Do Market Intermediaries Hedge their Risk Exposure with Derivatives? Evidence from UK Govt. Bond Dealers' Spot & Derivatives Positions

by

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Abstract

Using a comprehensive dataset from the Bank of England of UK government bond dealers' spot and derivatives positions at the end of each day, we find that dealers actively hedge their spot risk with derivatives. However, they hedge selectively rather than engage in full cover hedging. Some of these dealers hedge not only their main risk factor, i.e., Duration exposure, but also the second risk factor, Twist exposure. Their decision to hedge depends on the efficiency of the hedge instrument available. Dealers hedge changes in their spot exposure to a greater extent when the bond market volatility is higher, when the level of their spot exposure is high and changing in a direction that exacerbates the magnitude of the exposure, and when the cost of hedging is lower. Overall these findings support the predictions of Stulz (1984), Stultz (1996) and Froot and Stein (1998). Finally, we find that the profits of dealers from the "view taking" implied in their selective hedging are statistically and economically indistinguishable from those that would have arisen from following a "full cover" hedging policy.

Do Market Intermediaries Hedge their Risk Exposure with Derivatives? Evidence from UK Govt. Bond Dealers' Spot & Derivatives Positions

While the theoretical literature contains several motivations as to why corporations should hedge, there is little theoretical modelling of risk management by market intermediaries[1]. Indeed, academics know remarkably little about risk management practices (hedging or otherwise) of market intermediaries like securities dealers even though every securities firm operating in countries like the US or UK reports its risk exposures at periodic intervals to relevant regulatory authorities[2]. For example, every dealer making a market in UK government bonds reports to the Bank of England at the end of each day her position (long or short) in every UK government bond issue and in every related derivatives contract. This paper is based on these reports. It empirically investigates for the first time the use of derivatives by market intermediaries for risk management.

The risk management practices of corporations have received wide attention in recent years. This is mainly due to some well publicised cases of losses incurred by firms as a result of their trading policy in derivatives[3]. Our understanding of corporate risk management practices has improved significantly in recent years thanks to Wharton/CIBC surveys, to changes in the public disclosure requirements (annual reports, 10-K filings), to case studies

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[1] See for example, Holthausen (1979), Anderson and Danthine (1980, 1981), Amihud and Lev (1981), Stulz (1984), Smith and Stulz (1985), Shapiro and Titman (1986), Campbell and Kracaw (1987), DeMarzo and Duffie (1991, 1995), Froot, Scharfstein and Stein (1993), Ljungqvist (1994), May (1995), Stulz (1996), Raposo (1996), Degeorge, Moselle and Zeckhauser (1996), Breeden and Viswanathan (1998), Mello and Parsons (2000) for risk management by firms or managers of firms, and Froot and Stein (1998) for risk management by financial intermediaries.

[2] The reports typically consist of total risk exposure and its breakdown in to components such as contribution of the spot position, derivatives positions etc. These reports are filed at regular intervals and are used for capital adequacy and other regulatory purposes by the relevant authorities.

[3] Metallgesellschaft, Orange County, and Proctor and Gamble reported large losses as a result of trading in derivatives. In contrast, Daimler Benz reported large losses in 1995 as a direct result of not using derivatives to hedge its expected dollar receivables. See Sinkey and Carter (1999) for the reaction of bank stock prices to news

written about risk management practices of specific firms, and to extensive empirical research that has examined the relationship between the risk management decisions of different firms and the *cross-sectional* differences in their attributes[4]. Indeed, we know a lot more today about risk management practices of corporations than what we knew a decade ago. In contrast, we still know remarkably little about risk management practices of market intermediaries. Our paper plugs this gap in the literature and contributes to the empirical literature on risk management in several ways. For clarity of exposition, we summarize here the salient contributions and findings, and in Section I, describe in more detail how our work complements existing research.

First, our paper examines the *time-series* variation in the risk of spot positions, and its management via the use of derivatives by a *homogeneous* group of firms as opposed to the *cross-sectional* variation in firm characteristics and its relationship with the use of derivatives by a *heterogenous* group of firms examined in the literature. In this context, our paper examines the *daily* snapshots of spot and derivatives exposures as opposed to *quarterly* or *annual* snapshots. Second, in contrast to the indicative proxies or, at best, estimates of spot risk earlier researchers have had to rely on, our paper uses precise values of spot risk and derivatives risk. Third, by aggregating the end of day positions across all the UK government bond dealers, our paper examines the aggregate behaviour of dealers as a group -- something difficult to quantify in case of other industries. Finally, our paper investigates the extent of

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of derivatives losses by corporate clients.

[4] See Tufano and Serbin (1993), Tufano and Headley (1994), Tufano (1994) and Haushalter (1997) for case studies, and Booth, Smith and Stolz (1984), Block and Gallagher (1986), Wall, Pringle and McNulty (1990), Francis and Stephan (1990), Lewent and Kearney (1990), Mayers and Smith (1990), Nance, Smith and Smithson (1993), Dolde (1993, 1995), Mian (1996), Tufano (1996), Cummins, Phillips and Smith (1996), Hogan and Rossi (1997), Peterson and Thiagarajan (1997), Geczy, Minton and Schrand (1997), Allayannis and Ofek (1997), Haushalter (1997), Allayannis and Weston (1998), Schrand and Unal (1998), Henschel and Kothari (1998), Guay (1998), Whidbee and Wohar (1999), Lynch Kosky and Pontiff (1999), Graham and Smith (1999), Graham and Rogers (2000) among others for extensive empirical research. See Barnes (2000) for a

selective risk taking activity of dealers and compares the profits arising therefrom with those arising from following a *full cover* policy.

We find that dealers actively use derivatives to *hedge* their spot risk. In particular, we find that changes in individual dealer's derivatives exposure are significantly negatively related to changes in their spot exposure. When we segregate the changes in their spot exposure into a part arising from Nominal bonds and a component arising from Index-Linked (inflation adjusted) bonds, we find that the changes in the derivatives exposure are significantly negatively related to the former but not the latter. We also find that dealers hedge changes in their spot exposure to a greater extent when the bond market volatility is higher, when the level of their spot exposure is high and is changing in a direction that exacerbates their spot exposure, and when the cost of hedging is lower because of the predictable change in the direction of futures mispricing. Overall these findings support the predictions of Stulz (1984) and Froot and Stein (1998) and leads to the conclusion that dealers engage in "selective" hedging as argued by Stulz (1996). Interestingly, we find that the profits from their "view taking" are indistinguishable from those which would have arisen from following a "full cover" hedging policy. Finally, we find that dealers use derivatives to hedge primarily the changes in their Duration (term structure shift) exposure and to a lesser extent their Twist (term structure rotation) exposure. Overall, these findings help in significantly enhancing our understanding of the attitude of intermediaries towards risk management.

The rest of the paper is organised as follows. Section I sets our paper in the context of the existing literature on risk management. Section II describes the salient features of the UK Government bond market and the data set analysed in this paper. Section III outlines the

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comprehensive survey of articles on risk management.

measures used for analysing the risk exposure of spot and derivative positions. Section IV examines whether dealers use derivatives to hedge their duration exposure. Section V investigates different factors that potentially can cause time variation in the extent of hedging. Section VI quantifies the profitability of following a selective hedging rather than a full cover hedging policy. Section VII analyses whether dealers also hedge twist exposure. Section VIII offers concluding remarks.

I. Literature on Risk Management and Our Contribution

In this section, we elaborate on how our study complements the existing literature on hedging and risk management[5]. To begin with, our paper examines the evolution of spot risk and its management via derivatives *over time*. All the literature to date has focused on *cross-sectional* differences in the attributes of the firms and their relationship with the firms' risk management policies. The only study which sheds some light on time-series evolution of firms' risks is by Schrand and Unal (1998). They use quarterly data on measures of individual thrift's interest rate risk and credit risk. They study how these risks evolve over time and whether thrifts that convert from mutuals to stock charters show a different risk evolution as compared with the thrifts that do not. Our paper differs from theirs in many ways. First of all, we use 358 snapshots of precise end-of-the-day spot and derivatives risk exposures while they use 20 quarterly snapshots of *proxies* of different types of risk exposures[6]. Hence, we

[5] There exists a literature on demand for insurance which addresses a problem that is similar to the problem discussed in the literature on hedging. However, for firms, purchase of insurance provides real services due to the expertise of insurance companies in evaluating some types of risks and administering claims settlement procedures (see Mayers and Smith (1982, 1990)), while futures contracts provide no apparent real service of this nature.

[6] For instance, Schrand and Unal (1998) use excess volatility of weekly stock returns as a measure of total risk, excess of net one-year gap after the impact of off-balance-sheet activities divided by total loans as a proxy for interest rate risk and excess of the proportion of commercial loans to total loans as a proxy for credit risk where the excess amount is computed vis-a-vis an appropriate benchmark.

regress daily changes in derivatives exposures on daily changes in spot exposures to examine risk management policies at a day-to-day level while they regress their risk proxies on quarterly time dummies to study evolution of different types of risk over time. Second, we investigate how market intermediaries facing a single source of risk micro-manage that risk with derivatives while they study whether the managers of thrifts facing multiple sources of risk substitute one type of risk with another. This makes our paper very different from Schrand and Unal (1998) as well as any of the other studies of risk management in the literature.

Given the cross-sectional nature of previous studies, the power of their test lies in maximizing the cross-sectional variation in the attributes exhibited by the firms in their sample (see, e.g., Geczy, Minton and Schrand (1997)). In contrast, since we conduct a time-series investigation, the power of our tests relies on long time series observations for a group of intermediaries who are largely similar in their essential attributes. This is indeed the case for the dealers investigated in this paper because during our sample period, UK government bond dealers were required to be separately capitalized and were required to adhere to the same set of capital adequacy and other rules. They all dealt in securities bearing the same sovereign risk and had access to the same set of derivatives markets. They had a similar organizational culture, employed professionals with similar education and compensation levels and were mainly based within the same square mile of 'the City'. Thus, it is not surprising that we find different dealers behave in a similar manner when it comes to managing their spot risk[7]. It also reinforces the importance of our findings, since the findings represent systematic, rather than idiosyncratic, behaviour of a group of intermediaries.

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[7] Arguably, our sample of dealers form a more homogenous group compared even to firms belonging to the same industry as the latter can differ in terms of their plant locations, supply sources, product markets,

Our paper investigates the risk management practices of securities dealers as opposed to the risk managers of traditional firms. This difference is important since, as compared to managers of traditional firms, dealers making a market in government bonds are likely to be in a better position to understand and quantify their spot position risk. This is because the spot positions of our dealers are exposed to a single source of risk, namely, interest rate risk as opposed to traditional firms who are exposed to multiple sources of risks such as interest rate risk, currency risk, credit risk and so on. Moreover, the dealers are also likely to be in a better position to manage the interest rate risk as there exist highly liquid derivatives markets that are specifically designed to manage interest rate risk and, as dealers, they face lower trading costs compared to other market participants. In contrast, it has been argued that firms like Proctor & Gamble, Orange County etc. were not fully aware of the risks involved while entering into derivatives contracts. This is unlikely to be the case with our dealers and therefore we would argue that our findings capture the attitude of well-informed market professionals towards risk management.

Our data provides individual dealers' end of day positions (long or short) in each UK government bond issue and in related derivatives contracts, specifically the short sterling futures contract and the long gilt futures contract. This information enables us to compute the exact spot risk exposure and derivatives exposure of individual dealers[8]. In contrast, due to data constraints most of the literature to date has had to rely on dichotomous variable relating

technology, organizational form, compensation packages, capital structure etc.

[8] Using a transactions dataset from the London Stock Exchange similar to that used in Hansch, Naik and Viswanathan (1999) we have examined the changes in inventory of each dealer in each UK government bond issue and have found that the end of day positions reported in the Bank of England dataset are extremely accurate. Our observation is also confirmed by Hansch and Saporta (1999) in an independent study examining trading revenues of the government bond dealers.

to risk management activity[9]. The papers which use continuous measures of risk management activity use estimates that only partially capture the total spot risk and derivatives risk. For example, Dolde (1993, 1995) asks finance managers to estimate what 'percentage of inherent exposure from operations (their firms) attempt to offset, on average'. Tufano (1996) uses delta of the derivatives and divides it by the amount of gold the Reeve report shows as expected to be produced over the three years. Schrand and Unal (1998) use thrifts' net one-year maturity gap as a measure of total interest risk exposure. Although all these papers provide us with important insights, they rely on *estimates* of spot risk and derivatives risk. In sharp contrast, our findings are based on *exact* measures of spot risk and derivatives risk exposures and the contribution of individual positions towards the total risk of the portfolio.

In the theoretical literature, Froot and Stein (1998) propose a model regarding the risk management decisions of financial intermediaries. They focus on the frictions faced by these intermediaries in real world - frictions that are assumed away in the classical approach - and argue that some *but not all* risks can be hedged in capital markets. They show, *inter-alia*, that a financial intermediary will always wish to completely hedge its exposure to all risks that can be traded in an efficient market[10]. Froot and Stein (1998) motivate their model by illustrating several examples where there have been a bundling of risks. They argue for example, that an investment bank entering into a currency swap takes on the currency risk as well as the credit risk. The bank can lay off the currency risk in the market but not the credit risk. In a similar spirit, Schrand and Unal (1998) unbundle the interest rate risk and the credit risk in a thrift's loan portfolio. They call the interest rate risk as *homogenous* risk and the

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[9] See, for example, Booth et al (1984), Block and Gallagher (1986), Houston and Mueller (1988), Wall and Pringle (1989), Francis and Stephan (1990), Nance et al (1993), and Gerczy et al (1997).

credit risk as *core business* risk, the idea being that homogenous risks are zero NPV projects in an efficient market and the economic rents of a firm arise primarily from its comparative advantage in taking on core business risk.

In the case of market intermediaries, like government bond dealers, the distinction between these two risks is somewhat blurred, part of their core business risk is what other market participants at large call homogeneous risk. There is a vast literature in market microstructure arguing that public order flow is informative and dealers learn about the fundamental value of the assets by observing the order flow. The extent of informativeness of order flow depends on the type of the asset being traded. Even in markets like the FX market where the common view is that private information does not exist, Ito et al (1998) find evidence that is incompatible with lack of private information. They argue that the private information may not be "fundamental" but may help predict prices over a short horizon - information that is valuable for dealers running market making business. If this was the case, then dealers would arguably chose *not* to hedge away all of the market risk of their portfolio.

Interestingly, almost 90% of the derivatives users in Dolde's (1993) survey say that they do not hedge away all of the homogenous risks. Citing this evidence, Stulz (1996) emphasizes the importance of comparative advantage and warns firms of the potential dangers of engaging in selective hedging instead of following a full cover policy. The major risk is that, when firms hedge selectively, they assume that their information is better than that of the market, when, in fact, it may not be. One may argue that dealers see a large part of the order flow and hence may be in a better position to predict the bond prices, at least over a short

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[10] See Froot and Stein, 1998, Proposition 2 pp 63-64.

horizon, and therefore may chose to hedge selectively. Fortunately, our data help us to quantify the extent of selective hedging on the part of the dealers. It also enables us to compare the profits arising from following a selective hedging policy with those that would have arisen from following a full cover policy. In contrast, due to the sensitive nature of the issue being examined, sufficiently rich data to draw statistical inference on the profitability of selective hedging by traditional industries is likely to be much harder to come by.

II. Description of the UK Government Bond Market and the Data

In August 1995, there were ninety different issues of UK Government bonds with a nominal outstanding value of £205 billion (See Appendix A for details)[11]. The ninety bond issues can be divided into two broad categories: Nominal bonds and Real (Index-linked), and within Nominal bonds into Conventional bonds, Double-dated bonds and Undated bonds. A conventional bond is the simplest and most common form of a government bond where the government guarantees to pay the holder a fixed cash payment (coupon) at fixed time intervals until the maturity date, at which point the holder receives the final coupon and the principal. Double-dated bonds are conventional bonds with a band of maturity dates. The government can choose to redeem these bonds on any day between the first and final maturity dates[12] while Undated bonds are perpetuities that pay a fixed coupon indefinitely. Real bonds

[11] The British Government's National Debt has a long and interesting history. In 1694, King William the third, and the parliament were seeking ways to fund war with France. Their solution was to set up the Bank of England and entrust it the task of raising £1.2 million through public subscription. To be precise, the financiers who took up the first issue of the National Debt of £1.2 million were given the charter to form a bank which became the Bank of England. Although King William's fund raising exercise was completed within days, it set a pattern that continues to the present day. The British Government still raises funds by the issue of loan stocks through the Bank of England.

[12] Where the coupon on a double-dated bond is higher than the prevailing market rate, the government will usually have an incentive to redeem on the first maturity date and refinance the bond at the lower prevailing rate. Where the coupon is lower than the market rate, as for example in the case of 3.5% Funding 1999-2004, there is less incentive to redeem early.

differ from the Nominal bonds in a fundamental way since the coupon payments and the principal are adjusted in line with the UK Retail Price Index. This means that both the coupon and the principal on redemption paid by these bonds are adjusted to take account of accrued inflation since the bond's issue[13]. In our sample there are 54 conventional bonds comprising 80% of the total value; 14 double-dated bonds comprising of 8% of the total value; 8 undated bonds comprising 3% of total value; and 14 index-linked bonds comprising of 10% of total value[14].

Trading in these UK government bonds is organised around the London Stock Exchange where a large number of dealers compete with each other to execute the public order flow[15]. During our sample period, each dealer was required to be separately capitalized from the parent firm and had to be registered with the Bank of England - the supervising regulatory authority. In order to ensure that the dealers were adequately capitalized, individual dealers were required to report to the Bank of England their daily close-of-business inventory positions in each government bond issue. They were also required to report to the Bank of England their positions in all related derivatives contracts.

The data used in this study consists of the daily close-of-business reports filed with the Bank of England from August 1, 1994 to December 30, 1995 period (358 days)[16]. The data

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[13] UK was one of the earliest developed economies to issue index-linked bonds. The first issue took place in 1981.

[14] During our sample period, there was no Strips market or Repo market in the UK Government bonds. These developments took place in 1996-97.

[15] See Proudman (1995), Vitale (1998), Hansch and Saporta (1999), and Naik and Yadav (1999) for microstructure details of UK government bond market and Hansch, Naik and Viswanathan (1998) for microstucture details of UK equity market.

[16] Hansch and Saporta (1999) also use a similar dataset to study the gross trading revenues in the UK government bond market and offer interesting insights. The focus of our paper is very different. While they study the contribution of derivatives positions to the trading revenues of dealers, we examine how the dealers use the derivatives to manage their interest rate risk exposure.

provides individual dealers' inventory positions - number of bonds and whether long or short - in each bond issue and in related derivatives contracts. We analyse the close-of-business positions of a total of fifteen registered UK government bond dealers. Out of these fifteen dealers, five dealers report positions in seventy or more bonds, six dealers between fifty to seventy bonds and remaining four dealers in less than fifty bonds. They also report positions (number of contracts - long or short) in Long Gilt futures contracts and Short Sterling futures contracts traded on London International Financial Futures Exchange (LIFFE). These positions are typically in the nearest maturity contract. However, starting from the first week of the contract expiry month, they start rolling their positions in the next maturity contract[17].

III. Measures of Hedgeable Risk Exposure

Spot market risk exposure of Government bond dealers consists of a security-specific component and an overall market component. The overall market component arises from changes in the term structure of interest rates and can be hedged using derivatives like futures contracts. In the fixed income literature, it is fairly standard (see Kahn, 1995) to use two factors for risk management of bond portfolios: Duration (or Shift) and Twist.

The Modified Macaulay Duration (hereafter Duration) is the most important measure of bond portfolio risk. It provides an exact measure of risk for the case of a flat term structure changing by an infinitesimal amount to another flat term structure. Even for the general case of a non-flat term structure changing to another non-flat term structure, this measure has

[17] The dealers are required to report their positions in *all related derivatives contracts*. They don't report positions in options on interest rate futures contracts. This may be because during our sample period, the options market in London was relatively illiquid and not very deep. In particular, the average net exposure of the Long Gilt Futures Options contracts was of the order of 2% to 3% of the open interest in Long Gilt Futures contracts.

excellent explanatory power, and hence, is widely used as the main market risk factor in risk management of bond positions. For example, Chaumeton, Conner and Curds (1996) report in their Table 3 that, over the data period examined by them, Shift (i.e., Duration) explains about 86% of the changes in prices of individual bonds in the UK.

We define the Duration at time t $D_{i,t}$ of bond i maturing at time T as:

$$D_{i,t} = \frac{1}{P_{i,t}} \sum_{s=1}^{T} \frac{sC_{i,t+s}}{(1+y_{t,s})^s} \quad \textbf{(1)}$$

where $P_{i,t}$ is the market price of bond i at time t; $C_{i,t+s}$ is the cash flow received from bond i, s periods after time t; and $y_{t,s}$ is the s period spot rate at time t.

We denote the *Spot (Derivatives) Duration Exposure* of dealer k as at the end of day t by

$$SpotExp_{k,t} = \sum_{i=1}^{90} \frac{V_{i,t}^{k} D_{i,t}}{100} \quad \textbf{(2)}$$

where $V_{i,t}^{k}$ is the Pound Sterling value of the position (duly signed) of dealer k in bond i at the end of day t; and $D_{i,t}$ is as defined in equation (1).

Similarly, we denote the *Derivatives Duration Exposure* of dealer k at the end of day t as

$$DerivExp_{k,t} = \sum_{j=1}^{J} \frac{W_{j,t}^{k} D_{j,t}}{100} \quad \textbf{(3)}$$

where $W_{j,t}^{k}$ is the Pound Sterling value of the position (duly signed) of dealer k in derivatives contract j at the end of day t; and $D_{j,t}$ is the duration of the derivatives contract at the end of day *t*.

As defined above, the *Spot (Derivatives) Duration Exposure* measures, to a first order approximation, the amount a dealer stands to gain or lose on her spot (derivatives) inventory portfolio from a one percent change in a flat term structure. We examine the time series evolution of these exposures to infer the attitude of dealers towards risk management.

Consistent with standard practice, we use the *Twist* as the second factor or risk exposure, where Twist measures the bond price response to changes in the *slope* of the term structure just as duration measures the bond price response to changes in the *level* of the term structure. The calculation of Twist Exposure requires the pre-assignment of the fulcrum point (called *mid*) around which the shock related change in slope or 'twist' takes place, so that a shock to the term structure causes spot rates longer than the fulcrum point to increase and spot rates shorter than the fulcrum point to decrease (and vice-versa), the size of the change being proportional to the time distance from the fulcrum point[18]. Following Chaumeton, Conner and Curds (1996), we define the *Twist* at time *t*, $T_{i,t}$ of bond *i* maturing at time *T* as:

$$T_{i,t} = \frac{1}{P_{i,t}} \sum_{s=1}^{T} \frac{(mid - s) s C_{i,t+s}}{(1 + y_{t,s})^{s}} \qquad \textbf{(4)}$$

where *mid* is the pre-assigned fulcrum point around which a shock related change in slope of term structure takes place, and $P_{i,t}$, $C_{i,t+s}$ and $y_{t,s}$ are as defined in equation (1) above.

We define the *Spot Twist Exposure* of dealer *k* at the end of day *t* as

[18] Based on Steeley (1996), and our discussions with Government Bond Dealers in London, we pre-assigned the fulcrum point as 14 years for our UK data.

$$SpotTwistExp_{k,t} = \sum_{i=1}^{90} V_{i,t}^{k} T_{i,t} \qquad \textbf{(5)}$$

where $V_{i,t}^{k}$ is the pound sterling value of the position (duly signed) of dealer k in bond i at the end of day t; and $T_{i,t}$ is as defined in equation (4).

Twist is the second most important factor in bond risk management. However, its incremental explanatory power is an order of magnitude smaller than that of Shift (Duration) factor. For example, Chaumeton, Conner and Curds (1996) report (see Table 3) that, over the data period examined by them, Twist adds an extra about 3.4% explanatory power for the UK over the 86.4% explanatory power provided by duration[19]. In view of the relatively high explanatory power of Duration for bond portfolio risk management, we use the Duration (or Shift) exposure for most of the analyses in this paper. However, for completeness, in the final section, we also analyse the relative importance of the Twist exposure. For the sake of notational convenience, until the final section where we introduce Twist factor, we use the word exposure to denote duration-based exposure.

IV. Do Dealers Hedge their Duration Risk Exposure with Derivatives?

A. Development of Testable Hypotheses

In the theoretical literature, Froot and Stein (1998) focus on the risk management decisions of financial intermediaries. Arguing that some *but not all* risks can be hedged in capital markets,

[19] They also report the correlation between duration and twist is small, -0.11 for the UK. The correlation we observe in our data is –0.14.

they show, in their Proposition 2, that a financial intermediary will always wish to completely hedge her exposure to all risks that can be efficiently hedged[20]. That said, a firm which carries no risk will not earn any economic profit. Hence, while firms should fully hedge the risks in which they do not have a competitive advantage (i.e., areas in which they cannot earn positive economic profits), they should arguably not fully hedge risks in bearing which they have a competitive advantage, informational or otherwise, see Stulz (1996)[21].

There are at least three other reasons why UK bond dealers in particular may engage in selective hedging rather than full cover hedging. First, trading in the spot market is opaque. Although all trades are reported by the dealer to the exchange, only small trades are published. Given such a disclosure regime, the spot market positions of bond dealers are not transparent to other market participants[22]. In contrast, the futures market (LIFFE), is a highly transparent open outcry market. Oftentimes the size of the futures positions needed for full cover hedging are fairly large. Therefore, if dealers do not want to risk signalling their position to the rest of the market, they may prefer to hedge selectively rather than fully. Second, the open interest in derivatives contracts of all bond dealers taken together has been about 20%-35% of the total open interest in the relevant derivatives contracts on the LIFFE. Given the open interest in the derivatives market from market participants other than bond dealers, and the fact that changes in spot exposure across different dealers are positively

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[20] Efficient hedging transactions are those that have a net present value (NPV) of zero. Such a view is consistent with Arrow's (1963) proposition that a risk averse individual insures fully if offered fairly priced insurance. It is also consistent with the insurance view of hedging in which a firm seeks to minimise the total variability of its returns, earnings or cash flows (eg Johnson (1960) and Ederington (1979)).

[21] The concept of selective hedging was first introduced by Working (1953) and re-emphasised more recently by Culp and Miller (1995) in the context of the Metallgesselschaft debacle. However, in both cases, the focus was narrow since the selective hedging was intended to profit from the predicted change in futures mispricing. Stulz (1996) generalizes this concept of selective hedging into a broader theory of risk management based on comparative advantage in risk-bearing. The comparative information advantage of dealers in carrying overall market risk need not be real. Even if the dealers think that they have a comparative information advantage, they are likely not to hedge completely.

[22] See Naik, Neuberger and Viswanathan (1999) for issues relating to trade disclosure regulation and risk

correlated[23], the available depth in the derivatives market could potentially be a constraint for full cover hedging. Finally, dealers may opt for selective hedging to profit from the predicted change in futures mispricing. Unlike commodity futures contracts, there is significant mean reversion in financial futures mispricing even at the daily horizon[24]. This predictable change in futures mispricing can be an important contributor to selective hedging.

In the context of the above, we test the following two hypotheses:

Hypothesis H_{1A}: *Dealers use derivatives for hedging (i.e. to reduce duration risk exposure) rather than for speculation (i.e. to increase duration risk exposure).*

Hypothesis H_{1B}: *Dealers do not engage in 'full cover' but selective hedging.*

Strictly speaking, 'full cover' hedging means that if all risks of a position could be completely hedged efficiently with derivatives, the derivatives risk exposure of any particular dealer will always be equal and opposite to the spot risk exposure across all spot bond inventory holdings. If one were to take a less restrictive view that allows for the presence of a fixed level of directional risk, then 'full cover' hedging means that the *change* in the derivatives risk exposure of any particular dealer will always be opposite to the *change* in the spot risk exposure across all spot bond inventory holdings.

However, if dealers only hedge selectively, they will take time varying directional risks in view of their (real or perceived) comparative advantage. Under these circumstances, a useful

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sharing among participants.

[23] This is because public traders often arrive on the same side of the market, i.e. they either buy generally or sell generally, while dealers take the opposite sides of these trades.

[24] See, for example, Merrick (1988) or Yadav, Pope and Paudyal (1994).

measure to quantify the extent of hedging is the hedge ratio $h_{k,}$ i.e. the coefficient of dependence in a regression of the change in derivatives risk exposure on the change in spot risk exposure. h_k will be -1 if derivatives are used for full cover hedging, between 0 and -1 for selective hedging, not significantly different from zero for absence of either hedging or speculation, and greater than zero when derivatives are used largely for speculation. Hence, to test Hypotheses H_{1A} and H_{1B}, we run the following regression for each dealer separately and for the aggregate group of dealers as a whole:

$$\Delta DerivExp_{k,t} = \alpha_k + h_k \Delta SpotExp_{k,t} + \varepsilon_{k,t} \qquad \textbf{(6)}$$

where k indicates the dealer (k=1, 2 .... 15); $\Delta DerivExp_{k,t}$ is the change in Derivatives Exposure of Dealer k from end of day t-1 to end of day t; $\Delta SpotExp_{k,t}$ is the change in Spot Exposure of Dealer k from end of day t-1 to end of day t; h_k is the hedge ratio; and α_k and $\varepsilon_{k,t}$ are the intercept and error terms respectively.

For Hypothesis $H_{1A,}$ we test whether h_k is significantly less than zero and the R-square of the regression is significantly greater than zero. For Hypothesis $H_{1B,}$ we test whether h_k is significantly greater than -1 and the R-square of the regression is not significantly different from 100%.

B. Effect of the Hedgeability of the Spot Bond Portfolio

The extent of hedging a spot position in a particular bond issue will arguably be greater if that bond can be hedged more ‘efficiently’ with available hedging instruments. Hence, if a dealer holds two bonds *A* and *B*, and available hedging instruments can hedge a large fraction of the price variation of bond *A* but only a small fraction of the price variation of Bond *B*, one would expect that, *ceteris paribus*, the extent of hedging for Bond *A* will be much higher than the extent of hedging for Bond *B*. In this context, it is also important to note that the Froot and Stein's (1998) Proposition 2 (cited earlier) is conditional on whether it is possible to hedge spot inventory risk *efficiently* with derivatives.

In the light of this, we test the following hypothesis:

Hypothesis H_2: *Dealers will hedge relatively more (less) when they hold more (less) efficiently hedgeable individual bond securities.*

To test Hypothesis $H_{2,}$ we examine two categories of bonds that exhibit significantly different degrees of hedging efficiency with respect to available hedging instruments. In the UK, the bond portfolios of dealers include both Nominal bonds and Index-Linked bonds. The risk exposure of Nominal bonds depends on unexpected changes in the nominal term structure of spot rates. On the other hand, the risk exposure of index linked bonds depends not only on unexpected changes in the nominal term structure of spot rates but also on the unexpected changes in term structure of inflation expectations. However, while available exchange traded derivatives cover the different maturity segments of the nominal term structure, no derivatives exist to hedge changes in the term structure of inflation expectations. Hence, the efficiency with which Nominal bonds can be hedged with derivatives is clearly greater than the efficiency with which Index-Linked bonds can be hedged.

In view of this, we examine whether the hedge ratio for spot duration exposure in Index-Linked bonds is significantly lower than the hedge ratio for spot duration exposure in Nominal bonds by running the following regression for each dealer separately and for the aggregate group of dealers as a whole:

$$\Delta DerivExp_{k,t} = \beta_k + h_k^{NOM}\Delta SpotExp_{k,t}^{NOM} + h_k^{I-L}\Delta SpotExp_{k,t}^{I-L} + \eta_{k,t} \quad \textbf{(7)}$$

where k indicates the dealer (k=1, 2 .... 15); $\Delta DerivExp_{k,t}$ is the change in Derivatives Exposure of Dealer k from end of day t-1 to end of day t; $\Delta SpotExp_{k,t}^{NOM}$ and $\Delta SpotExp_{k,t}^{I-L}$ are the changes in Spot Exposure of Dealer k arising from Nominal and Index-Linked bond holdings respectively from end of day t-1 to end of day t; h_k^{NOM} and h_k^{I-L} are the hedge ratios for Nominal and Index-Linked bond holdings respectively; β_k and $\eta_{k,t}$ are the intercept and error terms respectively.

C. Descriptive Analyses of Spot and Derivatives Duration Exposure

Table I describes the distribution of the absolute value of total (spot plus derivatives) exposures carried by the dealers overnight. The dealers are ranked in decreasing order of their mean absolute overnight exposures. As can be seen, there is considerable variation in the extent of their average risk exposures. The largest (smallest) dealer stands to gain or lose about £32 million (£1.5 million) from a one percent change in interest rate. Their median exposures also leads to very similar ranking. Interestingly, the maximum exposure carried by dealers 4, 5 and 6 exceeds that of dealers 1 and 3. The last row of all tables, denoted as Overall, represents the intermediary function served by the dealers as a group. We construct the Overall positions by aggregating the duly signed positions of each individual dealer in every bond issue and in every derivatives contract. As can be seen, the exposure carried by the dealers in the aggregate is huge (£161 million on average, minimum £81 million, maximum £296 million). Indeed, Table I clearly documents that dealers engage extensively in selective risk taking activity.

Table II reports the magnitude of derivatives exposure as a fraction of the magnitude of spot exposure and derivatives exposure for individual bond dealers. If the spot and the derivatives exposures are of the same order of magnitude, this fraction will be one-half. As the relative value of the derivatives exposure increases (decreases), the fraction tends to one (zero). As can be seen, the average value of this fraction varies from 0.16 to 0.60 at an individual dealer level. The last row of the Table II reports this fraction when one examines the dealers as a group. At an aggregate level this fraction has a mean of 0.47 (median 0.49) suggesting that on average the derivatives exposure is of the same order of magnitude as their spot exposure.

In this context, we report in Figure 1 the end of the day spot risk exposure and derivatives risk exposure of the group of dealers in aggregate and for a medium sized dealer. Both the graphs clearly show that derivatives are being used to hedge the spot risk exposure since the derivatives exposure appears to vary generally in a direction opposite to that of the spot exposure. When the spot duration risk exposure increases, the derivatives duration exposure appears to decrease, and vice versa. This seems to suggest that dealers use derivatives to offset their spot exposure. We examine this issue in the next section.

D. Regression Results

To test Hypothesis 1A, we run regression in equation (6) and report the findings in Table III. We can see that the hedge ratio h_k is significantly negative (p-value $<< 0.001$) for each and every dealer. It is also significantly greater than -1 (p-value $<< 0.001$) in the case of each and every dealer. For the individual dealers, the hedge ratio varies from -0.23 to -0.69 while for the group of dealers as a whole, the hedge ratio equals -0.27. The R-squares of the regression for most of the dealers are also high, indicating significant correlation between changes in spot and derivatives exposures ranging from -0.24 to -0.82. These results provide strong support to the view that derivatives are used for hedging the spot exposure. However, it is important to remember that, as is evident from Table I, in each of these cases the hedging is selective and far from full cover hedging.

In order to test Hypothesis 2, we run regression in equation (7) and report the results in Table IV. We find that, in each and every case, the hedge ratio for Nominal spot exposure continues to remain negative, highly significant and of the same order of magnitude as found in Table III. The hedge ratio for Index-linked spot exposure, however, is not statistically indistinguishable from zero in a vast majority of the cases (12 out of 15 dealers). The results for all the dealers taken as group also re-affirms this finding. The hedge ratio for Nominal exposure is negative and highly significant while that for Index-linked exposure is not, which lends strong support to Hypothesis 2.

V. Factors Influencing the Time Varying Hedge Ratio

In this section, we examine the factors that influence the inter-temporal variation in the day to day hedging behaviour. Towards that end, we examine factors that can influence changes in the hedge ratio from one day to the next[25]. In particular, we examine whether the level of overall bond market volatility, the magnitude of unfavourable spot exposure, and the cost of

[25] Clearly, in our context, factors like corporate taxes, capital structure, managerial incentives, managerial risk aversion, agency costs or changing investment and financing opportunities (Smith and Stulz, 1985; Froot, Scharfstein and Stein, 1993) are unlikely to be in a position to explain changes in the hedge ratio of our bond dealers from *day to day*.

hedging can explain the time variation in the hedge ratio.

First, from a risk minimising point of view of hedging, if a dealer does not hedge her spot risk fully but does so selectively, she should arguably hedge to a greater extent when the perceived risk is greater. Hence, we should observe a higher hedge ratio on days on which the volatility of spot price changes is relatively greater.

Second, for avoiding "bankruptcy", the elimination of lower tail outcomes is particularly important (Stulz, 1996). In case of bond dealers, these lower tail outcomes can cause breach of capital adequacy requirements and lead to "regulatory distress". The risk of regulatory distress is greater when the level of spot exposure is relatively higher *and* when the change in spot exposure is in a direction which increases the magnitude of this exposure. Therefore, we should observe higher hedge ratio on days when the risk of regulatory distress is higher.

Third, as emphasized in Stulz (1984), costs should play an important role in the dealer's decision to hedge. It is important to note that dealers are short horizon hedgers and, as documented analytically and empirically in Merrick (1988), a major cost specifically facing short horizon hedgers is a predictable change in futures mispricing over the life of the hedge. Unlike commodity futures, mispricing of financial futures contracts displays strong mean reversion even at daily horizons since large price deviations from fair value triggers arbitrage[26]. This means that the change in mispricing, and hence the expected cost of the hedge, depends on the level of futures mispricing at the time at which the hedge is initiated. Short hedges established with underpriced futures, and long hedges established with

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[26] Mispricing is defined as the difference between the actual futures price and its fair value calculated from the cost of carry model. LIFFE data provides both these numbers, details of the cheapest to deliver bond, etc.

overpriced futures, are relatively costly while short hedges established with overpriced futures, and long hedges established with underpriced futures, are relatively cheap. Clearly, dealers will have a lower incentive to hedge in time periods when hedging is costly (due to the predictable unfavourable change in futures mispricing) relative to time periods when hedging is cheap (due to the predictable favourable change in futures mispricing)[27].

In view of these arguments, we test the following hypotheses:

Hypothesis H_{3A}: *Dealers hedge relatively more (less) when the bond market volatility is greater (lower).*

Hypothesis H_{3B}: *Dealers hedge relatively more when the level of spot exposure is greater and the change in spot exposure is in a direction that increases the magnitude of this exposure.*

Hypothesis H_{3C}: *Dealers hedge relatively more when hedging requires buying (selling) underpriced (overpriced) futures and dealers hedge relatively less when hedging requires selling (buying) underpriced (overpriced) futures.*

We test Hypotheses H_{3A}, H_{3B} and H_{3C} by estimating the following regression model:

$$\Delta DerivExp_{k,t} = \gamma_0 + \left(\Sigma D_{k,t} h_k + \gamma_1 Vol_t + \gamma_2 Magn_t + \gamma_3 D_t^{MISP}\right)\Delta SpotExp_{k,t} + \omega_t \quad \text{------------}\textbf{(8A)}$$

$$\Delta DerivExp_{agg,t} = \gamma_0 + \left(h_{agg} + \gamma_1 Vol_t + \gamma_2 Magn_t + \gamma_3 D_t^{MISP}\right)\Delta SpotExp_{agg,t} + \omega_t^{agg} \quad \text{------------}\textbf{(8B)}$$

where $\Delta DerivExp$ and $\Delta SpotExp$ are as defined in equation (6), $D_{k,t}$ is a dummy variable which takes the value 1 for observations corresponding to dealer *k;* h_k (h_{agg}) are the base level

[27] This is the reason why Working (1953) underscored the importance of the expected change in the cash-futures basis in determining whether dealers engage in selective hedging. More recently, Culp and Miller (1995) have re-emphasised this ‘economics of synthetic storage’ in the context of Metallgesellschaft.

hedge ratios for individual (aggregate) dealer, Vol_t is the duly normalised absolute value of the open-to-close price change of the nearest bond futures contract, $Magn_t$ is the duly normalised magnitude of the spot duration exposure at time t multiplied by a dummy variable which takes the value 1 when the change in spot exposure is in a direction that increases the magnitude of this exposure, D_t^{MISP} is a dummy variable which takes the value 1 when hedging requires buying (selling) underpriced (overpriced) futures and the value -1 when hedging requires selling (buying) underpriced (overpriced) futures; and γ_0 and ω_t are the intercept and error terms respectively.

Tests of Hypotheses H_{3A}, H_{3B} and H_{3C} are equivalent to tests of whether the slope coefficients on volatility, magnitude and the mis-pricing dummy are less than zero, respectively. Since the time variation of the hedge ratio is an *incremental* effect superimposed on the "base level" of the hedge ratio reflected above in the coefficient $h_{k,,}$ these slope coefficients on volatility, magnitude and the mispricing dummy (i.e. γ_1, γ_2 and γ_3 above) are constrained in regression equation (8A) to be equal for all dealers to maximise estimation efficiency. In regression equation (8B), we estimate γ_1, γ_2 and γ_3 for the aggregate exposure of dealers as a group.

Table V reports results of regression (8A) and (8B). First of all, the "normal" base hedge ratio for individual dealers continues to be negative and of the same order of magnitude as in the previous two regressions, and continues to be highly significant statistically in 14 out of the 15 cases. The slope coefficients on the Volatility variable, the Magnitude variable and the Mispricing variable are each negative and statistically significant at the 5% level. The results for the group of dealers as a whole are qualitatively similar: the slope coefficients on the

Volatility variable, Magnitude variable and the Mispricing variable are all negative and statistically significant. These results are not sensitive to whether we used the total spot exposure as in regression (6), or the Nominal spot exposure as in regression (7). The results are also not sensitive to whether we measure mean reversion in mispricing around zero or the (negative) sample mean[28].

VI. Do Dealers Profit From *Not* Following a Full Cover Hedging Policy?

Our results from Section III clearly show that dealers engage extensively in selective hedging rather than full cover hedging. Selective hedging should arguably be undertaken in areas in which the firm has a comparative advantage (Stulz (1996)). Through such selective hedging the firm is effectively taking a directional risk in the expectation of a favourable price movement. Since it is relatively easy and cost-effective for bond dealers to hedge the market risk of their spot positions, any deviation from the policy of fully hedging of market risk can be argued as reflecting the dealer's decision to take that directional risk. Given that the firm should do selective hedging rather than full cover hedging only when it has comparative advantage, this deviation from full cover hedging should, on average, be profitable after adjusting for risk. In contrast, if markets are efficient, dealers should, on average, not be able to make any economic profit from taking on overall market directional risk. Whether they do or they do not make these economic profits is an empirical issue which we investigate in this section.

In this context, we test the following hypothesis:

Hypothesis H_4: *Dealers engaged in selective hedging generate economic profits from*

[28] T-bond futures are often underpriced due to the existence of the well-known quality and timing options.

their deviations from full cover hedging.

To test this Hypothesis, we examine whether the revenues earned from not fully hedging the duration exposure are significantly greater than zero. If these revenues are not significantly greater than zero, then the economic profits clearly cannot be greater than zero.

To estimate these revenues, we first calculate the number of nearest maturity futures contracts the dealer would have bought or sold at the end of each day, had he engaged in full cover hedging. We compare this with the number of nearest maturity futures contracts equivalent to the total derivatives exposure actually reported by the dealer. We multiply this difference (in terms of number of contracts) by the price change of that contract over the overnight interval (from close to next open) to obtain the profits made by holding the overnight position.

We report in Table VI the profitability of selective risk taking vis-à-vis full cover hedging calculated as above. We find that five out of fifteen dealers perform worse than with full cover hedging (their average revenue is negative) while the remaining ten dealers perform better. For the dealer group as a whole they seem to lose on average £39,000 per day. However, the daily profitability is highly volatile. Selective risk taking seems to deliver profits that are indistinguishable from the profits the dealers would have earned had they followed a full cover policy. This is true for each and every dealer as well as for them as a group[29]. We also find that, for the dealers as a group, the average overnight profit from the spot risk exposure is negative while that from derivatives risk exposure is positive. However, these profits are also very volatile from day to day and the average profits are

[29] For the sake of robustness, we repeated this exercise based on close to close of next day price of nearest maturity futures contract and found qualitatively very similar results.

indistinguishable from zero.

These results are consistent with the view that bond markets are efficient and whatever informational advantage the dealers may have from their knowledge of short term order flow does not enable them to earn significantly positive profits from selective risk taking.

VII. Do Dealers Also Hedge Twist Exposure?

As noted by Chaumeton et al (1996), the Duration factor (defined in equation (1)) has historically explained about 86% of the variation in bond price changes in the UK while the Twist factor (defined in equation (4)), has explained less than 4%. The Duration factor and the Twist factor are not completely orthogonal but the correlation between them is very small, only -0.14 in our data. Figure 2 plots the Duration and Twist of 8% coupon bonds as a function of maturity. As can be seen, Twist is positive for short maturity bonds and negative for long maturity bonds indicating that when the term structure of interest rates experiences a rotational shock, the prices of short and long dated bonds move in opposite direction.

We know from Section IV that all dealers hedge the changes in their spot duration exposure with derivatives. In this section, we investigate whether dealers also hedge their Twist exposure. Specifically, we test the following hypothesis:

Hypothesis H_5: *Dealers hedge their Twist Exposure <u>in addition to</u> hedging their duration risk exposure.*

To test this hypothesis by running the following regression for each dealer separately and for the group of dealers as a whole[30]:

$$\Delta DerivExp_{k,t} = \delta_k + h_k^{DUR} \Delta SpotExp_{k,t} + h_k^{TW} \Delta SpotTwistExp_{k,t} + \xi_{k,t} \qquad \textbf{(9)}$$

where k indicates the dealer (k=1, 2, ..., 15); $\Delta DerivExp_{k,t}$ is the change in Derivatives Duration Exposure from end of day *t-1* to end of day *t*; $\Delta SpotExp_{k,t}$ and $\Delta SpotTwistExp_{k,t}$ are the changes in Spot Duration Exposure and Spot Twist Exposure respectively of dealer k from end of day *t-1* to end of day *t*, h_k^{DUR} and h_k^{TW} are the hedge ratios for Duration Exposure and Twist Exposure respectively; δ_k and $\xi_{k,t}$ are the intercept and error terms respectively.

A test of Hypothesis H_5 is equivalent to testing if h_k^{TW} is significantly less than zero.

Table VII reports results of regression (9). When we include the changes in Twist exposure, the hedge ratio on the changes in duration based exposure continues to remain negative and significant in case of fourteen dealers as well as for them as a group (Overall). The hedge ratios on the changes in Twist exposure are negative and significant for six out of fifteen dealers. The results (not reported) using Twist exposure of Derivatives as the dependent variable are qualitatively similar. The dealers collectively taken as a group seem to use derivatives to hedge their Duration and their Twist based spot exposure. Given the large impact the Duration factor has on bond prices, almost all of them hedge their Duration based

[30] We also repeat regression (9) using the Twist exposure of derivatives as the dependent variable.

exposure and a large proportion of them hedge the Twist exposure as well. These results suggest that dealers perceive the risk in the bond markets as primarily arising from the Duration (or Shift) factor and to a lesser extent from the Twist factor. This is consistent with the relative contribution of the two factors to the risk of fixed income securities.

VIII. Concluding Remarks

In this paper, we employed a comprehensive dataset of the Bank of England containing the close-of-business spot and derivatives positions of UK government bond dealers to investigate whether market intermediaries hedge their risk exposure with derivatives. Using precise values of spot and derivatives risk exposures, we examined how UK government bond dealers manage their spot risk on a day-to-day basis at an individual dealer level as well as at an aggregate level as a group of intermediaries. We investigated whether the risk management depended on the efficiency with which the spot position could be hedged; whether the extent of hedging depended on the market volatility, magnitude of risk exposure, and the cost of hedging. Finally, we analysed the profitability of dealers' view taking activity.

We find that dealers actively use derivatives to hedge their sport risk exposure. However, they hedge selectively rather than engaging in a full cover hedging policy. They hedge not only their main risk factor, i.e., Duration, but also their secondary risk factor, namely Twist. Their decision to hedge depends on the efficiency of the hedge instrument available. Dealers hedge more when the market is more volatile, when their spot risk exposure (and therefore the risk of regulatory distress) is high, and when the cost of hedging is low. These findings are consistent with the implications of Stulz (1984), Stulz (1996) and Froot and Stein (1998).

We find that dealers carry significant total (spot plus derivatives) exposures overnight. Although there exist extremely cost effective ways of laying off the risk through futures contracts, dealers chose to take directional bets. We examine the profits they make from carrying these risks on their books overnight instead of laying it all off. We find that a majority of dealers make, on average, a positive profit on their overnight risk positions. However, their daily profits are so volatile, that the average profits of none of the individual dealers are statistically or economically indistinguishable from those they would have obtained from following a full cover policy. This suggests that the bond markets are reasonably efficient and any informational advantage the dealers enjoy by observing the order flow does not lead them to make significant profits.

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Appendix A: Names and Amounts Outstandng of the UK Govt. bonds

Short Maturity	**Amount £ m**	**Long**	**Amount £ m**
9 Treasury 1994	1,400	8 3/4 Treasury 2017	6,950
12 ½ Exchequer 1994	1,240	8 Treasury 2013	4,950
10 ¼ Exchequer 1995	2,500	9 Treasury 2012	5,150
12 ¾ Treasury 1995	840	9 Conversion 2011	4,273
12 Treasury 1995	2,350	6 1/4 Treasury 2010	4,750
10 Conversion 1996	3,409	8 Treasury 2009	3,100
15 ¼ Treasury 1996	1,150	**Double-dated**	
13 ¼ Exchequer 1996	800	11 3/4 Treasury 2003/2007	3,150
14 Treasury 1996	770	12 1/2 Treasury 2003/2005	2,200
8 3/4 Treasury 1997	5,550	8 Treasury 2002/2006	2,000
10 ½ Exchequer 1997	3,700	11 1/2 Treasury 2001/2004	1,620
7 Treasury Conv 1997	2,000	13 1/2 Treasury 2004/2008	1,250
13 ¼ Treasury 1997	1,290	6 3/4 Treasury 1995/1998	1,200
15 Exchequer 1997	830	12 Exchequer 2013/2017	1,000
7 1/4 Treasury 1998	7,850	5 1/2 Treasury 2008/2012	1,000
12 Exchequer 1998	3,909	14 Treasury 1998/2001	970
9 3/4 Exchequer 1998	3,550	7 3/4 Treasury 2012/2015	800
15 ½ Treasury 1998	935	3 1/2 Funding 1999/2004	543
6 Treasury 1999	5,900	12 Exchequer 1999/2002	105
Floating Rate 1999	2,500	13 3/4 Treasury 2000/2003	53
12 ¼ Exchequer 1999	3,050	15 Exchequer 1990/95	214
9 1/2 Treasury 1999	1,900	**Undated**	
10 1/4 Conversion 1999	1,798	3 1/2 War	1,909
10 1/2 Treasury 1999	1,252	3 1/2 Conv	119
Medium		2 1/2 Treasury	475
9 Conversion 2000	5,358	4 Consolidated	359
8 Treasury 2000	4,800	2 1/2 Consolidated	275
13 Treasury 2000	3,171	3 Treasury	56
8 1/2 Treasury 2000	109	2 1/2 Annuities	3
7 Treasury '2001'A	2,500	2 3/4 Annuities	1
10 Treasury 2001	4,406	**Index-Linked**	
9 3/4 Conversion 2001	35	2 1/2 I-L Treasury 2001	1,500
9 1/2 Conversion 2001	3	2 1/2 I-L Treasury 2003	1,050
9 3/4 Treasury 2002	6,527	4 3/8 I-L Treasury 2004	1,000
9 Exchequer 2002	83	2 I-L Treasury 2006	1,550
10 Conversion 2002	21	2 1/2 I-L Treasury 2009	1,550
9 1/2 Conversion 2002	2	2 1/2 I-L Treasury 2011	1,950
8 Treasury 2003	7,600	2 1/2 I-L Treasury 2013	2,300
10 Treasury 2003	2,503	2 1/2 I-L Treasury 2016	2,550
9 3/4 Conversion 2003	11	2 1/2 I-L Treasury 2020	2,400
6 3/4 Treasury 2004	6,250	2 1/2 I-L Treasury 2024	2,000
9 1/2 Conversion 2004	3,412	4 1/8 I-L Treasury 2030	1,300
10 Treasury 2004	20	2 I-L Treasury 1996	1,200
8 1/2 Treasury 2005	8,900	4 5/8 I-L Treasury 1998	800
9 1/2 Conversion 2005	4,842	2 1/2 I-L Treasury Conv 1999	2
7 3/4 Treasury 2006	3,900		
9 3/4 Conversion 2006	6		
8 1/2 Treasury 2007	5,497		
9 Treasury 2008	5,321		

Table I: Average Overnight Exposures of UK Government Bond Dealers

This table reports the absolute value of the total overnight exposure (spot plus derivatives) carried by the fifteen UK government bond dealers individually and collectively as a group (overall). Exposure is the amount by which the market value of their spot and derivatives position is expected to change from a one percent change in the interest rates. The dealers are ranked in decreasing order of the mean absolute value of total exposure they carry overnight. All figures are in millions of Pound Sterling. All dealers except dealer 12 and dealer 15 report positions throughout the sample period. Dealers 12 and 15 who are relatively small is size, report positions for 148 days and 195 days respectively after which they stopped being dealers.

Dealer *k*	Mean Exposure	Median Exposure	Q1 25%	Q3 75%	Minimum	Maximum
1	31.7	31.1	24.9	38.5	9.9	54.1
2	26.9	22.8	12.7	36.7	0.2	94.8
3	16.7	18.1	5.2	27.7	0.0	40.6
4	16.2	15.7	10.8	20.9	0.1	66.8
5	16.1	15.4	11.0	21.2	3.6	31.9
6	16.1	15.6	5.0	22.2	0.1	55.5
7	14.9	10.9	5.3	19.8	0.0	73.5
8	10.3	8.2	4.5	13.7	0.0	35.5
9	10.0	6.3	2.5	12.8	0.0	46.9
10	6.4	6.0	4.0	8.5	0.1	13.9
11	3.6	3.8	2.3	4.6	0.0	8.2
12	3.6	3.0	2.3	4.8	0.0	8.7
13	3.5	3.2	1.9	4.2	0.0	13.3
14	2.1	1.7	0.7	3.0	0.0	9.3
15	1.5	1.3	0.5	2.1	0.0	5.1
Overall	161.0	152.7	128.7	187.9	80.9	295.5

Table II: Derivatives Exposure as a Fraction of Total Exposure

This table reports the absolute value of derivatives exposure as a fraction of the absolute value of spot exposure plus the absolute value of derivatives exposure individually for the fifteen UK government bond dealers and collectively as a group (overall). By construction the fraction lies between zero and one. A value of half implies that the spot exposure is of the same order of magnitude as the derivatives exposure. As the relative magnitude of derivatives exposure increases (decreases), the fraction deviates away from half towards one (zero).

Dealer *k*	Mean	Median	Q1 25%	Q3 75%	Minimum	Maximum
1	0.22	0.15	0.07	0.30	0.00	0.99
2	0.43	0.36	0.17	0.73	0.00	1.00
3	0.32	0.23	0.10	0.51	0.00	0.99
4	0.20	0.16	0.02	0.32	0.00	0.95
5	0.60	0.61	0.41	0.79	0.02	1.00
6	0.33	0.25	0.12	0.49	0.00	1.00
7	0.55	0.57	0.42	0.69	0.00	1.00
8	0.52	0.52	0.41	0.64	0.00	0.99
9	0.41	0.35	0.21	0.60	0.00	1.00
10	0.26	0.18	0.08	0.37	0.00	1.00
11	0.24	0.16	0.08	0.35	0.00	0.97
12	0.16	0.11	0.06	0.17	0.00	0.64
13	0.31	0.24	0.09	0.48	0.00	0.95
14	0.37	0.37	0.21	0.52	0.00	0.99
15	0.48	0.49	0.31	0.62	0.00	0.98
Overall	0.47	0.49	0.22	0.67	0.01	1.00

Table III: Relationship between Changes in Derivatives Exposure and Changes in the Spot Exposure

This table shows the coefficients of the following regression:

$$\Delta DerivExp_{k,t} = \alpha_k + h_k \Delta SpotExp_{k,t} + \varepsilon_{k,t}$$

where k indicates the dealer (k=1, 2 .... 15), $\Delta DerivExp_{k,t}$ is the change in Derivatives Duration Exposure of Dealer k from end of day t-1 to end of day t, $\Delta SpotExp_{k,t}$ is the change in Spot Duration Exposure of Dealer k from end of day t-1 to end of day t, h_k is the hedge ratio, and α_k and $\varepsilon_{k,t}$ are the intercept and error terms respectively. The table reports results for each of the fifteen bond dealers individually and collectively as a group (Overall) where the group results are obtained by aggregating across the fifteen dealers their positions in each security at the end of each day. t-stat. represents the t-statistic showing the significance of the slope coefficients and R^2 (Adj.) reports the adjusted R^2 of the above regression. Figures in bold face indicate significance at 5% level.

Dealer *k*	α_k	**t-stat.**	h_k	**t-stat**	**R^2 (Adj.)**
1	6.88	0.44	**-0.36**	-8.81	20.10
2	-9.02	-0.37	**-0.42**	-8.04	17.40
3	0.80	0.07	**-0.39**	-12.3	32.50
4	-0.34	-0.02	**-0.45**	-9.29	26.40
5	-2.71	-0.20	**-0.80**	-25.75	68.10
6	3.49	0.31	**-0.28**	-7.55	15.50
7	-7.66	-0.22	**-0.23**	-4.45	5.80
8	-9.88	-0.34	**-0.66**	-15.51	42.70
9	-8.93	-0.60	**-0.47**	-8.70	19.10
10	1.01	0.16	**-0.50**	-11.30	29.00
11	0.01	0.00	**-0.69**	-18.25	50.70
12	-0.02	-0.00	**-0.59**	-6.90	37.40
13	-0.07	-0.01	**-0.42**	-9.69	23.10
14	0.78	0.20	**-0.57**	-17.69	50.60
15	2.32	0.26	**-0.58**	-9.58	34.50
Overall	-52.73	-0.71	**-0.27**	-6.41	11.30

Table IV: Relationship between Changes in Derivatives Exposure and Changes in the Spot Exposure due to Nominal Bonds and due to Index-Liked Bonds

This table shows the coefficients of the following regression:

$$\Delta DerivExp_{k,t} = \beta_k + h_k^{NOM} \Delta SpotExp_{k,t}^{NOM} + h_k^{I-L} \Delta SpotExp_{k,t}^{I-L} + \eta_{k,t}$$

where *k* indicates the dealer (*k*=1, 2 .... 15), $\Delta DerivExp_{k,t}$ is the change in Derivatives Duration Exposure of Dealer *k* from end of day *t-1* to end of day *t*, $\Delta SpotExp_{k,t}^{NOM}$ and $\Delta SpotExp_{k,t}^{I-L}$ are the changes in Spot Duration Exposure of Dealer *k* arising from Nominal and Index-Linked bond holdings respectively from end of day *t-1* to end of day *t*, h_k^{NOM} and h_k^{I-L} are the hedge ratios for Nominal and Index-Linked bond holdings respectively, β_k and $\eta_{k,t}$ are the intercept and error terms respectively. The table reports results for each of the fifteen bond dealers individually and collectively as a group (Overall) where the group results are obtained by aggregating across the fifteen dealers their positions in each security at the end of each day. The t-stat. represents the t-statistic showing the significance of the respective slope coefficients and the R^2 (Adj.) reports the adjusted R^2 of the above regression. Figures in bold face indicate significance at 5% level.

Dealer *k*	β_k	**t-stat**	h_k^{NOM}	**t-stat**	h_k^{I-L}	**t-stat**	**R^2 (Adj.)**
1	6.18	0.4	**-0.35**	-7.79	**-0.49**	-3.56	20.1
2	-8.98	-0.37	**-0.46**	-8.39	-0.15	-1.15	18.5
3	2.04	0.18	**-0.42**	-12.96	-0.12	-1.37	34.7
4	0.72	0.05	**-0.48**	-9.49	-0.19	-1.28	27.1
5	-4.23	-0.33	**-0.82**	-26.8	0.06	0.31	69.8
6	1.92	0.17	**-0.34**	-8.36	0.04	0.4	18.1
7	-6.81	-0.19	**-0.23**	-4.45	-0.12	-0.62	5.6
8	-9.92	-0.34	**-0.66**	-15.53	0.09	0.1	42.6
9	-10.4	-0.71	**-0.5**	-9.09	0.05	0.22	20.3
10	1.06	0.16	**-0.5**	-11.25	**-0.92**	-3.06	29.2
11	-0.52	-0.22	**-0.82**	-25.54	0.13	1.86	67.2
12	-0.05	-0.01	**-0.58**	-6.59	**-0.69**	-2.02	36.7
13	-0.54	-0.1	**-0.44**	-10.04	-0.04	-0.26	24.3
14	2.45	0.87	**-0.85**	-28.96	-0.03	-0.82	73.4
15	2.32	0.26	**-0.58**	-9.37	-1.11	-1.38	34.3
Overall	-52.06	-0.69	**-0.26**	-5.93	-0.28	-1.71	10.6

Table V: Hedge Ratios in different Market Conditions

This table shows the coefficients of the following regressions:

$$\Delta DerivExp_{k,t} = \gamma_0 + \left(\Sigma D_{k,t} h_k + \gamma_1 Vol_t + \gamma_2 Magn_t + \gamma_3 D_t^{MISP}\right)\Delta SpotExp_{k,t} + \omega_t \quad \textbf{(8A)}$$

$$\Delta DerivExp_{agg,t} = \gamma_0 + \left(h_{agg} + \gamma_1 Vol_t + \gamma_2 Magn_t + \gamma_3 D_t^{MISP}\right)\Delta SpotExp_{agg,t} + \omega_t^{agg} \quad \textbf{(8B)}$$

where $\Delta DerivExp$ and $\Delta SpotExp$ are as defined in Table III, $D_{k,t}$ is a dummy variable which takes the value 1 for observations corresponding to dealer *k*, h_k, h_{agg} are the base level hedge ratios, Vol_t is the duly normalised absolute value of the open-to-close price change of the nearest bond futures contract, $Magn_t$ is the duly normalised magnitude of the spot duration exposure at time *t* multiplied by a dummy variable which takes the value 1 when the change in spot exposure is in a direction that increases the magnitude of this exposure, D_t^{MISP} is a dummy variable which takes the value 1 when hedging requires buying (selling) underpriced (overpriced) futures and the value -1 when hedging requires selling (buying) underpriced (overpriced) futures. The first two columns of the table report results for equation (A) above using individual dealer exposures while the last two columns report results of equation (B) above using the aggregate exposure over all fifteen dealers. Figures in bold face indicate significance at 5% level.

	Regression with individual dealer exposures		Regression with aggregate exposure of dealers as a group	
	Coefficient	**t-stat**	**Coefficient**	**t-stat**
γ_0	1.14	0.25	-28.80	-0.40
γ_1	**-0.02**	-2.09	**-0.13**	-3.14
γ_2	**-0.05**	-3.96	**-0.16**	-3.67
γ_3	**-0.05**	-1.99	**-0.39**	-4.34
h_{agg}			**-0.14**	-2.77
h_1	**-0.33**	-7.08		
h_2	**-0.41**	-10.56		
h_3	**-0.36**	-7.49		
h_4	**-0.43**	-6.41		
h_5	**-0.79**	-18.82		
h_6	**-0.25**	-4.45		
h_7	**-0.19**	-6.51		
h_8	**-0.65**	-24.69		
h_9	**-0.46**	-7.37		
h_{10}	**-0.49**	-4.27		
h_{11}	**-0.65**	-3.10		
h_{12}	-0.64	-0.99		
h_{13}	**-0.41**	-3.22		
h_{14}	**-0.54**	-3.80		
h_{15}	**-0.56**	-3.65		
R^2 (Adj.)	29.5%		19.5%	

Table VI: Profitability of Selective Risk Taking vis-à-vis Full Cover Hedging

This table reports the profits arising from carrying non-zero exposure overnight individually for the fifteen UK government bond dealers and collectively as a group (overall). All figures are in millions of Pound Sterling.

Dealer *k*	Mean	Median	Q1	Q3	Min.	Max.	t-stat
1	-0.058	0.097	-0.57	0.64	-10.09	3.18	-0.83
2	0.017	0.009	-0.41	0.50	-4.99	5.38	0.31
3	-0.077	0.000	-0.24	0.24	-6.93	2.72	-1.71
4	-0.052	0.003	-0.28	0.30	-7.91	2.31	-1.12
5	0.008	0.044	-0.27	0.36	-5.18	1.81	0.25
6	0.046	0.002	-0.17	0.30	-3.87	2.90	1.13
7	-0.004	0.005	-0.15	0.24	-8.70	3.30	-0.08
8	0.037	0.011	-0.12	0.18	-3.46	2.30	1.59
9	0.023	0.010	-0.07	0.16	-4.08	2.03	0.83
10	0.000	0.004	-0.11	0.12	-2.62	0.86	-0.01
11	0.014	0.014	-0.05	0.08	-1.20	0.71	1.52
12	-0.017	-0.005	-0.07	0.04	-0.48	0.42	-1.49
13	0.010	0.001	-0.04	0.07	-0.65	0.49	1.39
14	0.003	0.000	-0.04	0.03	-0.58	0.75	0.44
15	0.000	0.000	-0.02	0.01	-0.47	0.35	0.09
Overall	-0.039	0.573	-2.84	3.37	-43.10	16.66	-0.11

Table VII: Relation between Changes in Derivatives Exposure and Changes in Shift Exposure and Changes in Twist Exposure of the underlying Spot Position

This table shows the coefficients of the following regression:

$$\Delta DerivExp_{k,t} = \delta_k + h_k^{DUR} \Delta SpotExp_{k,t} + h_k^{TW} \Delta SpotTwistExp_{k,t} + \xi_{k,t}$$

where k indicates the dealer (k=1, 2 .... 15), $\Delta DerivExp_{k,t}$ is the change in Derivatives Duration Exposure from end of day *t-1* to end of day *t*, $\Delta SpotExp_{k,t}$ and $\Delta SpotTwistExp_{k,t}$ are the changes in Spot Duration Exposure and Spot Twist Exposure respectively of dealer k from end of day *t-1* to end of day *t*, h_k^{DUR} and h_k^{TW} are the hedge ratios for Duration Exposure and Twist Exposure respectively, δ_k and $\xi_{k,t}$ are the intercept and error terms respectively. Figures in bold face indicate significance at 5% level.

Dealer Code	δ_k	t-stat	h_k^{DUR}	t-stat	h_k^{TW}	t-stat	R^2 (Adj.)
1	4.75	0.31	**-0.22**	-3.98	**-0.017**	-3.56	23.1
2	-9.94	-0.41	**-0.31**	-3.59	-0.011	-1.71	17.9
3	0.5	0.04	**-0.37**	-8.99	-0.001	-0.52	32.4
4	-0.6	-0.04	**-0.48**	-6.95	0.001	0.5	26.1
5	-1.93	-0.15	**-0.61**	-9.03	**-0.015**	-3.33	69.1
6	3.56	0.31	**-0.26**	-4.41	-0.002	-0.43	15.3
7	-7.66	-0.21	**-0.23**	-2.37	-0.001	-0.01	5.5
8	-7.79	-0.27	**-0.56**	-9.46	**-0.011**	-2.45	43.5
9	-6.47	-0.45	**-0.19**	-2.37	**-0.026**	-4.37	23.5
10	0.98	0.15	**-0.37**	-5.01	**-0.012**	-2.21	29.9
11	0.22	0.08	**-0.78**	-11.11	0.009	1.76	51.1
12	0.63	0.15	0.06	0.28	-0.039	-3.54	45.6
13	0.12	0.02	**-0.44**	-7.26	0.002	0.61	23.1
14	0.49	0.13	**-0.69**	-7.95	0.008	1.48	50.8
15	2.12	0.24	**-0.69**	-8.34	0.009	1.85	35.6
Overall	-45.5	-0.61	**-0.18**	-3.11	**-0.01**	-2.18	12.4

Figure 1: Evolution of Spot and Derivatives Exposure over Time for the dealers as a group

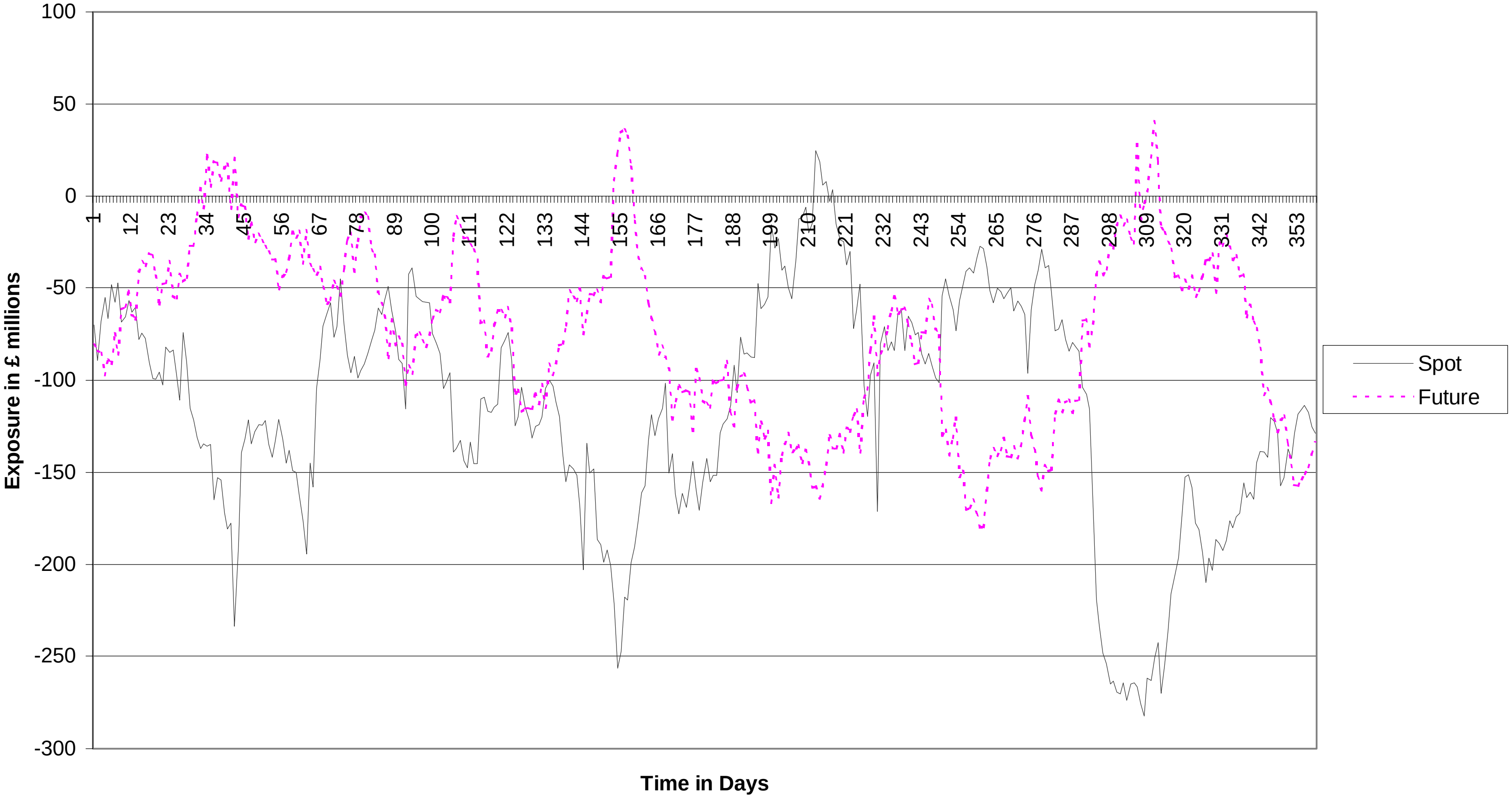

Figure 1(a) : Evolution of Spot and Derivatives Exposure over Time for a medium sized dealer

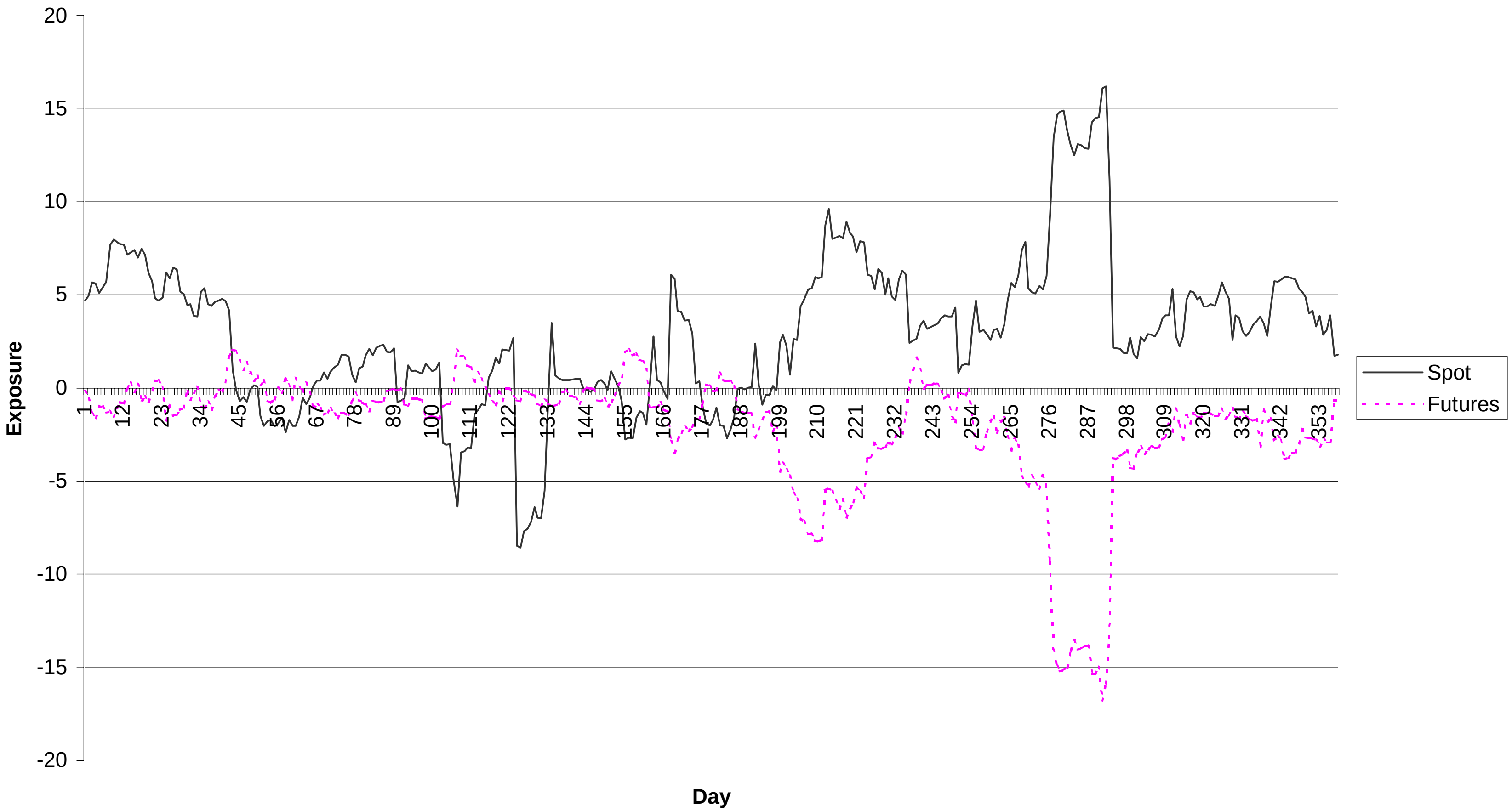

Figure 2: Duration and Twist of 8% coupon bonds with different maturities