT does not contribute to the error correction adjustment.

[4] Signs in tables 6a and 6b are reversed because of the normalization process.

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Turning to the short-run estimates for model 4 with QCPI (see table 7), the effect of inflation on the long-term interest rate is positive, while the short-term rate has a negative effect when lagged two quarters (-0.476**). Moreover, in the short run, a 1 percentage point increase in the dummy variable (1997q3) will result in a 116.5 basis point increase in the long-term interest rate, which confirms an increasing trend for the long-term interest rates in the period after 1997q3, in contrast to a declining trend after 1997q4.

Table 7: Short-run Adjustment Coefficients

Short-run Adjustment Coefficients (Model 4, Table 6)		
Model	**(QGILTS5Y, QTB3M, QCPI, QDEBT)**	
	Coeffi.	**Std. Error**
ECT	-0.418***	(0.112)
ΔQGILTS5Y(-1)	0.474***	(0.181)
ΔQGILTS5Y(-2)	0.330*	(0.173)
ΔQTB3M(-1)	-0.206	(0.198)
ΔQTB3M(-2)	-0.476**	(0.186)
ΔQCPI(-1)	0.00977***	(0.00338)
ΔQCPI(-3)	0.00711***	(0.00265)
ΔQCPI(-6)	0.00349*	(0.00191)
ΔQDEBT(-1)	-0.0361	(0.0673)
ΔQDEBT(-2)	0.0646	(0.0653)
Dum1996q2	0.108	(0.392)
Dum1997q1	-0.727	(0.514)
Dum1997q3	1.165*	(0.693)
Dum1997q4	-1.454**	(0.609)
CONSTANT	-0.189	(0.183)

Note 1: *, **, and *** imply significance at the 10 percent, 5 percent, and 1 percent levels, respectively.
Note 2: "ΔX(-1)" represents one lag of the first difference variable; "ΔX(-2)" represents two lags of the first difference variable X.

5.3 Stability Tests

A graphical procedure is deployed here to evaluate the constancy of the estimated coefficients. The procedure is based on recursive estimation to evaluate the stability of the cointegrating vector and the error correction terms. If the model is stable, one should expect the estimated coefficients to display random fluctuation and noise. The stability tests are carried out by starting

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with a subsample of 30 observations, then sequentially adding one observation at a time, then running the regression until the end of the sample is reached. The results are plotted in figure 29.

The top panel in figure 29 shows the series of recursive estimated coefficients attached to the error correction terms. The error correction terms of the long-term interest rates equation (alpha1), short-term interest rates equation (alpha2), and government debt ratio (alpha4) are set to some fairly constant levels through the recursive procedures and are all stable. The error correction term of the inflation rates equation (alpha3) appears unstable and follows a declining trend at the start of the procedures. However, as sample size increases, the estimated coefficient settles down to a value around -40.

In the bottom panel of figure 29, the series of recursive estimated coefficients of the cointegrating vector are plotted. The estimated coefficients of CPI (beta3) and DEBT (beta4) are stable, while the estimated coefficients of short-term interest rates (beta2) appear unstable. However, as the sample size increases, the estimated coefficient settles down to a value around -1. Overall, figure 29 provides clear evidence of the stability of the coefficients in the estimated model.

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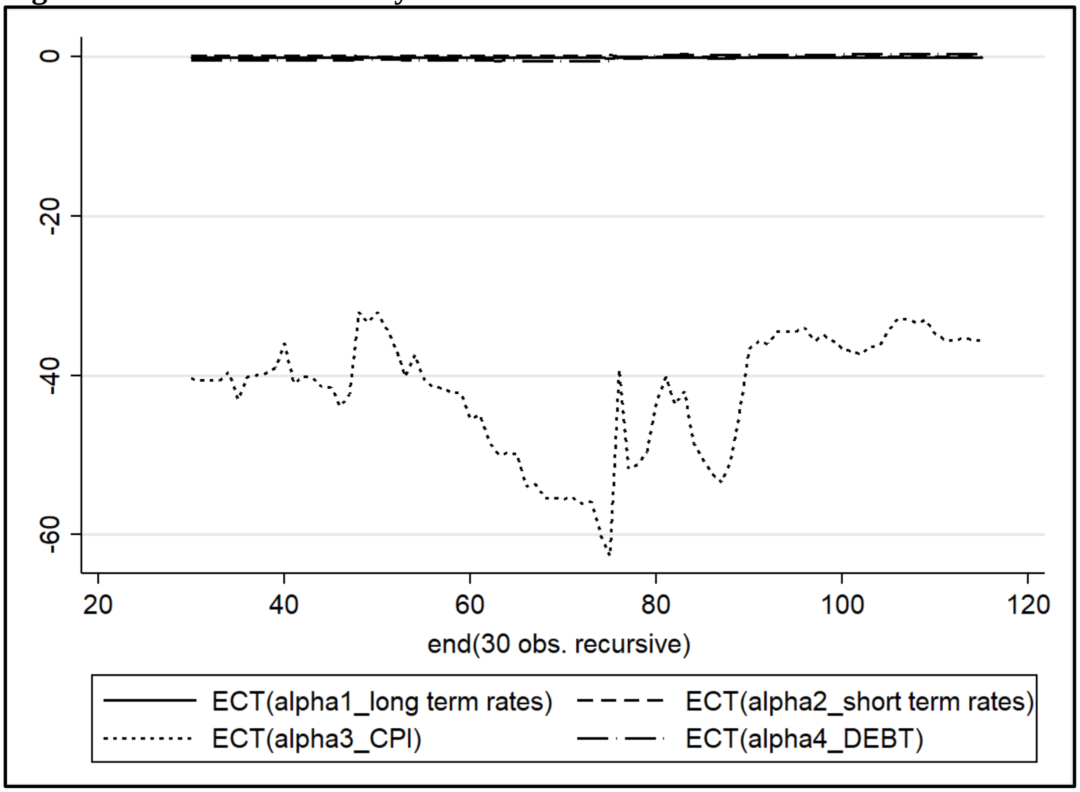
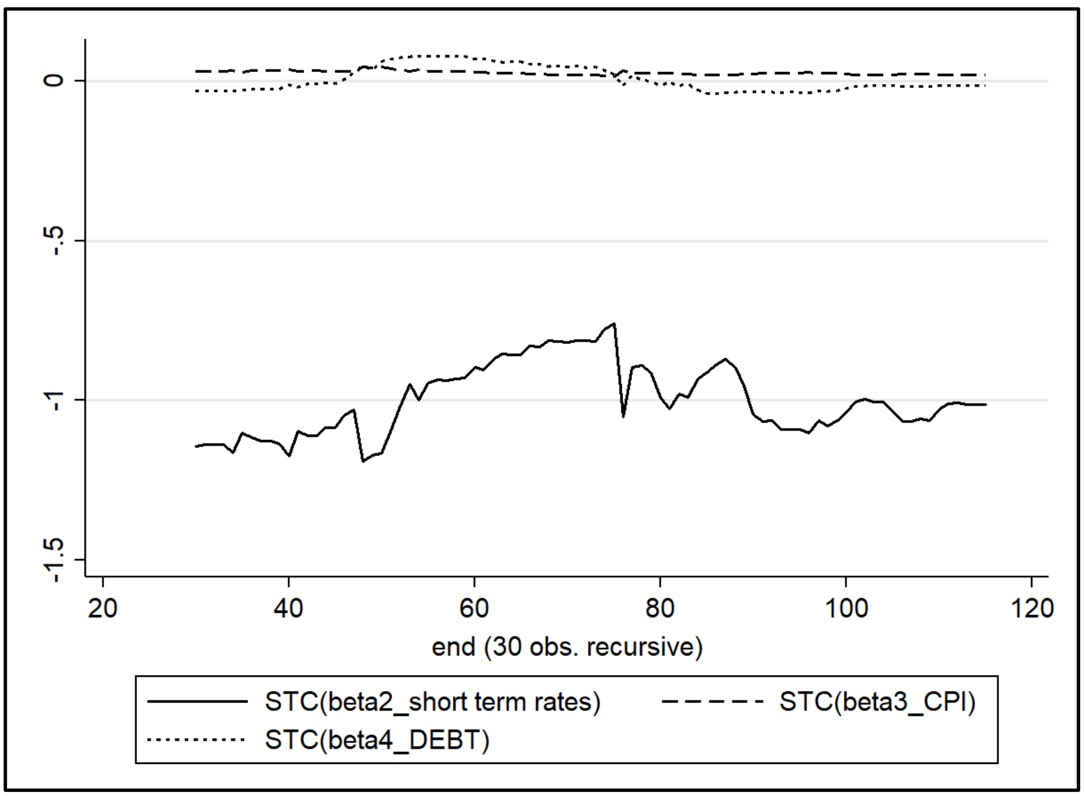
Figure 29: Results of Stability Tests





6. IMPLICATIONS, POLICY RELEVANCE, AND RELATION WITH THE LITERATURE

The empirical findings presented here have implications relevant for macroeconomic theory and economic policy.

First, the findings establish that the BOE can influence gilts' nominal yields and the shape of the gilts' yield curve. The BOE sets the policy rate. The short-term interest rate moves in tandem with the policy rates. A higher (lower) short-term interest rate is associated with a higher (lower) long-term interest rate on gilts. Hence, the BOE can influence the long-term interest rate on gilts through its decision on the policy rate. It can resort to other monetary policy actions that influence the long-term interest rates, such as forward guidance, conditional commitment on the part of the policy rate, large-scale asset purchase programs, yield curve control, and other policy measures and policy announcements.

Second, in contradistinction to the loanable funds view, the findings show that a higher debt ratio is *not* associated with higher yields on gilts for the United Kingdom. Indeed, it shows that after controlling for other factors, a higher debt ratio is associated with downward pressure on gilts' nominal yields, though the effect is not statistically significant.

Third, the findings suggest that there is considerable scope for activist monetary and fiscal policy. If the BOE can keep the long-term interest rate on gilts low through its monetary policy and if higher debt ratios do not lead to higher nominal yields on gilts, the fear of the consequences of expansionary monetary policy and fiscal policy would appear to be largely misplaced.

Fourth, the findings are quite germane to ongoing debates in the literature on government bond yields. There are two opposing theories. The loanable funds theory holds that the long-term interest rate depends on the demand for and supply of funds, while the Keynesian theory holds that the long-term interest rate depends on the central bank's actions. The results obtained here support the Keynesian theory. The loanable funds view is widely represented in the empirical literature on government bonds as in Atasoy, Ertuğrul, and Ozun (2014), Baldacci and Kumar (2010), Doi, Hoshi, and Okimoto (2011), Gruber and Kamin (2012), Horioka, Nomoto, and

Terada-Hagiwara (2014), Hoshi and Ito (2013, 2014), Lam and Tokuoka (2013), Poghosyan (2014), Reinhart and Rogoff (2009), Tokuoka (2010), and Tkačevs and Vilerts (2016, 2019), while the Keynesian perspective is associated with Akram and Das (2014, 2015, 2017, 2019), Akram and Li (2016, 2017, 2018, 2019), Kregel (2011), Lavoie (2014), Levrero and Deleidi (2019), and Simoski (2019).

Fifth, the findings are pertinent to a wide range of macroeconomic issues, such as: (1) the effects of government fiscal variables on government bond yields (Gruber and Kamin 2012; Horioka, Nomoto, and Terada-Hagiwara 2014; Hoshi and Ito 2013, 2014; Poghosyan 2014; Tkačevs and Vilerts 2019); (2) operational issues in central banking and government debt management (Bindseil 2004; Fullwiler [2008] 2017, 2016; Malliaropulos and Migiakis 2018; Mattos et al. 2019); (3) fiscal theory of price (Bölükbaş 2018; Sims 2013); (4) functional finance (Lerner 1943, 1947); (5) fiscal and monetary policy and financial markets (Paccagnini 2016; Sau 2018; Tcherneva 2011); and (6) monetary theory (Wray [1998] 2003, 2012).

7. CONCLUSION

The empirical findings of this paper show that for the United Kingdom, the short-term interest rate has a decisive role in determining long-term gilts' nominal yields, even after controlling for several economic and financial variables, such as inflation, industrial production, and the government debt ratio. Since the BOE sets the policy rate, which in turn affects the short-term interest rate, it exerts crucial influence on the long-term interest rate of gilts of various maturity tenors. The findings presented here back Keynes's contention that the central bank can influence the long-term interest rate on gilt-edged securities and their yield curve through setting the policy rate and various monetary policy actions. Another important empirical finding of this paper is that a higher debt ratio is not associated with higher government bond yields in the United Kingdom. This is in contradistinction to the loanable funds view of the interest rate and the widely held notion that a higher government debt ratio leads to higher bond yields.

The findings of the paper are relevant for macroeconomic theory and policy. They can contribute to the advancement of ongoing debates concerning the determinants of government bond yields, monetary-fiscal policy coordination, the fiscal theory of price, debt deflation, modern money theory, and the sustainability of government debt.

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APPENDIX

Table A1: Unit Root Tests (Levels)

Variable		Tests	Statistic	P-value	Obs.
Q_GILTS2Y	Trend	ADF	-3.854	0.014	114
		PP	-3.966	0.010	114
	No trend	ADF	-3.040	0.031	114
		PP	-2.972	0.038	114
	No trend, No constant	ADF	-3.536		114
		PP	-3.414		114
Q_GILTS3Y	Trend	ADF	-3.883	0.013	114
		PP	-3.973	0.010	114
	No trend	ADF	-2.797	0.059	114
		PP	-2.783	0.061	114
	No trend, No constant	ADF	-3.349		114
		PP	-3.343		114
Q_GILTS4Y	Trend	ADF	-3.882	0.013	114
		PP	-3.975	0.010	114
	No trend	ADF	-2.556	0.102	114
		PP	-2.567	0.100	114
	No trend, No constant	ADF	-3.174		114
		PP	-3.235		114
Q_GILTS6Y	Trend	ADF	-3.808	0.016	114
		PP	-3.860	0.014	114
	No trend	ADF	-2.434	0.132	114
		PP	-2.468	0.123	114
	No trend, No constant	ADF	-3.112		114
		PP	-3.249		114
Q_GILTS7Y	Trend	ADF	-3.995	0.009	114
		PP	-4.030	0.008	114
	No trend	ADF	-2.550	0.104	114
		PP	-2.592	0.095	114
	No trend, No constant	ADF	-3.178		114
		PP	-3.339		114
Q_GILTS8Y	Trend	ADF	-3.732	0.020	114
		PP	-3.729	0.021	114
	No trend	ADF	-2.356	0.155	114
		PP	-2.415	0.138	114
	No trend, No constant	ADF	-3.047		114
		PP	-3.277		114
Q_GILTS9Y	Trend	ADF	-3.644	0.026	114
		PP	-3.638	0.027	114
	No trend	ADF	-2.316	0.167	114
		PP	-2.372	0.150	114
	No trend, No constant	ADF	-3.025		114
		PP	-3.255		114
Q_GILTS20Y	Trend	ADF	-2.595	0.282	114
		PP	-2.611	0.275	114
	No trend	ADF	-1.661	0.452	114
		PP	-1.664	0.450	114

Variable		Tests	Statistic	P-value	Obs.
	No trend, No constant	ADF	-2.617		114
		PP	-2.774		114
Q_GILTS30Y	Trend	ADF	-2.605	0.278	81
		PP	-2.531	0.313	81
	No trend	ADF	-1.127	0.704	81
		PP	-0.964	0.766	81
	No trend, No constant	ADF	-1.582		81
		PP	-1.752		81
Q_RPI	Trend	ADF	-8.037	0.000	114
		PP	-7.856	0.000	114
	No trend	ADF	-8.033	0.000	114
		PP	-7.850	0.000	114
	No trend, No constant	ADF	-4.958		114
		PP	-4.675		114
Q_CCPI	Trend	ADF	-12.453	0.000	89
		PP	-12.456	0.000	89
	No trend	ADF	-11.872	0.000	89
		PP	-11.717	0.000	89
	No trend, No constant	ADF	-6.345		89
		PP	-6.448		89
QCCPIXESF	Trend	ADF	-10.223	0.000	89
		PP	-10.172	0.000	89
	No trend	ADF	-9.772	0.000	89
		PP	-9.771	0.000	89
	No trend, No constant	ADF	-4.958		89
		PP	-4.769		89
QCCPIXEUF	Trend	ADF	-11.081	0.000	89
		PP	-10.957	0.000	89
	No trend	ADF	-10.631	0.000	89
		PP	-10.546	0.000	89
	No trend, No constant	ADF	-5.269		89
		PP	-5.150		89
QCCPIXE	Trend	ADF	-11.288	0.000	89
		PP	-11.094	0.000	89
	No trend	ADF	-10.861	0.000	89
		PP	-10.743	0.000	89
	No trend, No constant	ADF	-5.615		89
		PP	-5.624		89

Note: The ADF and PP test critical values are 1 percent: -3.960, 5 percent: -3.410, 10 percent: -3.120 (Trend); 1 percent: -3.430, 5 percent: -2.860, 10 percent: -2.570 (No trend); 1 percent: -2.580, 5 percent: -1.950, 10 percent: -1.620 (No trend, no constant). PP test, ADF test (H_0: series has a unit root).

Table A2: Unit Root Tests (First Differences)

Variable		Tests	Statistic	P-value	Obs.
ΔQGILTS2Y	Trend	ADF	-9.056	0.000	113
		PP	-8.978	0.000	113
	No trend	ADF	-8.973	0.000	113
		PP	-8.899	0.000	113
	No trend, No constant	ADF	-8.795		113
		PP	-8.731		113
ΔQGILTS3Y	Trend	ADF	-9.409	0.000	113
		PP	-9.351	0.000	113
	No trend	ADF	-9.334	0.000	113
		PP	-9.276	0.000	113
	No trend, No constant	ADF	-9.131		113
		PP	-9.076		113
ΔQGILTS4Y	Trend	ADF	-9.575	0.000	113
		PP	-9.537	0.000	113
	No trend	ADF	-9.525	0.000	113
		PP	-9.483	0.000	113
	No trend, No constant	ADF	-9.314		113
		PP	-9.265		113
ΔQGILTS6Y	Trend	ADF	-9.873	0.000	113
		PP	-9.865	0.000	113
	No trend	ADF	-9.823	0.000	113
		PP	-9.807	0.000	113
	No trend, No constant	ADF	-9.576		113
		PP	-9.543		113
ΔQGILTS7Y	Trend	ADF	-10.115	0.000	113
		PP	-10.132	0.000	113
	No trend	ADF	-10.062	0.000	113
		PP	-10.069	0.000	113
	No trend, No constant	ADF	-9.805		113
		PP	-9.788		113
ΔQGILTS8Y	Trend	ADF	-9.923	0.000	113
		PP	-9.937	0.000	113
	No trend	ADF	-9.879	0.000	113
		PP	-9.880	0.000	113
	No trend, No constant	ADF	-9.620		113
		PP	-9.584		113
ΔQGILTS9Y	Trend	ADF	-9.968	0.000	113
		PP	-9.985	0.000	113
	No trend	ADF	-9.929	0.000	113
		PP	-9.933	0.000	113
	No trend, No constant	ADF	-9.661		113
		PP	-9.628		113
ΔQGILTS20Y	Trend	ADF	-10.202	0.000	113
		PP	-10.211	0.000	113
	No trend	ADF	-10.213	0.000	113
		PP	-10.221	0.000	113
	No trend, No constant	ADF	-9.928		113
		PP	-9.911		113
ΔQGILTS30Y	Trend	ADF	-9.495	0.000	80
		PP	-9.954	0.000	80

Variable		Tests	Statistic	P-value	Obs.
	No trend	ADF	-9.497	0.000	80
		PP	-9.875	0.000	80
	No trend, No constant	ADF	-9.436		80
		PP	-9.744		80
ΔQRPI	Trend	ADF	-14.666	0.000	113
		PP	-17.779	0.000	113
	No trend	ADF	-14.657	0.000	113
		PP	-17.605	0.000	113
	No trend, No constant	ADF	-14.706		113
		PP	-17.636		113
ΔQCCPI	Trend	ADF	-20.812	0.000	88
		PP	-40.247	0.000	88
	No trend	ADF	-20.914	0.000	88
		PP	-40.417	0.000	88
	No trend, No constant	ADF	-21.036		88
		PP	-40.688		88
ΔQCCPIXESF	Trend	ADF	-19.039	0.000	88
		PP	-31.088	0.000	88
	No trend	ADF	-19.139	0.000	88
		PP	-31.308	0.000	88
	No trend, No constant	ADF	-19.251		88
		PP	-31.522		88
ΔQCCPIXEUF	Trend	ADF	-20.312	0.000	88
		PP	-35.957	0.000	88
	No trend	ADF	-20.418	0.000	88
		PP	-36.161	0.000	88
	No trend, No constant	ADF	-20.537		88
		PP	-36.404		88
ΔQCCPIXE	Trend	ADF	-22.535	0.000	88
		PP	-35.094	0.000	88
	No trend	ADF	-22.666	0.000	88
		PP	-35.352	0.000	88
	No trend, No constant	ADF	-22.799		88
		PP	-35.576		88

Note: The ADF and PP test critical values are 1 percent: -4.035, 5 percent: -3.448, 10 percent: -3.148 (Trend); 1 percent: -3.505, 5 percent: -2.889, 10 percent: -2.579 (No trend); 1 percent: -2.598, 5 percent: -1.950, 10 percent: -1.611 (No trend, no constant). PP test, ADF test (H_0: series has a unit root).