

## Robin Greenwood and Dimitri Vayanos Price pressure in the government bond market

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## COVER PAGE

Paper title: Price Pressure in the Government Bond Market

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## **Price Pressure in the Government Bond Market**

Robin Greenwood and Dimitri Vayanos\*

January 2009

What determines the term structure of interest rates? Standard economic theory links the interest rate for maturity  $T$  to the willingness of a representative agent to substitute consumption between times 0 and  $T$ . The standard model contrasts sharply with a more informal view based on investors' preferred habitat, proposed by John Culbertson (1957) and Franco Modigliani and Richard Sutch (1966). According to the preferred-habitat view, there are investor clienteles with preferences for specific maturities, and the interest rate for a given maturity is influenced by the demand of the corresponding clientele and the supply of bonds with that maturity. For example, the typical clientele for long-term bonds are pension funds. An increase in their demand would be expected to raise prices of long-term bonds and thus lower long-term interest rates. In short, preferred habitat implies that there is price pressure in the bond market.

While the preferred-habitat view has intuitive appeal, it has not entered into the academic mainstream, typically being relegated to a paragraph in MBA-level textbooks. One reason for this is the mixed findings in early empirical studies of the term structure. Specifically, between 1962 and 1964, the US Treasury and Federal Reserve raised the supply of short-term government debt while simultaneously lowering the supply of long-term debt. This program, known as Operation Twist, aimed to raise short-term interest rates, and so improve the balance of payments, while also lowering long-term rates to stimulate private investment. A number of papers evaluated Operation Twist, and while they reached different conclusions, none found

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strong evidence that the operation was effective in flattening the term structure (e.g., Modigliani and Sutch (1966), Myron Ross (1966)). This lack of evidence reflected poorly on the preferred-habitat view, on which the success of the program was predicated.

A second reason why the preferred-habitat view has not received much academic attention is theoretical. An extreme version of preferred habitat is that the interest rate for a given maturity evolves independently of other maturities. If interest rates for nearby maturities were very different, then arbitrageurs could realize unbounded profits by exploiting these differences (John Cox, Jonathan Ingersoll and Stephen Ross (1985)).

In this paper we argue for the relevance of the preferred-habitat view by presenting two recent episodes that strongly support it: the UK pension reform of 2004, and the US Treasury's buyback program of 2000-2002.<sup>1</sup> Building on our other work (Robin Greenwood and Dimitri Vayanos (2010), Vayanos and Jean-Luc Vila (2009)), we then explain how these episodes can be understood within a modern theory of preferred habitat. We conclude by discussing the relevance of preferred habitat for central bank policies during the 2007-2009 financial crisis.

In the episodes that we consider, long-term interest rates experienced large and long-lasting shifts because of a regulation-induced change in the demand of a long-maturity clientele in one case, and a government-induced change in the supply of long-term bonds in the other. Thus, a broader message of our analysis is that term-structure movements cannot always be understood in terms of changes in expected short-term interest rates, inflation or other macroeconomic variables, but that shifts to clientele demand and bond supply are also an important driver.

## **I. The UK Pension Reform of 2004**

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<sup>1</sup> Our account of the buyback episode draws on Kenneth Garbade and Matthew Rutherford (2007), who provide a general discussion of Treasury buybacks in historical context.

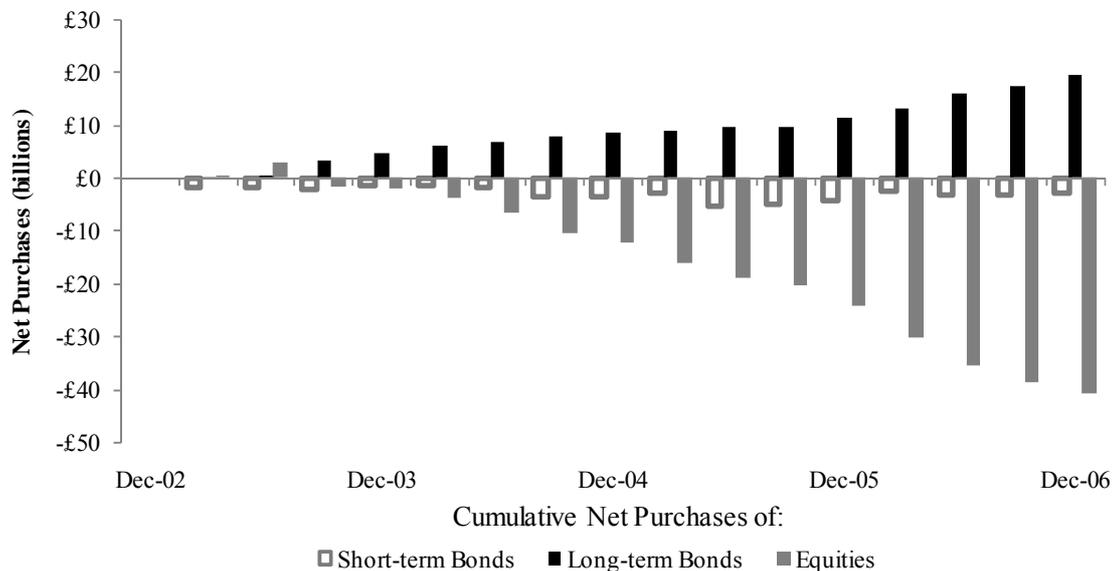
Pension reform in the UK over the past twenty years evolved in two major stages. The first stage was motivated by the failure of a large corporate pension fund during the early 1990s. The Pensions Act of 1995 instituted minimum funding requirements, to ensure that pension plan members could be paid in full even if the sponsoring firm went bankrupt. The funding requirements coincided with accounting reforms that linked the valuation of pension liabilities to market-based discount rates. The combination of the funding requirements and the accounting change created demand for long-dated assets, lowering bond yields. Because this exposed weakness in many pension plans, the act was perceived as exerting undue influence on plans' investment policy. At the behest of the pension industry, the regulations were ultimately abandoned in the early 2000s.

We focus on the second stage of reform: the Pensions Act of 2004. This legislation created a government fund which would serve as a lifeboat for bankrupt schemes. At the same time, a new pensions regulator was given the power to take over funds that were perceived to be at risk of not meeting their obligations. One of the criteria used by the regulator to determine whether intervention was necessary was a plan's "accounting deficit," the difference between the market values of a plan's assets and its liabilities. Because pension benefits were fixed and could be expected to grow with inflation, the present value of pension liabilities was linked to the price, and thus the prevailing yields, of long-term inflation-linked government bonds. Pension funds running an accounting deficit were said to be "underfunded."

The best hedge for pension liabilities is the asset providing the discount rate used to calculate the value of these liabilities. Thus, underfunded pension plans could reduce the volatility of the gap in value between their assets and liabilities by buying government bonds. The Pensions Act

of 2004 instituted fines for underfunded pension plans, providing strong incentives to buy more long-term government bonds.

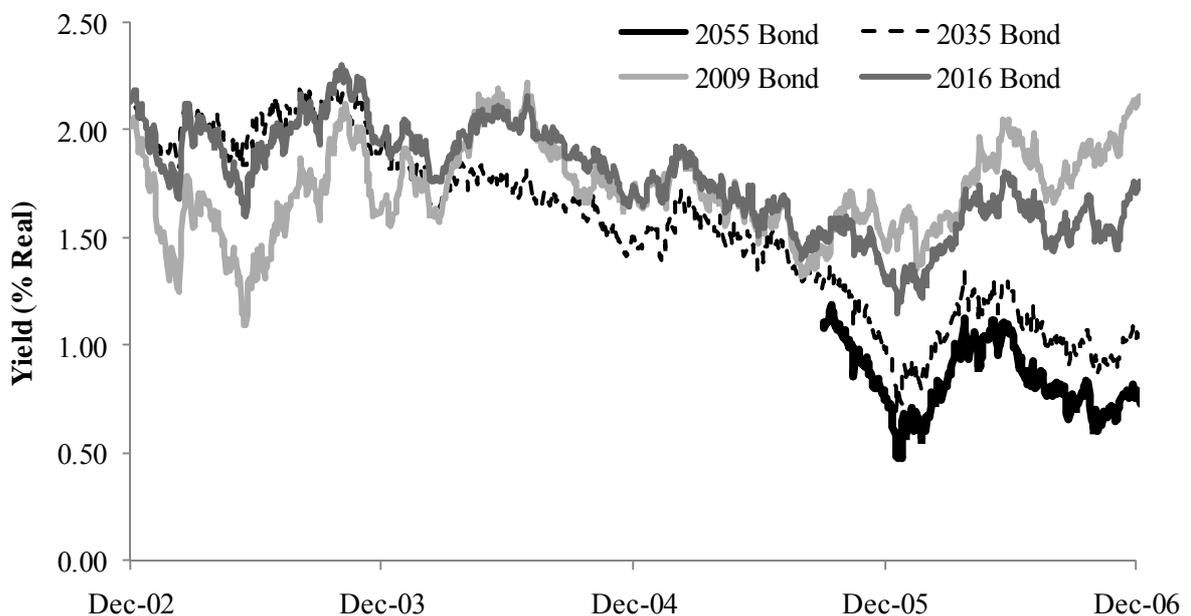
Figure 1 shows that as a consequence of the reform, pension funds increased their exposure to long-term government bonds and reduced that to equities. Between the first quarter of 2005 and the last quarter of 2006, pension funds bought approximately £11 billion of inflation-linked bonds and bonds with maturities longer than 15 years. This understates their demand for long-dated assets, however, as pension funds swapped as much as £50 billion of interest rate exposure in 2005 and 2006 to increase the duration of their assets.<sup>2</sup> The net increase in pension funds' demand for long-dated assets is substantial compared to approximately £73 billion of net government issuance of inflation-linked and long-term bonds between April 2005 and March 2007.



**Figure 1. Pension funds' cumulative net purchases of long-term government bonds, short-term government bonds, and equities.** *Notes:* Bonds with less than 15-years of remaining maturity are classified as short-term. Bonds with 15-years or more of remaining maturity, and inflation-linked bonds, are classified as long-term.

<sup>2</sup> The numbers for the debt market are compiled from quarterly releases of UK National Statistics, release MQ5. The estimate for the swap activity is from a Barclays Capital report by Moyeen Islam (2007), p.57.

Figure 2 shows that the effects of pension-fund demand on the shape of the term structure were dramatic. The figure plots yields to maturity on a variety of inflation-linked government bonds. The spread between the 2035 and 2016 bonds turned negative in October 2003, and decreased throughout 2004 and 2005 to reach an all time low of -0.49% in January 2006. At that time, the 2035 and 2055 bonds were yielding 0.72% and 0.48%, respectively, which are extremely low relative to the historical average of 3% of long real rates in the UK. This inversion of the term structure is hard to rationalize based on the expectations hypothesis: one would have to argue that expectations about short-term interest rates past 2016 dropped sharply during 2004 and 2005, and to levels below 0.5%. The spread between the 2035 and 2016 bonds reached a new all time low of -0.68% in December 2006. A similar inversion appeared in the nominal term structure.



**Figure 2. Real yields on selected U.K. inflation-linked government bonds, December 2002-December 2006.**

In response to the change in yields, pension-fund managers lobbied the government to expand the supply of long-term debt, claiming that long-term interest rates reflected a pension-

fund demand-driven bubble. The U.K. Debt Management Office appears to have agreed with this assessment—it attributed the drop in long-term yields to “structural” demand, and acknowledged that “long conventional yields fell to 50-year lows reportedly reflecting sustained purchases of long-dated gilts by the pension industry.”<sup>3</sup> In 2005, the government agreed to issue nominal and inflation-linked bonds with initial maturities of up to 50 years, simultaneously shifting the overall mix of maturities: 55% of total bond sales between April 2005 and March 2006, and 68% of total bond sales between April 2006 and March 2007, were long-term or inflation-linked, compared to 45% between April 2004 and March 2005, and 36% between April 2003 and March 2004.

## **II. Treasury Buybacks of 2000-2001**

The US Treasury announced during the fall of 1999 that it was considering a program to buy back long-term bonds. The impetus for this decision was that following a few years of budget surpluses, reduced government financing requirements had led to smaller and fewer new bond listings. And because short-term debt had been retiring without being replaced, the average maturity of outstanding debt had increased. Treasury officials argued that buybacks would “enhance our ability to exert greater control over the maturity structure of outstanding debt [and] will provide us the option of managing the maturity structure of the debt by selectively targeting the maturities of debt to be repurchased.”<sup>4</sup> The final rule was adopted on January 19, 2000, although Treasury Secretary Summers announced its arrival a few days sooner, on January 13, 2000.

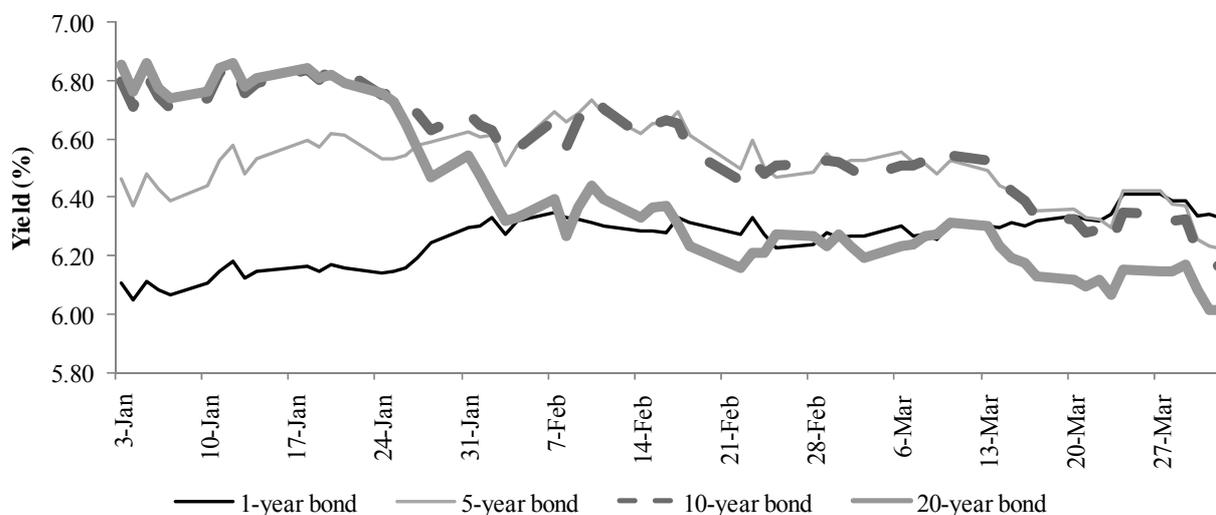
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<sup>3</sup> UK Debt Management Office Annual Review 2005-06, p.4.

<sup>4</sup> U.S. Treasury Press Release August 4, 1999. <http://www.ustreas.gov/press/releases/l43.htm>.

Between March 2000 and December 2001 the Treasury conducted 42 buybacks covering 42 long-term bonds with a combined face value of \$63.5 billion. This was approximately 10% of the December 1999 outstanding value of marketable long-term government bonds of \$644 billion, and approximately 2% of all marketable interest-bearing government debt. The weighted-average remaining maturity of repurchased bonds was approximately 18 years, ranging from the 11.75% 2010 bond to the 6.125% 2027 bond.

Figure 3 shows the dramatic effects of the buybacks on the term structure. Prior to the announcement of the final rule, on January 18, the spread between the 20- and the 5-year spot rates was 0.26%. Three weeks later, on February 8, the spread had decreased to -0.39%, a drop of 0.65%. The sharp drop in the spread was mainly driven by the 20-year spot rate, which fell by -0.58%; the 5-year spot rate rose by 0.07%.



**Figure 3. Yields on 1-year, 5-year, 10-year, and 20-year zero-coupon bonds, January – March 2000.**

While the buybacks targeted only bonds with maturities of 9 years or longer, they appear to have impacted the yields on intermediate-term bonds as well. The spread between the 5- and the 1-year spot rates dropped from 0.43% on January 18, to 0.33% on February 8, then to -0.11% on

March 31. Thus, while the buybacks had larger and more immediate effects on long-term interest rates, they appear to have contributed to a more general inversion of the term structure.

### **III. Theory**

The episodes described in Sections I and II are hard to rationalize within the standard representative-agent model: to explain the decrease in long-term interest rates, one would have to argue that the UK pension reform or the US Treasury buybacks signaled significant drops in aggregate consumption 20-30 years into the future.<sup>5</sup> On the other hand, both episodes support the preferred-habitat view: the UK pension reform was a positive shock to the demand for long-term bonds, while the US Treasury buybacks were a negative shock to the supply of long-term bonds. Consistent with the preferred-habitat view, long-term rates fell relative to short-term rates.

A salient feature of these episodes is that the effects of demand and supply shocks were not isolated to the specific maturities of the shocks' location. For example, while the Treasury buybacks targeted only bonds with maturities of 9 years or more, their effect on rates extended to the 5-year maturity. Similarly, while the effects of the UK pension reform were most pronounced for the longer maturities, the spread between the yields of intermediate- and short-term bonds narrowed as well. One would expect such effects because bonds with nearby maturities are close substitutes—therefore arbitrageurs transmit shocks local to one maturity to nearby maturities.

Characterizing how demand and supply shocks manifest themselves in an arbitrage-free term structure requires a formal model of preferred habitat. Vayanos and Vila (2009) develop such a model, which Greenwood and Vayanos (2010) extend to accommodate shocks to debt maturity structure. The term structure in the model is determined through the interaction between investor clienteles who prefer bonds with specific maturities, and risk-averse arbitrageurs. Without

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<sup>5</sup> Or, in the spirit of the expectations hypothesis of the term structure, one would have to argue that these episodes signaled significant drops in short-term interest rates in the distant future.

arbitrageurs, the term structure would exhibit extreme segmentation: the yield for a given maturity would be influenced only by the demand of the corresponding clientele, and would evolve independently of other maturities. Such segmentation does not happen in equilibrium, however. Arbitrageurs intermediate across maturity markets, buying bonds with maturities for which clientele demand is low, and selling bonds with maturities for which demand is high. Their presence ensures that bonds with nearby maturities trade at similar prices.

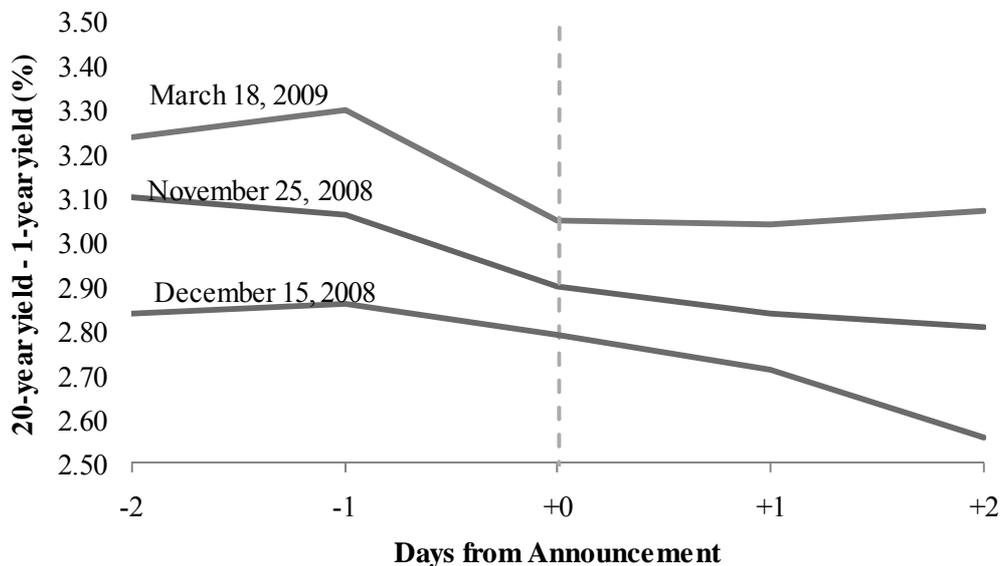
In bridging markets across different maturities, arbitrageurs face both fundamental and non-fundamental risk. The fundamental risk is that the short-term interest rate rises (falls) in the future, thereby flattening (steepening) the term structure. The non-fundamental risk is that there will be shocks to the demand for bonds with particular maturities. Because arbitrageurs are risk averse, they receive compensation for accommodating demand shocks. If arbitrageurs' risk aversion is low, then changes in short-term interest rates are the dominant source of risk, and demand shocks affect the term structure by altering the market price of short-rate risk. This in turn implies that the specific location of demand effects is unrelated to that of the underlying shocks: bonds most sensitive to the shocks are those most sensitive to changes in the market price of short-rate risk. If arbitrageurs' risk aversion is high, however, then multiple risk factors become relevant. In this case, arbitrageurs are less able to intermediate across maturity markets, and demand effects become more local.

#### **IV. Policy Implications**

The preferred-habitat view of the term structure is particularly relevant in the context of recent central bank policies. In the midst of the global financial crisis of 2007-2009, central banks around the world conducted unprecedented open-market purchases of long-term securities—all with the hope of influencing long-term bond yields. The largest of these programs

was the Federal Reserve’s asset purchase program, which initially targeted government-backed agency securities and agency-backed mortgage-backed securities, and later expanded to include long-term government bonds.

Remarkably, the motivation for these government purchase programs was similar to that of Operation Twist, suggesting a revival of policy interest in the preferred-habitat view. For example, the December 2008 minutes of the Federal Open Market Committee (FOMC) outline Board members’ view that purchases would reduce interest rates on long-term instruments, which in turn would stimulate private borrowing and investment.



**Figure 4. Yield spreads between 20- and 1-year bonds on days surrounding Federal Reserve announcements.**

Bond market responses to the Federal Reserve’s asset purchase program suggest that it had the desired effect. Figure 4 plots the yield spread between the 20-year bond and the 1-year bill during a two-day window around three announcements: the initial announcement of the asset purchase program on November 25, 2008; the FOMC announcement on December 16, 2008 that purchases might extend to government bonds; and the announcement on March 18, 2009 that up to \$300 billion of government bonds would be purchased as well. All three events were

accompanied by a drop in the spread, with the average drop being 0.30%. Moreover, the drop was mainly driven by the 20-year yield, which fell by an average of 0.33%.

While a theory of preferred habitat is useful for evaluating these recent central bank interventions, there remain important empirical challenges. First, developing precise quantitative estimates of the price impact of supply and demand shocks on the term structure is difficult because shifts to the supply and demand for bonds are infrequent, and because the availability of arbitrageur capital may fluctuate over time. A second and related challenge is that the desirability of central bank intervention depends in large part on whether supply shocks have transitory or permanent effects on interest rates. If the effects are only transitory, then government actions to alter the term structure are expensive. Yet, to distinguish between transitory and permanent effects would require the econometrician to identify numerous exogenous shocks to bond supply or demand. A third challenge is that one must account for segmentation not only across maturities, but also across types of bonds, e.g., Treasuries, mortgage-backed and corporate. For example, announcement effects of the Federal Reserve buybacks differed between mortgage-backed securities and Treasury bonds, suggesting segmentation between the two markets (Xavier Gabaix, Arvind Krishnamurthy and Olivier Vigneron (2007), Krishnamurthy and Annette Vissing-Jorgensen (2009)).

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