IPF Investment Property Forum

INVESTMENT PROPERTY FORUM Educational Trust

# Pricing Property Derivatives: An Initial Review

## Research Findings

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**September 2006**

This research was commissioned by the IPF ET and IPF Joint Research Programme

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## The IPF Educational Trust and IPF Joint Research Programme

This research was commissioned and funded under the auspices of the IPF Educational Trust and IPF Joint Research Programme.

The three-year programme supports the IPF's wider goals of enhancing the knowledge, understanding and efficiency of property as an investment class. The initiative provides the UK property investment market with the ability to deliver substantial, objective and high quality analysis on a structured basis. It will enable the whole industry to engage with the other financial markets, wider business community and government on a range of complementary issues.

The programme is funded by a cross-section of 16 businesses, representing key market participants. The IPF Educational Trust and the IPF gratefully acknowledge the contributing organisations; Capital & Regional, Donaldsons, Grosvenor, GVA Grimley, Investment Property Databank, KPMG, LaSalle Investment Management, Land Securities, Lovells, Morley Fund Management, Nabarro Nathanson, Prudential Property Investment Managers, Quintain Estates & Development, Scottish Widows Investment Partnership, SJ Berwin and Strutt & Parker.

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## The project steering group

The Property Derivatives Interest Group (PDIG) steering committee reviewed the research findings. The IPF gratefully acknowledges the contribution from the Chairman, Iain Reid (Protego), and the members Anne Leckie (Standard Life), Becky Worthington (Quintain), Colin Barber (Propex), James Adam (ICAP), Paul McNamara (PruPim), Rawle Parris (ABNAmro), Richard Sutherland (Tavistock), Sabrina Wisner (IPF), Tim Horsey and Charles Follows (IPF).

The views expressed in the report are those of the researchers alone and do not necessarily represent the views of PDIG or the individual members of the PDIG steering group.

PDIG is a special interest group of the IPF.

### Disclaimer

# Pricing Property Derivatives: An Initial Review

## Context

The last two years have seen the emergence of a burgeoning property derivatives market that continues to develop and mature apace. Along with property derivatives, the widespread use of indirect property vehicles and the impending introduction of REITs in 2007 bring to the property investment market products long established in the other asset classes and other markets. These developments will benefit the UK property investment market and reinforce its position as one of the main asset classes for investors.

However, most property practitioners are not schooled in derivatives and the theoretical framework underlying their pricing. Property fund managers, surveyors and other property market practitioners may struggle fully to understand these financial products. On the other hand, derivatives people are engaging with the property market for the first time.

In order to fill these knowledge gaps the IPF ET and IPF joint research programme commissioned this research. This research helps the transparency, efficiency and operation of the property investment market by reviewing the development of the property derivatives markets and exploring the underlying pricing framework. In addition, the researchers interviewed a number of market participants and report on their views of the pricing mechanism currently used in this developing market.

The IPF ET and IPF congratulate the research team and invite comments on the findings. Please address comments or suggestions to Charles Follows, Research Director, IPF, New Broad Street House, 35 New Broad Street, London EC2M 1NH.
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# Pricing Property Derivatives: An Initial Review

## Executive summary


- This report reviews the development of property derivatives and, in particular, total return swaps in the UK market. It considers pricing processes observed in the market and compares them to those that would be expected based on finance theory and the experience of other asset markets.
- Formal attempts to establish an active UK property derivatives market were hampered by the failure of London FOX and a set of regulatory and tax obstacles. PICs and PIFs were successfully launched and traded but a change in the regulatory environment – driven by PDUA/PDIG – has revived interest in the market and seen the development of an over the counter total return swap market.
- It is estimated that some £800 million of trades took place in 2005, a figure matched in the first half of 2006. Further evidence of interest comes from the trading forums organised by HERMES, GFI and ICAP and new initiatives by others, including MSS Capital and Goldman Sachs.
- A fundamental financial principle is that efficient markets will eliminate arbitrage opportunities. The same assets available in two different markets should have the same price. If an investor can sell one cashflow from an asset, receive a second cashflow in exchange and can use that cashflow to buy the original asset, the total net present value must be zero.
- A second key financial principle is that risk should be priced appropriately. Apparently similar assets may exhibit differences in prices due to differences in their relative risk. Direct property investment and investment in property derivatives represent different assets and to the extent that they are different their prices must be different.
- These principles hold in swap markets. In fixed to floating interest rate swaps, the fixed rate produces payments that, when discounted at forecast LIBOR rates, produce zero NPVs. In financial market index swaps, risk adjusted returns equalise. Thus, for equity-interest rate swaps (for example FTSE to LIBOR) the margins (spreads) are very small – a few basis points. The same is observed in bond-interest rate swaps. The margins do not simply reflect differences in expected returns, as they reflect the fact that risks are not equal.
- The limited evidence that exists on real estate swap pricing, from the trading forums and indicative prices available on Bloomberg, Reuters and Propex for example, suggest that property / LIBOR swaps have traded at large margins – as much as 500bps to 600bps for one year swaps, 400bps to 450bps for two year swaps, over 300bps for three year swaps. What is the source of such large margins?
- Evidence from a set of interviews with market participants in early 2006 suggests that the base approach is to look at the difference between expected returns for the two assets. This establishes an initial margin that may then be risk adjusted. This approach is inconsistent with financial theory.
- The survey provided evidence that investors were using derivatives to change their exposure to the asset class while avoiding transaction costs in the underlying market. This identifies property market characteristics and inefficiencies in that market as a potential source of margin.
- Property markets are more complex due to the nature of the asset class. It is not easy to reproduce or track IPD due to large lot sizes, high specific risk and, critically, high transaction costs that drive long holding periods for direct investors.
- There are also index issues mostly relating to the valuation-based nature of most property indices. This produces serial correlation, smoothing from temporal aggregation effects and issues concerning timeliness and insider knowledge.

# Pricing Property Derivatives: An Initial Review

- As yet there is a limited theoretical literature on property derivatives. The papers that do exist show that expected margins should be very small or zero – consistent with the equity market swap literature. The results, though, assume market efficiency. Actual margins may reflect inefficiencies in the underlying market but, once again, should not result primarily from differences in expected returns.
- In analysing swaps, it is important to emphasise that what is being swapped is a bundle of return and risk and that the risks differ. If LIBOR returns and property returns are correctly priced and lie on the securities market line (meaning that riskier assets offer higher returns to accurately reflect that risk differential) then there should be no margin. This assumes that investors hold well diversified portfolios and are thus concerned about systematic risk, not specific risk.
- In practice, a key issue that needs to be considered is whether it is possible to create a perfectly hedged portfolio despite tracking error and the return-eroding impact of transaction costs. The proposed FTSE Property Index, based on the MSS FTSEpx property fund, creates an (albeit imperfect) investable exchange-traded underlying asset. This introduces the possibility of perfect hedging.
- In conclusion, there appear to be pricing anomalies in the property derivatives market and in the pricing processes advocated by the market participants interviewed. As the market develops and as knowledge and understanding deepens, the margin should adjust to a value that reflects inefficiencies and trading costs in the underlying property market, but importantly not differences in expected returns.

# 1. Introduction

In this report, we review the development of the UK property derivatives market and, in particular, the growth of an over-the-counter market in total return swaps. We offer a view on approaches to pricing grounded in a literature review and in a series of interviews with market participants.

Commercial real estate was arguably, until recently, the only major asset class without a well-developed derivatives market. Early attempts to establish such a market were unable to achieve critical mass or trading volume. In particular, the 1991 failure of the property forwards markets on London FOX – where lack of trading led to insider deals to present the illusion of activity – created a climate of suspicion that hampered subsequent developments. Allied to regulatory constraints which, in large measure, excluded institutional investors from participating in markets, this meant that there was little activity during the 1990s, despite the work of energetic advocates from the industry.

With the exception of Property Index Certificates (PICs), investors seeking a rapid, low entry cost exposure to the property market or who wished to hedge their property investments had few, if any, options. More recently, regulatory change has created an environment in which it is possible to trade property derivatives. The last few years have seen a growing volume of bipartite deals, generally swapping total property returns for an interest rate exposure, mostly based on LIBOR. Seminars and simulated trading platforms have helped to raise awareness of the possible uses of property derivatives. The UK commercial property market is leading the charge, but activity is by no means confined to this market.

Abbey has developed a programme of derivative originations that include both short term futures and longer term swaps and the Newcastle Building Society has offered bonds with lives of five, seven or 10 years with returns linked to the Halifax House Price index. There has also been development of spread betting products in the online betting houses. In addition AXA launched a series of exchange traded products based on the EPRA listed property indices – a market that may develop in the UK if the UK REIT is a success.

In Australia, there is an active ASX futures contract traded on the performance of Listed Property Trusts, and in the US derivatives are now being traded against both the NCREIF commercial property index and against residential indexes. For example, 2006 saw the launch of the S&P CME housing futures and options contracts on the Chicago Mercantile Exchange, based around Shiller and Weiss's (1999) ideas. Activity has been announced in Switzerland and Sweden and suggested in other European markets. We appear to be on the point of seeing property derivatives markets emerge across the globe.

It is therefore an opportune time to review the pricing of derivatives. We start (in Section 2) with a literature review and a brief history of the development of the nascent real estate derivatives market. We then (in Section 3) review the fundamental pricing principles that sit behind the valuation of swaps and the establishment (where appropriate) of margins. We also consider the possibility that property, with its inherent illiquidity and valuation-based indices, may be different.

In Section 4, we report the survey results from a number of extensive interviews with market participants (and potential participants). These interviews establish UK market pricing practice and market thinking in the first half of 2006, in relation to total return swaps. They enable us to draw a comparison between theory and practice.

# 1. Introduction

To preview our results, the existing pricing of UK property total return swaps does not appear to be consistent with the experience in the equity index swaps market, where margins over LIBOR are very small. We conclude (in Section 5) by discussing whether this apparent anomaly results from the inherent characteristics of real estate as an investment asset (which precludes most arbitrage strategies, largely due to transaction costs) or from some form of mispricing that results from the novelty of the market and the new vehicles, and which will inevitably be eroded over time. The conclusion is, we hope, a clear one.

# 2. A very short history of the UK real estate derivatives market

## 2.1 Introduction

This brief section first describes a review of the relevant literature, and then goes on to highlight the main developments that have led to the current interest in total return swaps and other forms of derivatives.

## 2.2 A literature review

McAllister and Mansfield (1998a) generally categorise derivatives as futures, options and swaps and highlight the main characteristics which may favour them if compared with direct investment in real estate.

- They are highly liquid (as defined by the speed of execution, the time taken between a signalled intention to buy/sell and the cash out/inflow and transaction costs)
- They allow efficient diversification with a small minimum investment value, and 'synthetic property sales/purchases' without any actual transfer of the property rights
- They permit flexible and pro-active tactical allocation

In a second paper, McAllister and Mansfield (1998b) review the 'state of the art' in the UK real estate market and describe all products and intended products available to investors at that point: property futures (initially launched by London FOX in 1991), property index certificates (launched by Barclays in 1994), property index forwards (launched by BZW in 1996), property index notes (debt instruments with bond-like qualities paying an income return based on the IPD index, offered by BZW), property basket warrants (instruments allowing investors to obtain an exposure to indirect real estate investment, offered by Goldman Sachs and UBS Warburg) and the real estate index market (similar to PIFs and led by AMP Investment Management). These initiatives are reviewed in more detail in Section 2.3 below.

Jeyarajah (2006) produced a guide to UK property derivatives, mainly focusing on property total return swaps. This report includes an example of a contract and describes swaps based either on the IPD All Property Index or on the IPD Sector Indices (Office, Retail and Industrial). Jeyarajah points out the main implications of taxation on trading (given that gains and losses are treated as income) against non-trading contracts (where tax is split between income and capital components).

In the US market, the development of derivative products in the real estate market is also quite recent, with the first real estate-linked swap launched back in 1991. Fisher (2005) describes the total return swaps announced and to be offered by Credit Suisse First Boston (CSFB) in the USA. The credit for each contract will be backed by CSFB which will play a role as counterparty in an exchange of property returns – based on the NCREIF Property Index (NPI), either total return or capital growth – and priced at a spread which could be either positive or negative, depending upon market conditions. Fisher underlines the importance of high autocorrelations for valuation-based indices and the consequent lagging effects.

Finally, in the US total return swaps have also used commercial mortgage backed securities (CMBS) as underlying assets[1]. Goodman and Fabozzi (2005) describe this type of derivative using either the Lehman or Bank of America CMBS index or a sub-sector index. Their normal length is six months (although shorter

[1] While CMBS are debt products, the pricing of CMBS reflects the strength of the underlying real estate market which has an impact on default risk and loss on default. The relative importance of real estate risk and more general bond market risks depends on the payment structure of the vehicle.

# 2. A very short history of the UK real estate derivatives market

or longer contracts are available), with a monthly settlement frequency (based on the actual timing and exchange of cash flows). The two components of the CMBS total return are given by an income part (from the CMBS yield) and a capital component, estimated as the change in yield multiplied by the modified duration of the securities.

## 2.3 FOX, PICs and REIM

The UK property industry has long sought to develop a derivatives product that would enable strategic and tactical portfolio management and enable investors to alter their exposure to real estate without incurring high transaction costs or being exposed to public market price volatility. However, attempts have been hamstrung by complications concerning regulatory requirements and tax treatment and by the nature of the underlying indices.

Nonetheless, as suggested above, the first formal attempt in the UK to establish a commercial property derivatives market was the London Futures and Options Exchange (FOX). In May 1991 FOX launched four simple index derivatives based on IPD annual capital and total return indexes, a mortgage interest index and a residential price index. The market failed to develop sufficient depth or volume of trading activity to generate liquidity and was suspended in October 1991 amid allegations of trading irregularities and cross-trading by market makers. The failure of FOX was damaging for the development of a market for property derivatives, blighting attitudes of investors and regulators alike.

In 1994 BZW launched Property Index Certificates (PICs). PICS are essentially structured as Eurobonds with coupon payments linked to the IPD All Property income return in each year, and a capital redemption value linked to the IPD All Property capital gain over the life of the certificate. If acquired at par, this instrument effectively replicates IPD returns (less dealing fees and margins) for the bond holder, although any exit before maturity may result in a tracking error produced by variations in market price.

PICs were issued in 1994, 1995, 1996, 1999 and 2005, this last issue being made by Protego and Barclays Capital (who support a secondary market). Prices are available through Reuters. It has been suggested that around £800 million of PICs have been issued over the life of the vehicle, although it should be noted that typical maturities are short and the amount outstanding at any time to date will be less than this.

Barclays also issued Property Index Forwards (PIFs), a simple contract for difference product linked to the IPD All Property return – a market that ran between 1996 and 1998 but which, again, did not achieve critical mass in trading volumes or liquidity.

Other investors sought to create markets for total return swaps (for example the proposed real estate investment market, or REIM) but the development of these initiatives was hampered by regulatory constraints (particularly limitations on life funds holding property derivatives) and by taxation and accounting uncertainties. The Property Derivatives Users Association (now the Property Derivatives Interest Group, a special interest group of the IPF) lobbied for clarifications with considerable success.

In 2002 the FSA confirmed that life insurance companies could use property derivatives for efficient portfolio management, incorporated into the IPRU Integrated Prudential Source Book. The taxation issue was largely resolved in December 2003, when an Inland Revenue consultation paper confirmed that property derivatives would fall into the 'standard' derivatives regime, with most net cashflows subject to income, not capital gains, tax. This was confirmed in the 2004 Finance Act.

# 2. A very short history of the UK real estate derivatives market

Finally, the implementation of FSA consultation paper CP185 as the new collective investment scheme sourcebook, COLL, in 2004 allows authorised retail and non-retail funds to hold property derivatives, subject to various prudential limitations. Thus by 2005 the constraints that existed in the regulatory environment had largely been removed.

## 2.4 The new market

In the post-2004 environment, the derivative product that has attracted most attention has been the total return swap. It has been estimated that there were around £800 million (notional value) of trades in 2005, although it is not clear how much (if any) of this activity included exchange trades of PICs. Almost all swap trades have been over the counter bipartite deals, although brokers have been active in arranging the deals and investment banks have been essential players in trade execution. The emergence of financial intermediaries and market makers prepared to take positions, warehouse deals and carry inventory costs is critical to the development of a more liquid market and the emergence of price signals. Perhaps of more significance is the number of institutions, hedge funds and private investors expressing an interest or obtaining a mandate to trade in the property swaps market.

This is reflected in the attendance at a series of trading forums, organised by Hermes, GFI and ICAP. At the first trading forum in October 2005, three-year total return swaps were traded with LIBOR, initially at a margin of around 200 basis points (with quite a wide range around that), with the margin going out in trading. Later forums saw considerably higher margins being established. These differences suggest that, in its early days, the market was clearly unsure about the correct price for these trades.

However, the property swap transactions which took place in 2005 involved the largest insurance companies and property companies, including Quintain, British Land and Prudential. In 2006, the key players were increasingly hedge funds. This broadening of appeal is good news for the market, and has implications regarding the improving efficiency of pricing. Trading forums provide both valuable experience for potential traders and investors and an early indication of pricing levels. But are the trading forum margins (and the margins now being quoted by investment banks and traders seeking to make markets) consistent with the principles of swap pricing? We return to this issue in Section 3.

Related to the growing interest from hedge funds, details emerged in June 2006 of a hedge fund manager launching a property fund (the MSS FTSEpx fund[2]) whose performance was to be measured on a daily basis in order to produce a new FTSE property index. It is a fund of funds, but has an ambition to add direct property. Some of its current assets are geared but the fund can hold cash against that gearing. It will be 'daily priced' because the underlying funds and properties will report valuations and NAVs at different times[3], and (given growth in the fund) there will eventually be true daily activity. Because this moves the property derivative contract closer to the world of financial market traded derivatives, for which the pricing process is well developed and understood, this creates an interesting case study for derivative pricing, which we will also examine in Section 3.

[2] According to its press release, MSS, assisted by Insight Investment, created the FTSEpx Fund – a sterling-denominated, open-ended Guernsey property unit trust listed in the Channel Islands. The Fund has a diversified UK portfolio of just over £100 million of largely unlisted property funds providing exposure to a look-through portfolio of £7 billion of commercial real estate assets. The FTSEpx Fund, together with the FTSE UK Commercial Property Index Series, provides investors with daily capital value and total return indices on all property, retail, office and industrial.

[3] This means that there will be daily adjustments but, as with the NCREIF property index in the US, a problem of 'stale' valuations.

# 2. A very short history of the UK real estate derivatives market

In addition, in July 2006 Goldman Sachs launched a London Stock Exchange-listed property derivative product. Goldman Sachs' UK IPD Tracker matures in early 2010, four and a half years after its launch, and after the publication of the 2010 IPD Index. Investors will receive the annual return from property minus 2.8% per annum. "The liquidity aspect is a first," says Richard Fulton, director of structured sales at Goldman Sachs. "It is LSE-listed, and we are committed to showing two-way pricing on an intra-day basis, meaning investors can go in and out of the market whenever they wish." The product is aimed at both retail and institutional investors, with a minimum investment of £10. The product's initial issuance target was £25 million. In time, this instrument will provide more pricing data. Is the IPD index minus 2.8% a fair price for exposure to a liquid property derivative? Will the security move to a discount or premium?

In addition, forward starting contracts (for example, for calendar year 2008) and capital growth only contracts are becoming more popular. International swaps are also becoming interesting, especially as they involve limited currency risk (because there is no upfront capital payment). While the lack of a monthly or quarterly index outside the UK will limit liquidity and interest, we can expect increasingly deep and wide markets offering improved price discovery. As market efficiency improves, will pricing approach its theoretical level? Again, we begin to examine the relevant arguments in Section 3.

# 3. Pricing principles and their applicability to property

## 3.1 Financial market principles

The fundamental principle underlying derivatives pricing is that efficient markets will eliminate arbitrage opportunities. Arbitrage opportunities exist where an asset or investment is available in different markets at different prices and, hence, could be bought and sold generating a risk-free profit. This would be the case, for example, if there is a derivatives contract on an index or asset offering a different return from that obtainable by purchasing the index itself. Markets function to eliminate arbitrage opportunities, as is evident in equity markets where equity index futures and the underlying market are inextricably linked.

The starting point for an analysis of swap pricing is to consider an interest rate swap where a fixed interest rate liability or asset is swapped for a floating rate interest liability or asset, generally based on LIBOR or some other accepted benchmark. Since there are known forward rates for LIBOR at the various payment dates, the pricing exercise for this swap establishes the appropriate fixed rate that produces a zero value for the swap and hence eliminates any arbitrage opportunity. If one interest in an interest rate swap had a positive net present value (and, by implication, the other interest had a negative present value) there would be an arbitrage opportunity. Investors would act to exploit the opportunity, altering the supply and demand balance and eliminating the positive NPV.

In the fixed-floating rate swap, the pricing exercise is to establish the fixed rate that leads to a zero net present value for both participants. Market evidence is available in the form of LIBOR forward rates. The LIBOR forward rates are assumed to be unbiased and efficient estimates of the future spot rates on which payments will be based and can be considered as certainty equivalents (or risk free rates).

Consider a two year fixed to floating swap with a notional value of £10 million with payments made every six months. We have estimates of LIBOR for six months, one year, 18 months and two years from the market that will be used in the valuation of the fixed interest leg of the swap. These rates ($i_n$) are nominal and must be converted to effective annual rates using: $\{(1 + i_n / 2)^2 - 1\}$. This produces the effective annual rates shown in Table 1.

### Table 1: LIBOR rates and effective annual conversion

| Time | LIBOR | Effective Annual |
|---|---|---|
| 0.5 | 4.50% | 4.55% |
| 1.0 | 4.75% | 4.81% |
| 1.5 | 5.00% | 5.06% |
| 2.0 | 5.25% | 5.32% |

These effective rates are the appropriate discount rates to be utilised in the transaction. The total net present value (NPV) of the fixed interest component must be £10 million. The recipient will receive four fixed interest payments and, at year two, the notional return of the £10 million principal. The valuation then seeks to find the fixed coupon that leads us to an NPV of £10 million. It turns out that this solves at £261,690:

$261{,}690(1.0455)^{-0.5} + 261{,}690(1.0481)^{-1} + 261{,}690(1.0506)^{-1.5} + 10{,}261{,}690(1.0532)^{-2}$

= £10,000,000.

# 3. Pricing principles and their applicability to property

From this we can estimate that the *nominal* interest rate for the swap should be 5.23% that is (2 * 261,690) / 10,000,000.[4]

In practice, interest rate swaps are brokered; the broker will charge a small fee for setting up the deal and banks will take a fee for warehousing deals, for taking on any inventory risk and for counterparty risk should one or other participant default. This enables the market to function in a highly efficient manner, providing strong pricing signals and enhancing the information content of the forward rates.

Currency swaps are similar in nature to interest rate swaps. Here both parties face uncertainty given potential currency fluctuations over the life of the swap. However, there is an active and large market for currency forwards and futures that drives the current exchange rate and therefore provides a strong basis for the efficient pricing of swaps. A currency swap could, in principle, be replicated with a series of currency forward agreements, although this would not be an efficient approach.

As with interest rate swaps, the currency market is brokered, not over the counter. Swap dealers will therefore charge a fee for counterparty risk, inventory and warehousing costs and any other transactional costs. These margins are very small.

The development of financial market index swaps has been comparatively more recent. Here counterparties will swap exposure to, for example, the FT All Share Index for LIBOR. This market started, as with the UK property derivatives market, as an *over the counter market.* At first glance, it would appear that the party receiving the interest rate payments should demand a considerable margin over LIBOR since the expected returns for equity will be higher. Initially this was the case. However, as the market developed, what we would regard as theoretically correct pricing principles prevailed and margins are now very small indeed – a handful of basis points. Why is this?

As an example, take a plain vanilla LIBOR-Equity Index swap, where one party pays six monthly LIBOR payments for a set period, the counterparty paying the six monthly return on an agreed equity market index. There is a notional principal and an exchange of cash every six months (one party receiving, the other paying a balancing payment based on the difference between LIBOR and equity returns).

First, consider the recipient of the LIBOR payments. The notional LIBOR payments provide a cashflow which can be used to support a (floating rate) loan. This loan can then be used to acquire equities which track the underlying index that is the basis of the swap. At the end of the life of the swap, the equities can be sold to redeem the loan.

Through this mechanism the recipient has engineered a risk free position. If the return from LIBOR exceeds the return from the equity market, the excess payments can also (in principle) be invested in the equity market. The LIBOR recipient does not need to do this – indeed, in most instances, they will be trying to reduce exposure to the equity market – but they could. If the swap is set up such that the contract pays a large margin over LIBOR (say LIBOR plus 250 basis points), then the loan that can be supported is larger than the notional principal. More equities than are needed to satisfy the swap can be bought. This appears to create a profit for very low risk and would thus represent a pricing anomaly.

[4] Example adapted from Chance 1995, page 508-509.

# 3. Pricing principles and their applicability to property

In similar fashion, the recipient of the FT All Share returns has, in effect, made a geared investment in the equity market but could use the proceeds (if any) to buy down debt or to lend to other investors. Again, they is unlikely to do so – but they *could*. If there is a margin over LIBOR, the amount of debt that can be bought down is less than the notional principal. Given that an efficient market will seek to eliminate risk-free profits (and counterparty losses), the margin should be eroded. Thus the only required margins relate to the costs of managing the swap. If the deal is brokered by a third party, there will be other costs to pay, shared by the swap counterparties.

As a result, the margins that were initially present in equity index swaps narrowed rapidly. A similar process occurred with bond/interest rate swaps. For equity markets, it is also worth noting that there are well-developed equity index futures markets that provide key information about market expectations of returns. Given the nature of futures pricing, these are also generally assumed to be unbiased efficient estimators (given current information) that can act as certainty equivalents in pricing models.

It is a common thread in these examples of pricing derivatives that a riskless portfolio can in practice be created by an investor. In all cases, a perfectly matched long/short position can be acquired with reasonably low transaction costs. This means that all expected cash flows can be discounted at the risk free rate, and differences in risk between the swapped assets become irrelevant. More importantly, differences in expected returns also become irrelevant. The only reason for a margin then relates to the costs involved in creating the position. Is there any reason why property derivative pricing should be different?

## 3.2 Some specific problems in property markets

### 3.2.1 Tracking error

It is relatively straightforward to replicate an equity portfolio at modest cost. There are far stronger common components to equity returns, the typical lot size is small and a modest expenditure can produce a portfolio that will exhibit strong correlation with the underlying stock market or segment thereof. There is little or no 'basis risk'.

This is far from the case with real estate. Property is heterogeneous and lot sizes are large. As a result, only the very largest property portfolios will exhibit strong correlation with the underlying market and the majority of portfolios will contain a strong component of specific or basis risk. Consequently it is very difficult to imagine an investor using direct property investment to create the underlying arbitrage portfolio.

This is still more true at sector or segment level, and there is growing evidence that the returns of individual properties do not behave in line with the segment to which they are classified (see, for example, Devaney and Lizieri, 2005 and Baum and Struempell, 2006, and a forthcoming IPF research paper).

# 3. Pricing principles and their applicability to property

## 3.2.2 Liquidity and transaction costs

With the high transaction costs associated with real estate investment, most investors hold their real estate assets for some considerable time – an average of seven years (Bond *et al.*, 2004). By contrast, most swap products are relatively short term, a typical contract being for three years (although up to 10 year swaps have been offered). The short term swap realistically precludes the creation of an underlying portfolio of real assets because the round trip transaction costs over such a short period would badly damage returns. Moreover, as the *IPF Liquidity Report* showed (Investment Property Forum, 2005), the time taken to sell real estate assets is lengthy and uncertain. Thus, to create an arbitrage portfolio it would be necessary to look to indirect forms of investment.

Unfortunately, the most liquid and divisible indirect real estate forms – REITs and other public real estate securities – are unsatisfactory for this purpose. Evidence suggests that public real estate securities exhibit relatively low correlations with the available indices of property market performance, the basis of most swap contracts. This is certainly true of UK property companies, but is also true of US REITs. The effect is not simply a function of tax leakage. Listed property shares exhibit much greater volatility than the underlying real estate market, even once the impacts of valuation smoothing are removed.

However, unlisted real estate funds may provide an alternative, albeit imperfect, solution. This is the basis of a proposal by Beardsley (2006) and the MSS FTSEpx proposition. The implications of this are discussed in Section 5.

## 3.2.3 Index issues

It is important to consider the nature of the indices underlying commercial property derivative contracts. The Investment Property Databank (IPD) is established as the *de facto* standard benchmark for the UK investment property market with an enviable reputation. Nonetheless, the thin market and lack of trading that characterises commercial property means that the published indices rely on valuations for the estimation of capital growth and income return. This has a number of consequences of significance to property derivatives based on IPD indices.

The problem of smoothing describes the tendency for a valuation-based series to understate underlying market volatility. Research suggests that this results from a variety of factors including temporal aggregation effects (valuations spread around the due valuation date), reliance on historic comparables, cross-correlations and, most of all, the tendency for valuers, rationally, to update their prior valuations rather than process full information. Smoothing may be less of a problem where the annual index is used as the basis for trading, but becomes more problematic with higher frequency data. Smoothing effects are linked to a tendency to understate booms and troughs, which is critical for the use of derivatives as a hedge.

The valuation basis of the indices creates another potential problem: timeliness. Equity market indices are known with certainty at the close of trading. By contrast, the time taken to compile and process valuations means the IPD indices are published with a considerable lag and, although the use of information technology and data standardisation methods have reduced this lag, it still creates a trading window in which information on outcomes is known to insiders – an issue separate from the serial correlation produced by smoothing.

# 3. Pricing principles and their applicability to property

This is compounded by a third problem – the proportion of valuations in the indices that are carried out by a small number of firms. This contrasts with the equity indices used in stock swaps and futures which do not suffer from this potential influence.

Finally, and again in contrast with equity and bond indices, investors do not receive accurate intermediate price signals. For an FT All Share swap or future, the value of the FT All Share index is known in real time whenever trading is taking place throughout the life of the derivatives contract. By contrast, the only accurate information available on an IPD Total Return swap is the annual release. The monthly indices and the new quarterly indices do not perfectly track the annual index (their composition is different, although IPD do estimate a correction factor).

Hence the key issue – is there any reason why property derivative pricing should be different? Is the answer to do with the imperfections in property indices and property markets, and the extent to which these imperfections question the applicability of the fundamentals of general derivative pricing? We return to this point in Section 5.

# 4. Issues in market pricing: Results of an industry survey

## 4.1 Introduction

Prices paid for property-for-LIBOR swaps, both in real transactions and in the Hermes Property Derivatives Trading Forum, appear to have varied considerably over the opening of the post 2004 property derivatives market and, perhaps because of uncertainty regarding appropriate pricing approaches, pricing has not always been transparent. How do market participants think a typical property derivative contract should be priced? How have these contracts been priced in the market, and why? What have the prices been and how do they relate to theoretically correct pricing as discussed in Section 3?

The available evidence suggests that prices paid for property for three-year LIBOR swaps, both in real transactions and in the Hermes Property Derivatives Trading Forum, have varied from 80bp to 400bp. Initial prices appeared to be in line with the theory propounded in Section 3, as margins were small. A well-known early trade for a three-year all-property for LIBOR swap was priced at a margin of less than one per cent. However, it is not obvious that this is because both parties to the transaction were basing their approach on the arbitrage principles presented in Section 3. Another possibility is that margins were reduced by large risk premiums in a new and poorly understood market.

Whatever the reason for the low margins in early transactions, prices have been rising steadily since the end of 2005. Through the first three quarters of 2006, quoted margins or prices have become increasingly high, especially at the short end, so that margins now fall rapidly from one year contracts to five year contracts. At April 2006, Lehman Brothers (and, where available, a second unnamed dealer) were quoting the following prices based on a Quarter Two 2006 start: one year, LIBOR plus 580 (690); two year, 480 (400); three year, 325 (340); five year, 250. A one year two years forward contract was also quoted at LIBOR plus 220. By August, 800bps was a typical quoted margin for a calendar 2006 all-property derivative.

Price variations over time and a term structure for margins are increasingly evident. In this section we set out to explain and understand these prices by analysing the results of survey work. In February, March and April 2006 we conducted interviews with 12 market participants concerning their views as to how such derivatives were being priced; we also organised and facilitated an IPF event that considered property derivative pricing from a variety of positions.

We report the market approaches to pricing that participants considered relevant to the standard contract type exemplified; that is a three-year, all-property for LIBOR swap. We also summarise a series of issues affecting the detail of the pricing process.

## 4.2 Market approaches to pricing

### 4.2.1 Comparable evidence

Pricing property usually begins with comparable evidence. And given the recent development of securities such as the new Goldman Sachs instrument (see Section 1), it is increasingly available. At the time of undertaking the interviews it was estimated by one broker that around 30 swap deals had so far been completed, but many of these were small-volume deals intended to test the market and prices were not formally recorded or publicly available.

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There are two possible approaches to the assembly of comparable evidence as an indicator of contract price; direct evidence of similar recent transactions and indirect evidence based on transactions of other instruments that may have some relationship to the swap contract. The best example of the latter may be PICs, which have been around for more than 10 years. However, while it is suggested that PICs were selling in mid-2006 at a premium, PIC deals are not publicly reported. Issuers of PICs are restricted in practice to insurance funds, and there is an under-supply. The result is that there is a limited degree of liquidity and contracts are often held to redemption. In the view of some interviewees, these instruments are unlikely to directly influence mainstream derivative pricing for these reasons.

At present, given that this is a private market, there is imperfect knowledge of swap transactions and other private property derivative trades. Information that is held by parties to a transaction is regarded as commercially confidential and valuable and is therefore protected. Information about all deals is transmitted within an inner circle of three or four dominant inter-dealer brokers so that volumes are known, but this information does not always include prices. As a result, the market remains opaque to many property market participants. In this respect the nascent property derivatives market is no different from other over-the-counter markets.

Bloomberg, Reuters and Propex all carry indicative prices provided by Tullett Prebon. These are indicative bid-offer spreads based upon prices at which the broker's clients might be prepared to deal, but it cannot be assumed that this price will always be backed by a willingness to deal at the stated price. A daily history of these bid-offer prices is now available, which aids analysis. TFS also publishes indicative prices in its newsletters.

Finally, the four-year Goldman Sachs instrument, offering IPD returns less 2.8%, offers some pricing guidance. Longer term consensus return expectations are around 8% (see Table 2, below), so this contract appears to offer LIBOR plus a margin of less than 1%. Yet Table 2 below shows an asking margin of 235 basis points for a 2010 swap contract. Which (if either) of these indicates efficient pricing?

## 4.2.2 Early first-principle approaches to pricing

Given the lack of perfect comparables, those market participants we interviewed were forced back to first principles. For these interviewees, it became clear that the standard market practice was to price swap contracts by reference to the difference in expected returns between LIBOR and the IPD index. Interviewees suggested that by early 2006 current deals were showing a slight discount (a risk premium or a transaction cost?) against the average of the IPF consensus forecast less the average LIBOR rate, and this became the consensus view of how such a property derivative should be priced.

Initial public attempts to suggest pragmatic approaches to pricing appear to have been confined to occasional unpublished papers at conferences and the Hermes Property Derivatives Trading Forum. An initial presentation at the second trading forum was recorded in a brief note in the OPC newsletter of January 2006, and seems to have had some influence on the market – being cited in interviews and other private presentations describing approaches to pricing. The presentation focused on the then-standard three-year, all-property for LIBOR swap. The example used is presented and further developed in Appendix 1.

# 4. Issues in market pricing: Results of an industry survey

What is the value of expecting to be paid IPD returns and being paid LIBOR once a year each year for three years? The logic of the suggested pricing approach is as follows.

The appropriate price depends upon whether the buyer is a hedger or a speculator. For a pure speculator, Investment Property Forum (IPF) consensus return expectations for 2006-8 averaged (at Spring 2006) around 7.8%. The LIBOR (interest rate swap, three years) rate was approximately 4.8%. The seller of LIBOR should therefore pay a margin of around 3.0% less a risk premium and/or a trading fee. Moving on a step, the timing of returns should be accounted for. The IPF consensus for each year's annual returns in 2006, 2007 and 2008 is around 8.6%, 6.9%, and 7.5% in that order; LIBOR (interest rate swaps, each year for three years) are 4.5%, 4.8%, 5.0% respectively. If the differences are discounted (say, at 7.0%) the margin moves out slightly (see Appendix 1).

But which (IPD or LIBOR) is most uncertain? Over the period 1987 to 2004 the standard deviation of annual LIBOR rates was 3.2%; for IPD it was exactly three times greater at 9.6%. So IPD is three times riskier. But the risk of this deal is not quite this simple. What is the probability of IPD delivering less than LIBOR? Is there an even chance that IPD will exceed or fall below its expected value? This depends upon whether the series are correlated. A statistical approach is required to address these challenges in forming a view of the real risk involved in the contract. Given that the series are negatively correlated, the apparent risk of the swap for a speculator is increased and a high risk premium might be justified.

(It should further be noted that the recipient of property index returns has, in effect, bought a geared investment in real estate, adding financing risk to underlying asset risk.)

However, this approach is inconsistent with financial practice in pricing swaps. Is it possible to create a perfectly hedged portfolio? This was not the consensus view. Property was regarded as different. Nonetheless, it was argued in interviews that hedgers (investors with an existing position in the 'physical' property market) can use a different logic to speculators. What are the opportunity costs of using a derivative? What would investors do otherwise and so what can they afford to pay?

Hedgers wishing to *increase* their exposure by buying direct property would have to pay stamp duty and professional fees. In addition management costs would be incurred. This would make the derivative more attractive than the simple LIBOR return difference suggests.

Hedgers wishing to *reduce* exposure would have relatively lower transaction costs, but would suffer possible delay and certainly illiquidity risk if selling direct. In addition, writing a derivative would enable the manager to retain an investment management fee. Again, this makes the derivative more attractive than the simple LIBOR return difference suggests.

Normally, hedging would imply offsetting exposure. Thus, an investor with a high exposure to real estate would *sell* property returns via a derivative to reduce their exposure. As noted, this would enable a saving in transaction costs compared to direct sales and (if an active market existed) might reduce liquidity risk. However, there exists tracking error risk because the performance of the underlying portfolio may not follow that of the basis index.

Moreover, the counterparty is not obviously hedging exposure – unless they are firmly intending to acquire real estate at a known future date and want to ensure they are not adversely affected by positive capital growth in the asset class (in which case tracking error again becomes an issue).

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The issue of transaction costs and management costs also distinguishes real estate from equities and bonds because, typically, such costs are considerably higher. This has implications for arbitrage. It is possible to acquire an equity portfolio that matches a particular equity market index at relatively low cost; management costs are marginal (and relate largely to rebalancing to ensure that the index is tracked). This may not the case with direct real estate where round trip transaction costs are high (particularly if 'amortised' over the relatively short life of a swap).

This may have pricing implications for property derivatives in that margins may be higher than the zero margin implied for fully efficiently priced asset markets. To understand this fully, we need first to examine the mechanics of property derivative transactions and then to re-consider the key issue: *is there any reason why property derivative pricing should be different?*

We now examine the position of these two hypothetical parties in more detail.

### 4.2.3 The short term investor/speculator

It was argued by interviewees that the pure financial trader, who would not buy direct property, is not interested in out-performing the market or specific risk, nor in the cost of direct property ownership (stamp duty, legal fees and so on). They will focus on the difference in the expected returns on LIBOR and IPD and will keep a keen eye on movement in the underlying investment market in order to be able to trade in or out quickly.

They will also be interested in risk, because the reliability of the forecast IPD returns is different from the reliability of the LIBOR returns. There are two reasons for this. First, the volatility of the IPD annual total return has been three times that of LIBOR one year returns (9.6% against 3.2%, as suggested by OPC, 2006). Second, while market participants were placing considerable reliance upon the IPF consensus forecasts of IPD, there is considerable forecasting uncertainty, expressed both as changes in forecasts from quarter to quarter and a changing spread of forecasts among contributors (see Matysiak, McAllister and Newell, 2005).

By mid-2006 it appeared that rising margins were challenging the currency of the IPF consensus, as derivative prices themselves began to offer daily and immediate evidence of a consensus forecast of the IPD index. At late July 2006, for example, GFI estimated the available margins for spot (single year) contracts and the implied property market returns as shown in Table 2.

**Table 2: Implied market returns from derivative prices**

| Date | Margin | Implied return |
|---|---|---|
| Dec 2006 | LIBOR + 800 | 13.37% |
| Dec 2007 | 415 | 9.74% |
| Dec 2008 | 320 | 8.77% |
| Dec 2009 | 265 | 8.21% |
| Dec 2010 | 235 | 7.90% |
| Dec 2012 | 240 | 7.95% |
| Dec 2015 | 250 | 8.05% |

Source: CBRE/GFI

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Given that the risk is different, it was strongly argued the buyer of IPD will expect to receive a risk premium, meaning that the expected return on the contract for differences will (where the expected return on IPD is higher) be the expected return differential, discounted for the effect of time and reduced by the risk premium and by the costs of trading (the bank's spread or the dealer's brokerage fee). This does not accord with derivative pricing theory.

There is further debate concerning the relevance of the correlation between the IPD return and LIBOR. On the one hand, it can be argued if the two are positively correlated the chance of the buyer of IPD losing money is much reduced and the risk is low. If the two are negatively correlated the chance of the buyer of IPD losing money is much increased and the risk is high. Given that the historic correlation has been negative, at around -0.3, there is a good chance that the buyer of property risk will lose money in a period of strongly rising interest rates.

On the other hand, LIBOR can easily and cheaply be swapped for a fixed interest rate. The correlation between IPD and LIBOR is not especially interesting if LIBOR can be fixed. So as long as this is assumed, the volatility of the net payments is equal to the volatility of IPD, in turn dominated by the volatility of IPD capital returns. If LIBOR is assumed to be left floating, simulation approaches to pricing may be interesting but there is insufficient market efficiency to make this of value. At present the volatility of LIBOR appears to be irrelevant and as a result so is the correlation between LIBOR and IPD.

### 4.2.4 The long term property investor

The long term property investor will have a different view of pricing and may begin from an overweight or underweight position.

#### The underweight position

A multi-asset investor who is underweight in property may need to increase their exposure. They can buy direct property, or perhaps unlisted property funds, or a derivative. The buyer of the derivative will either save stamp duty and legal, survey and valuation costs, or will save the premium to net asset value which is typically charged on entry to a fund. If purchase costs total 6%, the annual margin on a three-year derivative contract could be up to 2% for this reason alone. The buyer also avoids management costs. This may increase the margin by another 0.5%.

The buyer of property risk also avoids property specific risk. There is no volatility (basis risk, or tracking error) in the derivative relative to the index. What is this worth? For an investor who is effectively an indexer, this is another reason for paying a higher margin. However, this argument rests on a presumption that a riskless portfolio cannot be created by an investor in 'physical' property assets.

Set against this, there are costs associated with buying the derivative – a broker's fee and/or a bank's profit for acting as middleman and credit enhancement – and the difficulty of dealing with a pre-determined termination of the exposure at a specific point. On balance, however, it appears at first sight that the underweight investor could pay more than the simple expected return difference.

#### The overweight position

It is interesting to note that one of the early 2005 deals (for a three-year swap) was apparently priced at a margin of only 80 basis points, while quoted margins for a similar contract in early 2006 were as high as 325 basis points. It is known that the seller was a life fund overweight in property and wanting to switch

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into equities. One year later, equities having out-performed property and the switch having been made, this was a good deal to have executed even at a very low margin.

If the seller of property risk is a hedger in this way, the opportunity cost is very different. As with the underweight investor, the opportunity cost is created by the illiquidity of direct property. First, direct property sales costs – roughly 2% spread over three years – are saved. Hence the seller of property risk can accept less than the difference in expected returns.

Second, the profit created by the retention of management fees is retained. This benefit accrues to the manager, not the client fund, and because of this the client fund would not be happy to see that enter the pricing of the derivative. However, this is not the case for property companies, where the single entity, specifically its shareholders, will benefit.

Third, if (as appears to be widely believed, albeit based on no robust empirical evidence) holders of property widely expect to enjoy positive alpha, they will retain this excess return while selling the market return through the derivative. Associated with this point, it is argued that selling direct property produces uncertainty over which buildings can be bought back, while using the derivative restores the ownership position of the current portfolio when the contract expires.

Fourth, buying the derivative creates a significant gearing effect that may exaggerate returns (with, of course, a commensurate increase in risk) and allow a property company to build market share and control sub-markets. Again, the contract is for a fixed term, which may cause difficulties as the exposure automatically increases at the end of the contract, and there will be derivative trading costs. All in all, however, it appears that the overweight investor can accept a lower price than the simple return difference suggests they should require.

### The impact of hedging

Hence the underweight hedger can pay more for IPD exposure than the pure speculator due to the cost savings to be made. The overweight hedger can accept less for selling IPD exposure than the speculator would require. Depending on who is dominant in the market or in the contract negotiation, prices may settle at the speculator's price plus or minus as much as 2%.

We note again here that this market practice appears to be inconsistent with the finance approaches to the valuation of swaps discussed in earlier sections and with the evolution of the market for equity index swaps. Given that most models indicate that efficient markets should generate zero margins, the finance approach suggests that any margin should reflect market inefficiencies including trading and transaction costs *alone*.

How does this relate to the hedging positions outlined above? The theoretical pricing position – a small margin – is closer to the pricing approach of the overweight hedger. This is logical as long as the overweight hedger holds a property portfolio that can be perfectly replicated by the derivative. If they can then sell a derivative for LIBOR plus a margin, this creates a risk free portfolio that will deliver a return of LIBOR plus the margin. If the portfolio is risk free, why should the margin be any higher than the transaction costs require? If investors with long diversified positions in the underlying physical asset were to enter the market in more weight, the margin may well erode toward this price level. Significantly, in 2006 this group did not yet appear to be the dominant player in the property derivatives market.

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## 4.3 Other pricing issues

While trading documentation is becoming standard, there remain a variety of issues regarding property derivative contracts which may have a pricing impact. The basic approaches to pricing described above are subject to considerable 'colour' given the details of the contracts and emerging market practices. These issues are discussed below.

### 4.3.1 Mechanics

#### Timing differences

The typical swap contract involves the exchange of three-month LIBOR for annual IPD; and while three-month LIBOR settles immediately on the last or first day of the month, there is a delay of over two months in reporting of the IPD annual index. This means that the buyer of IPD would have to pay LIBOR plus the agreed margin every three months in arrears, while receiving the annual IPD payment once a year in arrears and delayed by up to one quarter.

These timing differences, especially when applied to a contract size as large as £100 million, are important. The margin needs to be re-set (reduced) to account for the cash flow advantage. Second, the difference in timing of the cash flows creates a credit risk for the seller of LIBOR, who makes four payments before receiving anything. In these cases the lower credit risk party (say, a hedge fund) may have to settle against the IPD monthly index as if there were a margin call. This payment pattern also makes the derivative less attractive than the underlying property.

Variations can be agreed: for example, the LIBOR payments can be deferred and made annually. Such variations are becoming more common and will affect pricing. Given that total return swaps involve the exchange of income returns (low risk), and capital returns (higher risk), variations in contracts swapping the two incomes quarterly and pricing the riskier capital bullet payment separately are expected to develop.

#### Contract dates

Property swap contracts do not necessarily follow the calendar year. In all cases, the delay in the index release means that the monthly index is used as an estimate of the starting price. The quarterly index is likely to be used increasingly as the basis of contracts, because LIBOR rates are fixed for three months at January, April, July and October. Pressure on back offices to settle means contracts that create one or two month LIBOR 'stubs' can be a problem.

March and December contracts are popular with buyers because these coincide with reporting year ends and because there is more uncertainty at these points, where an abnormal valuation uplift is more likely (Baum, Crosby, McAllister *et al* 2000).

#### Tenor and forecast risk

As expected payments of IPD are deferred further into the future – the third year payment compared to the first year, for example – risk should increase as time goes by because autocorrelation in real estate prices means greater certainty is attached to the near term forecast. This means that even if returns are flat the price curve should fall as contracts lengths (tenors) increase. This raises interesting questions about the risk premiums applied to the cash flows, which should increase for later payments.

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Additional to this, interviewees made the point that there are considerable differences in the certainty surrounding forecasts of real estate returns and the LIBOR rate. The latter are much less variable, with much smaller confidence intervals around forecast values. This should be reflected in any sensitivity analysis around the mean and, possibly, in adjustments to the discount rate – which may be increased for real estate to reflect the greater dimension of confidence intervals around the forecast values. There is a possible danger of double counting here, with the expected returns in real estate already reflecting this uncertainty (see Section 4.4).

### Adaptive or rational expectations?

In 2005 and early 2006, the UK commercial property market consistently experienced positive shocks to delivered returns compared to forecasts. The implied return for 2006 of 13.37% implied in Table 2 can be compared with delivered monthly returns of around 2% each month for January, February and March 2006 which, when annualised, would imply annual returns of over 20%. It is interesting to speculate whether these early 2006 returns mean that future expectations should increase (through adaptive expectations) or fall (through a belief in mean reversion or rational expectations). Evidence suggests that a belief in short term momentum is the key driver, so high delivered returns have increased short term derivative prices.

### The impact of transaction costs

It was argued by interviewees that the impact of direct property transaction costs will colour prices, but that this depends on the length of the contract. For an underweight buyer of property risk, short contracts can be very much affected by cost savings, but five year contracts less so. (It was suggested that 10 year contracts may be affected in the same way as a five year contract because two trading round trips may be assumed.) However, this argument ignores the position of the overweight investor for whom the margin would be lower at the short end. In a market where overweight and underweight hedgers are in balance, transaction costs should not have a differential impact on margins according to tenor.

It was also suggested that derivative trading costs imply a present value of around 15bps on a five-year contract. An argument for this level of margin may have greater resonance among theoreticians and derivative market insiders.

### The impact of property/fund management costs

In buying the IPD index, the performance delivered is gross of fund management costs. The investor would thus save these costs because they have bought a well diversified portfolio and have no need to manage it. However, the investor will have spent time in setting up the swap contract and assessing counter-party risk and must continuously undertake due diligence to see whether it is worth selling. The impact on the required margin depends on whether the cost savings exceed or are less than the additional costs generated. (Direct property management costs do not make any difference to margins since, assuming accurate reporting, IPD reported performance is already net of these costs.)

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## 4.3.2 The role of banks and brokers

### Banks

Banks play a key role in the property derivative market and are the primary source of liquidity. As in other derivative markets, end users rarely trade with one another and each swap will typically be between one end user and a bank. In a 'matched' transaction, on one side the bank receives the IPD return and gives a floating rate return (LIBOR plus an agreed margin), and on the other the bank receives a floating rate (LIBOR plus) and pays out the IPD return. Typically, the bank will makes its profit by receiving a greater margin on the floating rate than the amount paid away.

As there is always a degree of counter-party risk, there is an additional charge for the bank's risk in the vast majority of situations. This charge will be added to the floating rate received by the bank. The total impact of the margin plus the risk charge may be in the order of 5bps to 30bps. This will have some indirect impact on pricing.

The bank may limit its counterparty exposure structure by structuring the transaction so that the amounts due are paid on a monthly or quarterly basis while the amounts paid out are on an quarterly or annual basis respectively.

Craig Tipping of Lehman Brothers quoted the potential sale of a derivative at the then-current one year price of 550bps over three month LIBOR, funded by a matching loan taken out by an interested bank at LIBOR plus a typical margin of 90bps, which locks in a return of 435bps (550 less the margin of 90 and the derivative trading costs of 25bps) and in addition allows the seller to retain alpha and investment management fees. As providers of liquidity, deal structurers, credit enhancers and possible speculators, he argued that banks are vital players and that they can enable risk free abnormal returns to be made.

### Brokers

Where brokers are involved, as they are very likely to be, commissions can be charged to both sides depending on the size of the transaction. Typical fees may be 10bps to 20bps. Again, this will have some indirect impact on pricing. Brokers are also instrumental in encouraging market liquidity and encouraging sellers of IPD to quote prices against buyers. The brokers interviewed suggested bid-ask spreads of 30bps to 50bps at the one to two year contract level but suggested that this spread can be expected to reduce as the market matures.

The market role of the broker is also important. Brokers will offer the opportunity to potential investors to discover the best dealable price in the market without alerting the market place to the intended trade. They arrange credit lines and manage standard documentation. They manage trade execution and, post-trade, they will provide independent pricing advice used where marking to market is necessary. They are also the main source of market education.

In sum, banks and brokers may take total fees and spreads of between 20bps and 50bps out of trades. There are signs that this total cost has been falling since the start of the new market, but this is higher than in many other derivative markets and will almost certainly remain so.

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### 4.3.3 Tax

The tax treatment of derivatives depends upon whether the derivative is seen as an investment or a trade (Jeyarajah, 2006). Most will be seen as trades, especially at the short end. This can create a difference between the tax treatment of derivatives and the tax treatment of direct real estate or real estate funds. However, in the interviews this issue was not regarded as significant in derivative pricing.

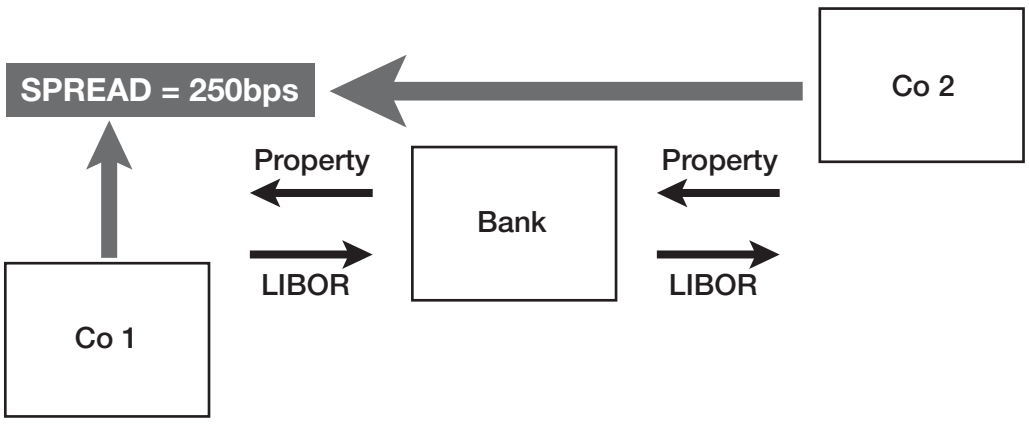
## 4.4 Where is risk?

We now return to the tension between derivative pricing theory and property market practice as suggested by the interviews.

Figure 1 shows an example of the current structure of property derivatives based on pricing ideas in the market. Since there is a difference in the expected return between property and the LIBOR rate, we assume a spread of around 250bps.[5]

The rationale behind this spread is as follows. Since Company Two (Co 2) reduces its exposure to real estate by paying property returns to the bank and receiving the LIBOR rate, it will require a compensation for the different performance offered by two assets. However, this analysis ignores the presence of risk. Investors normally look at the risk-return profile when they need to choose between assets, the selection depending on their risk aversion (that is, based on the appropriate utility function for the investor). The higher return, of course, is a compensation for higher (systematic) risk.

Figure 1: **An example of the current market pricing of property derivatives**




Consequently, if Company two decides to sell property through a swap contract, it will not only pay real estate returns, but it will also manage to shift real estate risk to the counter party. In this case, Company two needs to compensate the other party for taking on greater risk. This will then *reduce* the spread necessary to compensate a simple difference in expected returns.

[5] This spread may change according to the duration of the contract.

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Finance theory helps us to clarify this point. Figure 2 illustrates that the swap contract should not be thought as a horizontal game in which assets returns are exchanged. On the contrary, it represents an 'oblique' game where risk-return profiles are exchanged. If the two assets are lying on the security market line (SML)[6], it means that property will generate a higher return than LIBOR, but at the same time the investor will bear a higher risk. If the two assets are priced on the SML, this means that there is no mis-pricing and the spread of a property swap should then be equal to zero.

The resulting 'true' contract may then be represented as in Figure 3, where the two assets are priced in a return-risk framework and should then lead to a spread if, and only if, either or both of LIBOR and real estate are mis-priced. However, if we assume market efficiency, in a weak form[7], at least in the long run there should be no mis-pricing. So, the contract should lie on an oblique line and thus there is no reason for a margin simply as a result of return differentials.

Figure 2: **The security market line and return-risk pricing**

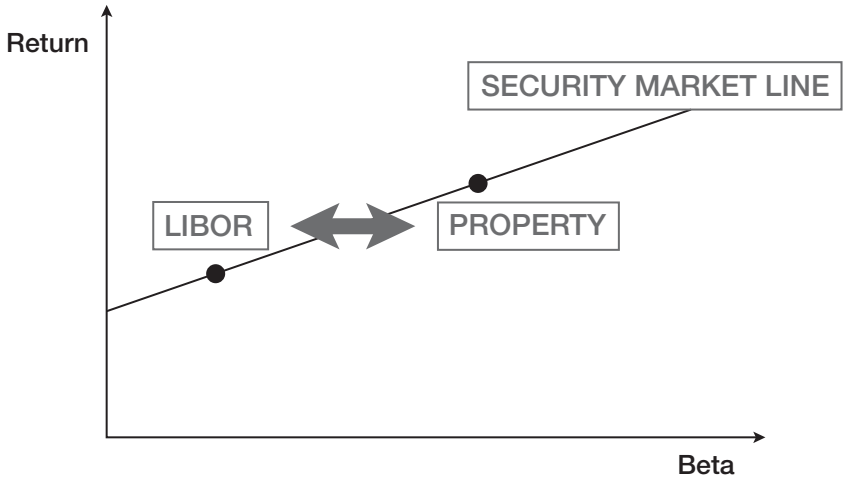
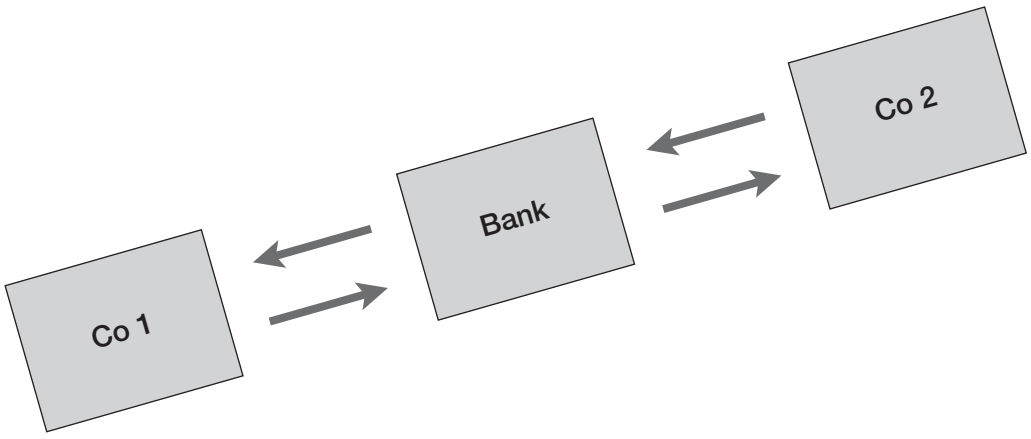



Figure 3: **Return, risk and the swap contract**




[6] The security market line, from the capital asset pricing model, shows the relationship between required return and sensitivity to systematic (or market) risk, measured by the asset's beta. The market portfolio has a beta of one. Assets with betas less than one have a lower sensitivity to systematic risk and, hence, investors demand lower returns. CAPM assumes that asset specific risk is diversifiable and, hence, is not rewarded.

[7] That is, all available public information is already incorporated in market prices.

# 4. Issues in market pricing: Results of an industry survey

Are property market investors concerned with total risk or with systematic risk? Finance theory suggests that specific risk is not rewarded and, assuming that an investor has a well-diversified portfolio, we should look only at systematic risk. However, there is considerable theoretical and empirical evidence that it is beyond the means of a representative investor to diversify a directly-owned real estate portfolio fully (see Lizieri and Devaney, 2005; Baum and Struempell, 2006; and forthcoming IPF research to be published later in 2006.)

Does, then, part of the margin represent the price premium for the purchase of full diversification? This can be linked back to the idea of the arbitrage portfolio and returns the discussion to the key issue: can property investors create perfectly hedged portfolios?

## 4.5 The IPD index and basis risk

In the discussion of risk above, an issue was raised concerning the extent to which the buyer or seller of an IPD swap against LIBOR would need to be compensated for the clearly higher uncertainty regarding the return of the IPD leg. In the interviews and the IPF seminar, two alternative positions were suggested. The first and most common position was to the effect that the IPD leg is clearly riskier than the LIBOR leg and that a risk premium needs to be used in discounting the expected net cash flow. However, as shown earlier in this report, it is commonplace in derivative pricing to discount cash flows at the risk free rate (say the LIBOR rate in this case). This was also the position adopted in the IPF derivatives seminar by Colin Beardsley.

The use of the risk free rate in discounting derivative cash flows is justified by the proposition that the marginal buyer who will set market price will be one who uses the derivative to neutralise any systematic or market risk they are currently exposed to in the 'underlying' asset class. Hence someone who holds a portfolio of UK equities to match the FTSE 100 index can sell a FTSE 100 derivative with the result that they hold a zero risk portfolio. If the derivative were a FTSE 100/LIBOR swap, then the net expected cash flow would be discounted at the risk free rate because the effect of the trade is to produce a zero risk portfolio.

Is this possible in property? It would be extremely difficult to achieve using direct real estate assets. The tracking error (or basis risk, or specific risk) of a direct real estate portfolio is very significant (Brown and Matysiak, 1995) and huge quantities of direct real estate are needed for portfolio tracking error to tend towards zero. However, Beardsley argues that a portfolio of unlisted real estate funds (open-ended property unit trusts) can replicate the performance characteristics of the IPD index, with the correlation between the AREF index and the IPD index being as high as 97.5%. This portfolio can be assembled with reasonably modest sums of capital, as MSS have demonstrated. Hence the 'underlying' or 'physical' can be replicated and the property derivative can be used to create a riskless portfolio. This is an interesting argument.

The problem with the argument is again to do with liquidity. In practice, investors cannot guarantee to access the underlying asset through open-ended funds because both access and exit can be deferred by fund managers by up to two years. There is also some discolouration of AREF fund returns relative to the IPD index through gearing and fees. Nonetheless, this is an issue of degree, not of principle, so the Beardsley point remains in place as a counter-argument against the consensus for risk adjusted discounting.

# 4. Issues in market pricing: Results of an industry survey

It is at least arguable that some reduction in the risk premium is justified by this point, and it is possible that riskless discounting may become common and defensible. It is our strong contention that in the early market stage inefficiencies and friction will drive a wedge between theory and the market, but that this will erode over time. Recent market developments will speed this process. In particular, the increasing tradability of unlisted funds and, in the foreseeable future, REITs, offer a different and, in principle, more efficient market terrain (see Appendix 2).

## 4.6 The FTSE property index

The recent launch of the MSS FTSEpx fund and the FTSE Property Index is very interesting in the context of derivative pricing. Derivative markets are driven by speculators and hedgers and, if both groups develop a serious interest in the instrument, volumes can become greater than in the underlying market and pricing will become transparent and arbitrage impossible.

Speculators need price volatility; so a daily property index is good for them. Hedgers need to be confident they can really hedge their position. Derivatives based on existing direct property market indices limit the investor's ability to do this, because the index is not itself investable. A long position in the underlying asset, property, cannot be perfectly matched by a short position in the indexed derivative because it is not possible to 'buy the index'. This introduces 'basis risk' and makes the derivative less attractive. It also complicates pricing of the derivative. If perfect hedging is possible – without basis risk – then the derivative can be priced in line with theory using a risk free rate because investors can produce a riskless portfolio.

So a daily-priced investable property fund used as the basis of a derivative will increase interest from speculators and hedgers alike as well as increase the value of derivative instruments. It could represent a huge step forward. There are several imperfections in the concept and in its execution, but this is an exciting development.

The MSS fund is the foundation for a daily FTSE property index and if this becomes the basis of accepted property derivatives, long/short property hedge funds and riskless derivative pricing may be close after all and high margins may soon be a thing of the past.

# 5. Conclusions

The existing pricing of UK property company return swaps does not appear to be consistent with the experience in the equity index swaps market, where margins over LIBOR are very small. We stated earlier that we would conclude by discussing whether this apparent anomaly results from the inherent characteristics of real estate as an investment asset (which precludes most arbitrage strategies) or from some form of mispricing resulting from the novelty of the market and the derivative vehicles and which will inevitably be eroded over time.

It was unanimously believed among interviewees that, especially in the early stages of market development, players need rules of thumb to gain confidence in market pricing. Only in the later, maturing, stages will sophisticated pricing models begin to dominate. Hence, current market pricing methods are not at all sophisticated and the approach to pricing used in the market as at April 2006 remains simplistic. Although signs of increasing hedge fund involvement are promising, the balanced and efficient market that would be created by a healthy balance of investors is not yet present, as pure speculators and long hedgers are not yet dominant in the property derivative market.

The market is instead led by asset class switching. Savings in direct property transaction costs become highly relevant on a three year swap. Because overweight and underweight hedgers will have different approaches to pricing deals, one above the clean theoretical price and one below, the clean price continues to set the market tone. Because volumes are not yet significant, differences in risk premiums are not yet significant in setting price and there is not enough liquidity to establish a market-clearing price.

For long contracts – the longest deals discussed are 10 to15 years and the shortest are six month contracts using IPD's rolling estimates of the annual index – the margin appears to take account of the transaction fees avoided, but the short end does not. Whether fee savings influence prices currently appears to depend on who is dealing.

Brokers talk about the 'relative benefit' as determining prices. If all dealers were long hedgers, then prices would fall, but arguably the enhanced liquidity and risk management opportunities in property would then reduce risk premiums for the underlying asset class and increase prices. It is then that derivative prices may begin to drive prices in the underlying market, which is a fascinating prospect.

In conclusion, initial pricing anomalies appear to be present. They appear to result from the perceived inherent characteristics of real estate as an investment asset (which precludes most arbitrage strategies), but successful derivatives based on a daily valued and investible fund (such as the MSS Capital FTSEpx fund) will solve this problem. Pricing anomalies are also created by the novelty of the market and the vehicles and in an increasingly active derivative market, this anomaly will inevitably be eroded over time.

Both theory and practice in other asset swap markets suggest that the margin on swap contracts should not reflect any differential in expected returns, since this does not account for differences in risk. If there were to be persistent margins in LIBOR-property swaps as the market matures, margins greater than can be explained by dealing and brokerage costs, then these must reflect the inherent characteristics of the asset class and the efficiency of pricing and institutional arrangements in the underlying real estate market. These characteristics focus on the difficulty of creating a risk free portfolio for which the derivative is a perfect hedge.

The signs in mid-2006 are that this will become increasingly possible. Even in the imperfect world of unlisted real estate there are powerful reasons to expect the erosion of the current return-driven margin towards a structural, and much lower, cost-driven margin.

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Paul Coleman, Barclays

Gianluca Marcato, University of Reading

Iain Reid, Protego

Ed Stacey, EuroHypo

# Appendix 1: A DCF pricing example

*Note: the following example does not describe the authors' recommended approach to pricing a property for LIBOR swap. It uses an extended example to illustrate points made in the main text and to reflect what appears to be the basis of a popular approach to the problem.*

### A simple example

Two parties, A and B, have entered into a three year all-property for LIBOR swap. This is a contract for differences based on a notional amount of capital. No payment is exchanged up front. Once a year (at the end of each year) the parties will make and receive a payment of the difference between the delivered returns on the IPD all-property index and LIBOR.

The IPF consensus for each year's annual returns in 2006, 2007 and 2008 is around 8.6%, 6.9%, and 7.5% in that order; LIBOR returns (interest rate swaps, each year for three years) are expected to be 4.5%, 4.8%, 5.0% respectively.

Party A is buying a three year IPD all property total return from party B and selling LIBOR. Party B is buying LIBOR from party A and selling IPD. The notional value of the contract is £100 million. What is the expected value of the contract as it stands?

### Assessing the value of the contract

The average difference in returns is around 3%. This would be worth £3 million each year to party A and would cost party B £3 million each year. It is to be expected, therefore, that some balancing payment would have to be made. Roughly speaking, this could be the present value of £3 million per annum paid annually in arrears for three years.

But no payment is exchanged up front in a contract for differences. Instead, a margin (an extra annual return) is added to the less attractive return to make the deal more balanced.

In this case the difference in the expected payments of £3 million per annum would establish a simple first view of the annual margin that should be agreed. The recipient of IPD return is doing on average 3% better than the recipient of LIBOR returns, so it would make sense to 'handicap' them by adding 3% to the LIBOR return. Then, if the IPD index does better than expected, party A will do well; if the IPD index does worse than expected, party B will do well.

This analysis ignores the small impact of the time value of money. If the differences are discounted (say, at 7.0%) the margin moves slightly to just over 2.5%. Table A1 illustrates the necessary calculation.

**Table A1: A DCF approach to pricing a property/LIBOR Swap (1)**

| Year | IPD | LIBOR | Difference | Value | PV |
|---|---|---|---|---|---|
| 1 | 8.60% | 4.50% | 4.10% | £4,100,000 | £3,831,776 |
| 2 | 6.90% | 4.75% | 2.15% | £2,150,000 | £1,877,893 |
| 3 | 7.50% | 5.00% | 2.50% | £2,500,000 | £2,040,745 |
| | | | | **Total** | **£7,750,414** |
| | | | | **Margin** | **2.58%** |

# Appendix 1: A DCF pricing example

The discounted present value of the differential cash flow is £7.75 million. Simply averaged, this is £2.58 million per annum, so that a margin of 2.58% on the £100 million notional capital added to the LIBOR 'leg' would be fair.

However, this is an approximation, as simple averaging of the margin again fails to accurately account for time value. Table A2 shows how an iterated margin of 2.9533% produces an expected net present value of zero for the swap.

**Table A2: A DCF approach to pricing a property/LIBOR Swap (2)**

| Year | IPD | LIBOR | Margin | Difference | Value | PV |
|---|---|---|---|---|---|---|
| 1 | 8.60% | 4.50% | 2.9533% | 1.15% | £11,467 | £10,717 |
| 2 | 6.90% | 4.75% | 2.9533% | -0.80% | -£8,033 | -£7,016 |
| 3 | 7.50% | 5.00% | 2.9533% | -0.45% | -£4,533 | -£3,700 |
| | | | | | **Total** | **£0** |

### Taking account of timing differences

The typical swap contract involves the exchange of three-month LIBOR for annual IPD; and while three-month LIBOR settles immediately, there is a delay of over two months in reporting of the IPD annual index. This means that the buyer of IPD would have to pay LIBOR plus the agreed proportionate margin every three months in arrears, while receiving the annual IPD payment once a year in arrears and delayed by up to one quarter. These timing differences, especially when applied to a contract size as large as £100 million, are important. The margin needs to be re-set (reduced) to account for the cash flow advantage.

Simplifying, let us assume that payment of the IPD 'leg' is delayed by three months (in practice it would be less). Let us assume that LIBOR settles on the last trading day of the quarter (it can also be the first trading day of the next quarter.) The cash flow for a three year contract based on Table A1 would then look like the cash flow shown in Table A3.

# Appendix 1: A DCF pricing example

Table A3: **Contract cash flows received by IPD buyers (£m)**

| Quarter end | IPD | LIBOR | Margin | Cash flows |
|---|---|---|---|---|
| 1 | | £1.13 | £0.65 | -£1.77 |
| 2 | | £1.13 | £0.65 | -£1.77 |
| 3 | | £1.13 | £0.65 | -£1.77 |
| 4 | | £1.13 | £0.65 | -£1.77 |
| 5 | £8.60 | £1.19 | £0.65 | £6.77 |
| 6 | | £1.19 | £0.65 | -£1.83 |
| 7 | | £1.19 | £0.65 | -£1.83 |
| 8 | | £1.19 | £0.65 | -£1.83 |
| 9 | £6.90 | £1.25 | £0.65 | £5.01 |
| 10 | | £1.25 | £0.65 | -£1.90 |
| 11 | | £1.25 | £0.65 | -£1.90 |
| 12 | | £1.25 | £0.65 | -£1.90 |
| 13 | £7.50 | £1.25 | £0.65 | £5.61 |

The annual IRR on the above cash flow is not 7%, the discount rate used to arrive at the margin estimate in Table A1, but 8.6%. The margin needs to be re-set (reduced) to account for the cash flow advantage. The correct margin accounting for timing is 2.52% (£0.63 million per quarter or £2.52 million per annum). The difference in timing of the cash flows also creates a credit risk for the seller of LIBOR, who makes four payments before receiving anything. In these cases the lower credit risk party (say, a hedge fund) may have to settle against the IPD monthly index as if there were a margin call.

### Taking account of risk

Tables A1 and A2 assume a discount rate of 7%. But what should the discount rate be? This depends on the risk of the difference. Which (IPD or LIBOR) is most uncertain? Over the period 1987 to 2004 the standard deviation of annual LIBOR rates was 3.2%; for IPD it was exactly three times greater at 9.6%. So IPD is three times riskier. This suggests the recipient of the IPD leg may wish to discount the expected cash flow at a high discount rate.

But the risk of this deal is not quite this simple, because the marginal cash flow – the difference – is dependent upon the relationship between LIBOR and IPD returns. What is the probability of IPD delivering less than LIBOR? Is there an even chance that IPD will exceed or fall below its expected value or is the distribution skewed? Are the series correlated? A statistical approach would be required to address these challenges in forming a view of the real risk involved in the contract, and simulation is the natural way to proceed with this analysis in order to form a more intelligent view of the risk of the contract and the appropriate discount rate.

# Appendix 1: A DCF pricing example

### The complication of hedging

This approach may be relevant for a dealer from Mars and a dealer from Venus who have just landed on Earth. But many likely market participants (Earth inhabitants) will already have an interest in UK property. They are likely to be sophisticated investors and may already hold property. Alternatively, they may see this contract as a way of getting exposure to the property market, which (if this contract were not available) would entail their buying property directly. Let us call these parties hedgers.

Hedgers can use a different logic. What are the opportunity costs of using a derivative? What would they do otherwise and so what can they afford to pay? Hedgers wishing to increase their exposure by buying direct property would have to pay stamp duty and professional fees. In addition management costs would be incurred. This makes the derivative more attractive than the simple LIBOR return difference suggests. Hedgers wishing to reduce exposure would have relatively lower transaction costs, but would suffer possible delay and certainly illiquidity risk if selling direct. In addition, writing a derivative would enable the manager to retain an investment management fee. Again, this makes the derivative more attractive than the simple LIBOR return difference suggests. More importantly, what if they can sell IPD returns for LIBOR plus a 3% margin while they continue to hold a portfolio of UK property?

Imagine that the held portfolio performs in line with the IPD index, with no tracking error or basis risk. Then the risk in the sold IPD returns – producing bad news if the property market does well, and good news if it does badly – are perfectly neutralised by the held portfolio, which produces good news if the property market does well, and bad if it does badly. The investor will receive LIBOR plus the margin, with no risk. What discount rate should be applied to a risk free return such as this? The answer is clearly not 7%.

# Appendix 2: Derivative pricing and real estate: A review

There is a body of literature dealing with the theoretical pricing of real estate derivatives. There are references to the pricing of traded securities based on a real estate index, and also a body of published material dealing with derivatives offered against well-established house price indexes. These papers offer an interesting contrast to the material presented in Section 4.

Buttimer *et al*. (1997) developed a two-state model for pricing securities based on a real estate index and a short-term interest rate (a swap contract). They do not assume any relationship between the underlying index and true market movements[8] and they start from Kau *et al*. (1990) who model the price of a building as a function of income and time. Buttimer *et al*. used a two-dimensional binomial tree, where the real estate index and interest rates could move either up or down, to price commercial real estate index-linked swaps (CREILS) at their origination date.

First, they found that the price should be symmetrically sensitive to volatility changes for both interest rates (a positive relationship) and the real estate index (a negative effect). This means that *"an increase in the volatility of the asset in which a party has a long position increases the value of the swap to that party, while increasing the volatility of the other asset decreases the value of the swap"*.

Second, the price at the origination of the contract is not dependent on the correlation between the index and the interest rate. *Ex post*, if the correlation is negative the contract will be more valuable for one of the two parties. However, *ex ante* there *"is no a priori information as to which side of the swap will become valuable"*.

Finally, they studied the impact of different initial interest rate term structures and found the value of the long position in real estate increases when the spot rate increases (through higher capital growth induced in their model assumptions). Analytically, they demonstrated a very small margin for the swap.

Bjork and Clapham (2002) reviewed the work of Buttimer *et al*. (1997) and showed their result was approximately correct because the true theoretical price of the swap – the margin – should be equal to zero. As a result, there is no *a priori* reason to expect a margin based on the assumptions that these papers make.

Finally Clapham *et al*. (2006) analysed the impact of retrospective index revision for the pricing of futures contracts and argued that indices less exposed to volatility in revision should be used as the underlying asset of house price derivatives. Therefore they suggested the use of hedonic indices (as opposed to repeat-sales indices), these tend to be more stable and are not subject to the systematic downward revision found in other construction methodologies.

For commercial real estate products, the question is whether valuation-based indices subject to smoothing and the underestimation of the underlying asset volatility are to be used as opposed to transaction-based indices. It is suggested that the latter would be problematic, as they tend to be less stable than house price indices due to the higher heterogeneity of the individual assets composing the index.

[8] If the index is not a good proxy for the market, the use of a derivative product may be affected (e.g. timing of purchase and sale), but its pricing is not.

# Appendix 3: Autocorrelation and derivative pricing

A particular stream of literature developed in equity markets looking at the extent to which autocorrelation affects the pricing of derivatives may prove to be of high interest in real estate markets.

The problem of smoothing is very well known (see Section 3.2.3 above) and has been studied by several authors – see, for example, Geltner *et al*. (2003) and Bond et al. (2006) for a general discussion, and Booth and Marcato (2004) for an application to UK returns. The main effect of smoothing is a high autocorrelation coefficient (as high as 0.85 for the UK IPD monthly index), which reduces standard deviation estimates.

Lo and Wang (1995) found that the predictability of asset returns impacts on derivative pricing through an impact on the variability of returns. In a simple Black and Scholes (1973) formula to price options, the variance increases the price since the purchase price of an option has higher value in markets (or for assets) which are highly volatile:

$$c = s\Phi(d_1) - xe^{-rt}\Phi(d_2)$$

where

$$d_1 = \frac{log(s/x) + (r + \sigma^2/2)t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

where *s, x, r* and *t* are respectively the current asset (e.g. share) price, the option striking price, the risk free rate and the time until option expiration; $\sigma$ represents the volatility of the underlying asset.

In order to understand the model, it is useful to divide it into two parts. The first (positive) part represents the expected benefit from acquiring a stock outright. This is found by multiplying stock price (*s*) by the change in the call premium with respect to a change in the underlying stock price – $\Phi(d1)$. The second (negative) part of the model – $xe^{-rt}\Phi(d_2)$ – computes the present value of paying the exercise price on the expiration day. The consequent 'market price' of the call option is then calculated by taking the difference between these two parts.

Lo and Wang demonstrated that it is necessary to correct the price for the impact of an underestimated variance (which increases *d1* and consequently increases the value of a call option).

A more recent paper by Korn and Uhrig-Homburg (2005) looked at the effects of a cross-sectional lead-lag structure between two assets on derivative pricing. This issue is particularly relevant in a swap contract where there are two assets involved, rather than in a single asset option or future contract where there is no need to account for relationships between assets. They find that this impact is substantial and provide a simple model to adjust for lead-lag effects, giving an example in the valuation of stock option plans.

Finally, Mezrin (2004) developed a model to quantify the effect of autocorrelation on option prices. He formalised an analytical relationship between return volatility, price volatility and return autocorrelation and tested it using a Monte Carlo simulation whose results are both statistically and economically significant. The option pricing model is developed from lognormal serially correlated returns and it shows that price volatilities cannot be expressed as a simple linear function of return volatilities and time.

# Appendix 3: Autocorrelation and derivative pricing

He suggested the following option pricing formula:

$$C = S_0 N(b_1) - E e^{-rT} N(b_2),$$

where

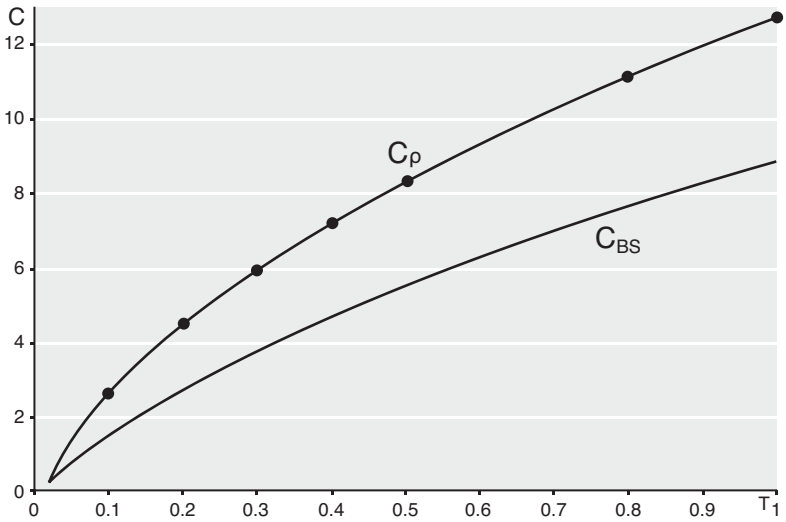
$$b_1 = \frac{In\frac{S_0}{E} + rT + \frac{1}{2}\sigma^2_{eff}T}{\sigma_{eff}(\rho)\sqrt{T}}$$

$$b_2 = b_1 - \sigma_{eff}(\rho)\sqrt{T},\ \sigma^2{}_{eff}(\rho) = \frac{1+\rho}{1-\rho}\sigma^2$$

where $\rho$ and $\sigma_{eff}$ represent, respectively, the autocorrelation coefficient and the 'effective standard deviation', as computed in the previous formula; *C, T, $S_0$* and *E* are respectively equal to *c, t, s* and *x* in the original Black and Scholes equation.

Mezrin showed that, if returns are serially correlated, his model is superior to the traditional Black and Scholes (BS) model, with absolute differences in option prices well exceeding 50%. Figure A1 shows (on the y axis) that BS prices ($C_{BS}$) underestimate 'true option prices' ($C_\rho$) for any duration (x axis) if returns are positively autocorrelated (0.4 in Figure A1). On the contrary BS prices overestimate option prices when the autocorrelation is negative (-0.4 in Figure A2).

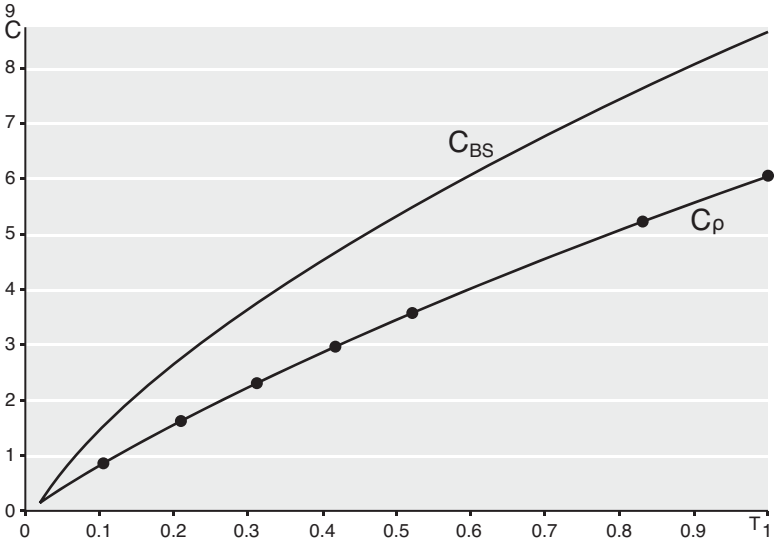
**Figure A1: Comparison between Black and Scholes and Mezrin models, with positive autocorrelation term *ρ=0.4***




Source: Mezrin (2004)

# Appendix 3: Autocorrelation and derivative pricing

Figure A2: **Comparison between Black and Scholes and Mezrin models, with negative autocorrelation term $\rho$=-0.4**




Source: Mezrin (2004)

In summary, the pricing literature suggests that, where there is no mis-pricing in asset markets or, equivalently, where the underlying asset markets are efficient, there should be *a zero margin or spread*. In practice, there will be some margin to account for dealing costs, particularly where deals are brokered by third parties or where deals are warehoused.

However, these strong conclusions are based on models of market efficiency that assume that investors could construct an arbitrage portfolio, that the index is an unbiased and efficient estimate of the underlying market, that there are no, or modest, transaction and management costs (or at least the costs are equal for both assets in a swap) and that the underlying asset market is efficiently priced. Violations of these assumptions may require adjustment – for example, positive autocorrelation of returns may affect pricing by reducing the reported risk of the real estate asset. The impact on margin is not always clear. What is clear is that the margin does not reflect differences in expected returns between the two assets in a swap.

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