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Pricing Property Index Linked Swaps with Counterparty Default Risk

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Abstract This paper extends Bjork and Clapham (Journal of Housing Economics 11:418–432, 2002) model for pricing real estate index total return swaps. Our extension considers counterparty default risk within a first passage contingent claims model. We price total return swaps on property indices with different levels of default risk. We develop this model under same assumptions as Bjork and Clapham (Journal of Housing Economics 11:418–432, 2002) and find that total return swap price is no longer zero. Total return swap payer must charge a spread over the market interest rate that compensates him for the exposure to this additional risk. Based on commercial property indices in the UK, we observe that computed spreads are much lower than a sample of quotes obtained from one of the traders in the market.

Keywords Total return swaps · Property derivatives · Default risk

JEL Classification C30 · G13 · G33

Introduction

Risk sharing in property markets is a vexing issue not only because property is the biggest store of wealth in the society but also because property markets are prone to speculative whips of investors as equity markets. Property owners in the UK who have witnessed soaring property values in recent years are no doubt worried that they cannot protect the values of their assets without having to sell them. Likewise, institutional investors and portfolio managers who could not gain an exposure to property markets without directly or indirectly owning the assets must have been

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equally frustrated. Greater risk sharing and an easier entry/exit access in these markets is a major concern to investors, portfolio managers, and banks that hold large collateralised loan portfolios on their balance sheets. Property derivatives can allow investors to increase/reduce exposure to property market, hedge current position, as well as change portfolio composition without having to buy or sell the physical asset.

For banks, property figure mostly off-balance sheet as loan collateral. The purpose of the collateral is to limit downside losses if the borrower defaults on the loan. Consequently, banks are exposed to property market risk. While several types of credit derivatives (such as credit default swaps) allow banks to hedge their credit risk, the market is not yet sufficiently wide enough to allow them to hedge credit risk of their entire portfolio of assets.

In the early 1990s, the London Futures and Options Exchange (FOX) launched four index based futures contracts in order to facilitate greater risk sharing and accessibility to residential and commercial property markets in the UK. These contracts, however, failed to gain sufficient liquidity and were quickly withdrawn. Since then there has been a steady activity in the over-the-counter property income certificates, a type of bond with an embedded return based on Investment Property Databank (IPD) index, sold by Barclays Capital and Protego. The two main types of property derivatives currently available in the market are property index certificates and total rate of return real estate index swaps (TRS). ABN AMRO bank led the recent attempt in the UK to provide two-way prices on property derivatives for all property and sector based swaps linked to total return on Investment Property Databank's All Property Index (Euroweek 2005). Eurohypo, Deutsche Bank, Tullett Prebon and ICAP are also seeking to provide such deals in the market. A TRS is a bilateral contract between a total return payer, who owns the asset, and a total return receiver, who will enjoy the asset's cash flows or returns without owning it. The total return payer pays the total return of the underlying asset and receives, from the total return receiver, a floating or fixed rate payment (when floating, this payment can be linked to LIBOR). At the maturity date of the TRS, the receiver must pay to the payer any depreciation in the value of the underlying asset value as shown in Fig. 1. One particular feature of this off-balance sheet contract is that, like a debt contract, it can give either positive or negative value to the counterparty at any given time.

Considering that the TRS payer is a bank, the bank transfers property market risk or volatility to the TRS receiver. Assuming that IPD is the right proxy for the bank's property asset portfolio (on and off balance sheet), this transaction allows it to hedge some of its property market risk and consequently reduce the economic capital

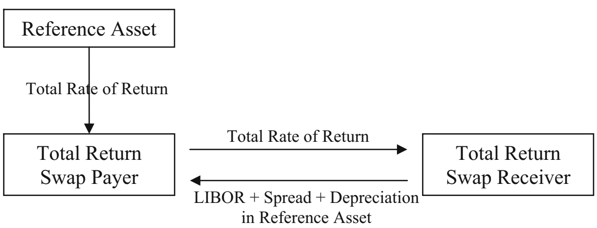

Fig. 1 Total return swap's cash flows

requirement. Basel Committee on Banking Supervision (BCBS 2004), under Basel II Accord Standardized approach, recommends that claims secured by residential or commercial property should be risk weighted at 35 and 100 percent, respectively. This risk weighting approach for secured loans is, however, justifiable only for assets that lack market liquidity. In a world where banks can swap property market risk, using a TRS, these risk weightings must be revised. The impact of the TRS on capital requirements is one of the factors in the development of property derivatives market.

The literature on valuation of property derivatives is scant. Nonetheless, given the TRS cash flows, property return swap can be valued by combining two distinct derivative valuation models: credit default swap and interest rate swap valuation models. Houweling and Vorst (2005) provide a good literature review of credit default swap valuation models. The latter valuation models are described in detail in Sun et al. (1993) and Minton (1993). To the best of our knowledge, only two papers describe property linked TRS valuation models. Buttimer et al. (1997) develop a two state model for pricing a TRS dependent on a property index as well as an interest rate. The authors use a bivariate binomial model to value a commercial property indexed linked swap. Assuming that the index value follows a geometric Brownian motion and the interest rate is described by the CIR model, the value of the swap is positive, although near zero. Bjork and Clapham (2002) point out several limitations of this model and demonstrate that the value of the swap should be zero. They develop an arbitrage-free framework that is more general than Buttimer et al. (1997). The TRS value equals the sum of individual swaplets, which are active over a small time interval. Although Bjork and Clapham (2002) model is theoretically robust and sound in an arbitrage-free world, it does not allow for the existence of counterparty default risk.

We demonstrate that the TRS fair value is no longer zero if we take into account counterparty default risk because in the short term the TRS value can be positive or negative. Obviously for practical implementation, the counterparty default risk is an important factor in pricing TRS. In an arbitrage-free world, the TRS payer must charge a spread over the reference interest rate. This spread should take into account special features of underlying property assets, such as lower liquidity and transparency in the market. This spread can be particularly important in property derivative products because, given infrequent trading in property markets, swap traders have to rely on valuations rather than actual market prices of underlying properties for pricing counterparty default risk.

The purpose of this paper is to extend Bjork and Clapham (2002) pricing model for a TRS payer assuming counterparty default risk. Cooper and Mello (1991) also discuss the problem of counterparty default risk, but they follow a different line of investigation by first pricing each counterparty promised gross payment separately and then add those valued together. Duffie and Huang (1996) show this procedure is erroneous and leads to an overestimation of default risk in a swap. Our results show that the spread over market interest rate that the TRS payer must charge is highly dependent on the volatility of index returns and on counterparty default risk. The higher the volatility of returns, and counterparty default risk, the higher the spread over market interest rate. Based on quotes from one of the traders of this type of property derivatives, we observe that computed spreads underestimate spreads quoted by traders in the market. An over-the-counter TRS on a US real estate index, which closely resembles IPD TRS, was also traded with a spread consistent with our results. This underestimation apparently arises because the market spread incorporates other components besides counterparty default risk, which are not considered in our analysis. In practice, the trader assumes additional exposures when he trades property derivatives. To evaluate the performance and accuracy of the model more precisely, it is necessary to quantify these additional components.

The rest of the paper is organised as follows. We first develop the model to value TRS with counterparty default risk. Next, we apply the model to a sample of IPD real estate indices, assuming different TRS contract maturities and different counterparty default probabilities. We then analyse the estimates of fair spreads obtained from our model with reference to the quotes on similar TRS trades observed in the market. In the final section we draw some overall conclusions.

The Valuation of Total Return Swaps with Counterparty Default Risk

In this section, we follow Buttimer et al (1997) and Bjork and Clapham (2002) procedures for the valuation of TRS swaps with counterparty default risk. Bjork and Clapham (2002) show that a total return property index linked swap can be valued as a sum of individual swaplets, which are active over a period of time denoted by $\Delta = t_k - t_{k-1}$. At the end of each time period, the TRS payer will have the following cash flows (TRS receiver will have the opposite cash flows) from the active swaplet:

- receive an amount equal to the spot market rate at t_{k-1}, such as LIBOR, plus a spread, δ, that for now we assume to be equal to zero, for the period Δ, times the notional amount and any depreciation of the index, I_t, over the time period;
- pay the total return on the index (appreciation plus income) generated over the time period.

Consider now the following trading strategy, that starts at time t and ends at time t_n, and which is repeated at each time period $[t_{k-1}, t_k]$, for k=1,..., n.

- At time t_{k-1}, sell the index I_{k-1} and lend this amount over the time period—at the spot LIBOR $L = L(t_{k-1}, t_k)$.
- At t_k buy the index I_t. Receive the principal of the loan, I_{k-1}, plus the accrued interest, $\Delta L I_{k-1}$.

This trading strategy exactly replicates the cash flows of the TRS payer. Since this strategy is self-financing and the initial cost of setting it is zero, its arbitrage free value must equal zero. This is also the value of the TRS.

Under the above considerations, regardless of the assumptions about the interest rate and the index value stochastic process, Bjork and Clapham (2002) show that the arbitrage-free price of the TRS is zero.

Theoretical Framework

The uncertainty in the economy is modelled by a filtered probability space (Ω, F, P), where Ω represents the set of possible states of nature, F_t is the information available to investors over time t and P is the probability measure. Besides this, we assume that the index process I_t is ex dividend and that there is a cumulative dividend (income) process D_t. The holder of the index receives over the interval (s, t) the amount $D_t - D_s$. The risk-free numeraire (or money market account) value at time t, B_t, follows the process: $e^{\int_0^t r_t dt}$ where r_t denotes the short-term interest rate, which can be deterministic or modelled by a stochastic process. The bond market is liquid and there are bonds of all possible maturities. The price at time t of a zero coupon bond that matures at T is denoted by $p(t, T)$. We assume a perfect arbitrage-free market, where there exists an equivalent martingale measure $Q \sim P$. Therefore:

1. The normalized gains process G_t^B in a risk neutral world is
$$G_t^B = \frac{I_t}{B_t} + \int_0^t \frac{1}{B_s} dD_s \tag{1}$$

2. Bond prices are defined by
$$p(t; T) = E^Q\left[e^{-\int_t^T r_s \mathrm{d}s} | F_t\right] \tag{2}$$

3. In a risk neutral world, the arbitrage-free price process $\Pi(t; X)$ at time t of a contingent claim X, paid out at time T is expressed by
$$\Pi(t; X) = E^Q\left[e^{-\int_t^T r_s ds} X | F_t\right] \tag{3}$$

Under these assumptions, assuming no counterparty default risk, the arbitrage-free value of a TRS at time t, considering it is a sum of swaplets, is

$$\Pi(t; TRS) = \sum_{k=1}^{n} \Pi(t; X_k)$$

X_k represents the TRS payer net payments, at time t_k,

$$X_k = (I_k - I_{k-1}) + \int_{t_{k-1}}^{t_k} e^{\int_s^{t_k} r_u du} dD_s - \Delta L(t_{k-1}, t_k) I_{k-1}$$

where the first term equals index appreciation, the second term represents the value, at time t_k, of the index dividend, produced during Δ, and the third term equals the cash inflow. In a risk neutral world, using (3), we have

$$\begin{aligned}
\Pi(t; X_k) &= E^Q\left[e^{-\int_t^T r_s ds} X_k | F_t\right] \\
&= E^Q\left[e^{-\int_t^{t_k} r_s ds} I_k | F_t\right] - E^Q\left[e^{-\int_t^{t_k} r_s ds} I_{k-1} | F_t\right] \\
&\quad + E^Q e^{-\int_t^{t_k} r_s ds} \int_{-t_{k-1}}^{-t_k} e^{\int_{-s}^{-t_k} r_u du} dD_s | F_t] - E^Q\left[e^{-\int_t^{t_k} r_s ds} \Delta L(t_{t-k}, t_k) I_{k-1} | F_t\right]
\end{aligned}$$

After simplification (see Bjork and Clapham (2002), we have:

$$\Pi(t; X_k) = B_t E^Q\left[G_k^B - G_{k-1}^B | F_t\right] \tag{4}$$

Since the normalized gains process is a martingale under Q, the arbitrage free value of the swap must be zero. However, when taking into account counterparty default risk in the valuation, the fair spread over the market rate is no longer zero. Within this framework, the TRS payer's net payments, at time t_k, is

$$X_k = (I_k - I_{k-1}) + \int_{t_{k-1}}^{t_k} e^{\int_t^s r_u du} dD_s - \Delta[L(t_{k-1}, t_k) + \delta] I_{k-1}$$

where δ is the spread over the market rate.

$$\begin{aligned}
\Pi(t; X_k) &= E^Q\left[e^{-\int_t^{t_k} r_s ds} X_k | F_t\right] \\
&= E^Q\left[e^{-\int_t^{t_k} r_s ds} I_k | F_t\right] - E^Q\left[e^{-\int_t^{t_k} r_s ds} I_{k-1} | F_t\right] \\
&\quad + E^Q\left[e^{-\int_t^{t_k} r_s ds} \int_{t_{k-1}}^{t_k} e^{\int_s^{t_k} r_u du} dD_s | F_t\right] - E^Q\left[e^{-\int_t^{t_k} r_s ds} \Delta[L(t_{k-1}, t_k) + \delta] I_{k-1} | F_t\right] \\
&= E^Q\left[e^{-\int_t^{t_k} r_s ds} I_k | F_t\right] - E^Q\left[e^{-\int_t^{t_k} r_s ds} I_{k-1}\{1 + \Delta[L(t_{k-1}, t_k) + \delta]\} | F_t\right] \\
&\quad + E^Q\left[e^{-\int_t^{t_k} r_s ds} \int_{t_{k-1}}^{t_k} e^{\int_s^{t_k} r_u du} dD_s | F_t\right]
\end{aligned} \tag{5}$$

The second term can be written as

$$\begin{aligned}
&E^Q\left[e^{-\int_t^{t_k} r_s ds} I_{k-1}\{1 + \Delta[L(t_{k-1}, t_k) + \delta]\} | F_t\right] \\
&= E^Q\left\{E^Q\left[e^{-\int_t^{t_k} r_s ds} I_{k-1}\{1 + \Delta[L(t_{k-1}, t_k) + \delta]\} | F_{t_{k-1}}\right] | F_t\right\} \\
&= E^Q\left\{E^Q\left[e^{-\int_t^{t_{k-1}} r_s ds} I_{k-1}\{1 + \Delta[L(t_{k-1}, t_k) + \delta]\}\right] E^Q\left[e^{-\int_{t_{k-1}}^{t} r_s ds} | F_{t_{k-1}}\right] | F_t\right\} \\
&= E^Q\left\{e^{-\int_t^{t_{k-1}} r_s ds} I_{k-1}\{1 + \Delta[L(t_{k-1}, t_k) + \delta]\} \frac{1}{1+\Delta L(t_{k-1}, t_k)} | F_t\right\} \\
&= E^Q\left\{e^{-\int_t^{t_{k-1}} r_s ds} I_{k-1}\left[1 + \frac{\Delta\delta}{1+\Delta L(t_{k-1}, t_k)}\right] | F_t\right\}
\end{aligned}$$

Substituting into Equation (5), we obtain the arbitrage-free value of a TRS at time t as

$$\begin{aligned}
\Pi(r; X_k) &= E^Q\left[e^{-\int_t^{t_k} r_s ds} I_k | F_t\right] - E^Q\left\{e^{-\int_t^{t_{k-1}} r_s ds} I_{k-1}\left[1 + \frac{\Delta\delta}{1+\Delta L(t_{k-1}, t_k)}\right] | F_t\right\} \\
&\quad + E^Q\left[e^{-\int_t^{t_k} r_s ds} \int_{t_{k-1}}^{t_k} e^{\int_s^{t_k} r_u du} dD_s | F_t\right] \\
&= B_t E^Q\left[\frac{I_k}{B_k} - \frac{I_{k-1}}{B_{k-1}}\left(1 + \frac{\Delta\delta}{1+\Delta L(t_{k-1}, t_k)}\right) + \int_{t_{k-1}}^{t_k} \frac{1}{B_s} dD_s | F_t\right] \\
&= B_t E^Q\left[G_k^B - G_{k-1}^B - \frac{I_{k-1}}{B_{k-1}} \frac{\Delta\delta}{1+\Delta L(t_{k-1}, t_k)} | F_t\right]
\end{aligned}$$

The last term inside brackets denotes the present value of the amount (I_{k-1} $\Delta\delta$) paid at time t_k. The arbitrage−free value of this amount must be equal to the expected loss incurred by the TRS payer given counterparty default risk. The counterparty default risk arises only when the TRS value is negative for receiver; otherwise the

TRS receiver has a net inflow. When the TRS value is negative and the TRS receiver defaults, we assume that the TRS payer receives a proportion [1 − Loss Given Default (LGD)] of the TRS value. The loss to the TRS payer, given counterparty default, is therefore, similar to the payoff of a contingent claim that pays $LGD[\max(X_k, 0)]$ at time t_k. This contingent claim can be seen as a European call option on X_k with exercise price zero and maturity date t_k or a European call option on the underlying index value, with spot price I_{k-1} and strike price $I_{k-1}\Delta L(t_{k-1}, t_k)$ and maturity date t_k. X_k represents the TRS value without counterparty default risk. Thus, the present value of the amount $(I_{k-1}-\delta)$ paid at time t_k must equal

$$\begin{aligned} E^Q\left[\frac{I_{k-1}}{B_{k-1}}+\frac{\Delta\delta}{1+\Delta L(t_{k-1},t_k)}|F_t\right] &= E^Q\left[LGD\, e^{-\int_t^{t_k} r_s ds}[\max(X_k,0)]f(t_{k-1},t_k)|F_t\right] \\ &= E^Q\left[LGD\, e^{-\int_t^{t_{k-1}} r_s ds}c(X_k)f(t_{k-1},t_k)|F_t\right] \\ &= E^Q\left[LGD\frac{1}{B_{k-1}}c(X_k)f(t_{k-1},t_k)|F_t\right] \end{aligned} \tag{6}$$

where $f(t_{k-1}, t_k)$ represents the probability of default by the counterparty between times t_{k-1} and t_k as seen at time t and $c(X_k)$ denotes the value at time t_{k-1} of a call option on X_k with exercise price zero and maturity date t_k. Expression (6) can be simplified to write the spread as

$$\delta = \frac{(LGDc(X_k)f(t_{k-1},t_k))(1+\Delta L(t_{k-1},t_k))}{\Delta I_{k-1}} \tag{7}$$

If probability of default by the counterparty or LGD equals zero there is no counterparty default risk and the spread should be zero.

Empirical Considerations

To empirically apply this model we need the following additional assumptions. First, both the value of the index, I, and the value of counterparty assets, V, are independent and follows a Geometric Brownian motion

$$\begin{aligned} \mathrm{d}I &= \mu_I I \mathrm{d}t + \sigma_I I \mathrm{d}z_I \\ \mathrm{d}V &= \mu_v V \mathrm{d}t + \sigma_v V \mathrm{d}z_v \end{aligned}$$

where μ_I and μ_V are the risk neutral expected growth rate of the index value and counterparty assets value, respectively. For a non-dividend paying asset, $r=\mu$ is the risk free rate and for a dividend paying asset $\mu = r - \theta$, where θ denotes dividend rate. σ_I and σ_V are the volatility of the index value and counterparty assets value. z_I and z_V are variables that follow a Wiener process. Second, LGD is assumed to be 49 percent (see, for example, Longstaff and Schwartz (1995), Eom et al. (2004)). Finally, counterparty defaults when the value of the asset fall below a specified level, K, the threshold level, which may change over time. Several studies present closed-form solutions to compute this default probability (see, for example, Black and Cox (1976), Ericsson and Reneby (1998) and Bielecki and Rutkowski (2001)). We use the formula presented in Black and Cox (1976)[1].

[1] Different closed-form formulae provide almost indistinguishable default probabilities. Therefore, the results are not sensitive to this parameter calculation.

According to Black and Cox (1976), with some simplifications, default occurs at the first time $t \in [0, \mathrm{T}]$ if the company value, V_s, falls below K and the time of default τ is given by $\tau = \inf\{s \geq t | V_s \leq K\}$. Under these considerations the risk-neutral probability of default before time T is

$$P[\tau \leq T|F_t] = 1 - N\left(\frac{\ln(V_t/K) + \left(r - \theta - 0.5\sigma_V^2\right)(\tau - t)}{\sqrt{\sigma_v^2(\tau - t)}}\right) + (V_t/K)^{1-\left(2(r-\theta)/\sigma_V^2\right)} N\left(\frac{\ln(K/V_t) + \left(r - \theta - 0.5\sigma_V^2\right)(\tau - t)}{\sqrt{\sigma_V^2(\tau - t)}}\right) \tag{8}$$

Equation (8) allows us to compute counterparty default probability over the life of TRS, until its maturity. Instead of using (8), we can use the credit rating if counterparty has credit rating given by a credit rating agency[2].

In practice, given that over the life of the TRS there is normally more than one payment that occurs at the end of each Δ, we need to compute counterparty default probability over each Δ given F_t or as seen at time t. Hull (1989) defines the probability of default during the time interval Δ as

$$P[t_{k-1} \leq \tau \leq t_k|F_t] = \exp(-\mathrm{ht_{k-1}}) - \exp(-\mathrm{ht_k}) \tag{9}$$

where h is the hazard rate or default intensity. A typical assumption is that the hazard rate, h, is constant over the period. However, to apply Equation (9) we need to extract from the company's default probability (Equation (8)), the equivalent estimate of h. From Li (2000) we know that counterparty survival time follows an exponential distribution with parameter h and that the default probability over the time interval $[t, t+x]$, for $0<x<1$, equals one minus the survival probability

$$P[\tau \leq t + x|F_t] = 1 - \exp(-\mathrm{hx}) \tag{10}$$

In this study, we use Equation (10) to extract from company's default probability the hazard rate, which is then used in Equation (9) to estimate the default probability over each Δ.

The additional assumption for the value of the index process allows us to use the standard Black and Scholes (1973) model to compute the value of European call option.

As mentioned earlier, the spread incorporates other components apart from counterparty default risk. If these other components are not taken into account, we expect to observe the predicted spread to be lower than the actual spread traded in the market.

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[2] Given that the default probability that correspond to a given credit rating class is a physical measure, we must convert it in a risk neutral measure before using it in this framework. We thank an anonymous referee for this suggestion. Hull et al. (2004) present a model that converts the credit rating default probability in the risk-neutral default intensity allowing us to use immediately Equation (9). Jarrow et al. (2005) provide a more detailed explanation of the process of converting physical default probabilities into risk-neutral default probabilities.

Application to Real Estate Index Linked Swaps

In this section we apply the model developed above to determine the TRS fair spread for the real estate index linked swaps, conditional on counterparty default risk, and discuss the results. We price TRS fair spread using a sample of data drawn from IPD indices, different maturities (1, 3 and 5 years), and different counterparty default probabilities. The IPD monthly and annual indices used in our analysis measure returns to direct investment in commercial property. The indices are compiled from valuations and management records of individual buildings, which are collected directly by IPD from property owners. The property valuations in the indices are carried out by qualified valuers, independent of property owners and managers, working to RICS guidelines. The indices show total returns on capital employed in market standing investments., where standing investments are properties held from one valuation period to the next. The market results exclude any properties bought, sold, under development, or subject to major refurbishment in the course of the month. The monthly and annual results are chain-linked into a continuous, time-weighted, index series. The total return is the overall return on capital employed, and is the sum of income return and capital growth. The income return is income receivable net of property management and irrecoverable costs divided by capital employed through the month. The capital growth is the change in capital value from one valuation to next net of any capital flows divided by capital employed. The capital employed is the capital value at the start of the month plus half of any net capital flow, minus half of income receivable (that is, the calculation assumes flows of capital and reinvested income are even through the month). The rental value growth is synonymous with estimated rental value growth and open market rental value growth. It is the percentage change in the rental value used in the valuation from one month end to next.

We use LIBOR as the market interest rate, with maturities up to twelve months denoted as[3]: $L(t_{k-1}, t_k) = [\exp(r\Delta) - 1]/\Delta$

In the absence of counterparty financial information, we cannot price a particular TRS using equation (8). Therefore, each TRS fair spread is computed using the term structure of default probabilities (see Table 1), per each credit rating class, provided by Moody's Report (2005). In this framework, and to simplify matters, default probability is not time varying, it only varies with TRS maturity as shown in Table 1. We use Moody's term structure of default probabilities in Equation (10) to compute hazard rate, h, of each credit rating class over different time horizon. Default probabilities over each Δ, given F_t, are computed using Equation (9).

The TRS fair spread, δ_{TRS}, is computed as a weighted average of the fair value of individual contract swaplet spread. This spread is computed using

$$\delta_{TRS} = \frac{\int_k^n \delta_k e^{\int_k^n r_s ds}}{e^{\int_k^n r_s ds} + 1} \tag{11}$$

where δ_k is the swaplet spread active between t_k and t_{k-1} and paid at t_k.

[3] British Bankers Association website: http://www.bba.org.uk

Table 1 Default probabilities' term structure, per credit rating class

Rating	1 year	3 years	5 years
Aaa	0.0000	0.0002	0.0019
Aa	0.0006	0.0032	0.0078
A	0.0008	0.0054	0.0122
Baa	0.0031	0.0169	0.0340
Ba	0.0139	0.0548	0.0993
B	0.0456	0.1524	0.2380
Caa-C	0.1507	0.3182	0.4050

Moody's Report (2005)

In this setting, the TRS fair spread depends largely on the volatility of the underlying real estate index. Since some real estate indices are re-valuated monthly and others annually, we present the standard descriptive statistics of the indices in see Tables 2 and 3. We also test for serial dependence in the indices, for which we have monthly data. According to the Ljung–Box statistics for returns, there is first order and higher order autocorrelation, significant at the 1 percent level, meaning that the series is serially correlated. The Augmented Dickey–Fuller test (ADF) allows us to conclude that, at the 5 percent significance level, the series are stationary. We present the ARMA (p, q) processes that minimize Schwarz criterion.

Tables 2 and 3 indicate that IPD indices have relatively low standard deviation and high-risk adjusted returns. During the period 1980 to 2004, the average return on All Property Income Return Index was 6.6 percent annum with only 1 percent of volatility. Even the simplest performance measures such as the Sharpe ratio reveal the extraordinary risk-adjusted performance of IPD indices. Obviously, the low volatility implies low TRS spreads.

We compute the TRS fair spreads using Equation (11). As explained earlier, the total value of a TRS fair spread is the sum all the intermediate swaplets. Table 4 reports TRS fair spreads (basis points) of IPD monthly Total Return and Capital Value Indices for different levels of default risk. The volatility of index returns is computed using a rolling window of the last 3 years of monthly observations. For these indices we consider that cash flows are paid semi-annually, meaning that swaplets have a 6 month maturity. Three key features are worth noting here: First,

Table 2 Descriptive statistics (monthly returns, 1991–2001)

	Capital value IPD		Total return IPD	
	All property	Office	All property	Office
Mean+	1.10%	−0.53%	8.93%	7.74%
Volatility+	2.22%	2.73%	2.21%	2.73%
LB Q(1)[a]	98.1	101.2	97.8	100.8
LB Q(12)[a]	369.6	493.6	363.7	477.2
ADF (12)[b]	−3.1	−2.9	−3.2	−3.0
ARMA (p, q)	(2, 2)	(2, 1)	(2, 2)	(2, 2)

+ Annualised data. LB Q(L) is the Ljung–Box test for returns, using L lagged observations. ADF (L) is the Augmented Dickey–Fuller test. The ADF 5% critical value is −2.8859. ARMA (p, q) model is selected using Schwarz criterion

[a] Significant at the 1% level

[b] Significant at the 5% level

Table 3 Descriptive statistics (yearly returns, 1980–2004)

Sector	Index	Mean (%)	Volatility (%)
All property	Capital Growth Index	3.5	8.0
	Income Return Index	6.6	0.9
	Rental Value G. Index	3.8	7.6
	Total Return Index	10.0	7.7
Retail	Capital Growth Index	5.3	6.9
	Income Return Index	5.9	0.8
	Rental Value G. Index	5.4	5.1
	Total Return Index	11.1	6.6
Office	Capital Growth Index	2.0	9.9
	Income Return Index	6.8	1.1
	Rental Value G. Index	2.6	11.0
	Total Return Index	8.7	9.5
Industrial	Capital Growth Index	3.0	8.2
	Income Return Index	8.3	0.9
	Rental Value G. Index	3.2	6.8
	Total Return Index	11.3	8.1
Other property	Capital Growth Index	3.8	6.7
	Income Return Index	5.2	0.8
	Rental Value G. Index	2.9	3.4
	Total Return Index	9.0	7.0

spreads of IPD Office Indices are higher than those of IPD All Property Indices. This can be explained by the higher volatility of the former index. Second, for investment-grade rated investor, the TRS fair spread increases with TRS maturity, because default intensity also increases with time, meaning that for these investors, the probability of bankruptcy over the period $[t_k, t_{k-1}]$ is greater than the probability of bankruptcy over the previous period. Third, for a speculative-grade (B and Caa-C) rated investor, the TRS fair spread decreases with TRS maturity, because default intensity also decreases with time, meaning that the probability of bankruptcy over the period $[t_k, t_{k-1}]$ is lower than the one over the previous period.

Table 4 Average TRS' spread (b.p.-monthly data, 1994–2001)

	Total return IPD						Capital value IPD					
	All property			Office			All property			Office		
	1	3	5	1	3	5	1	3	5	1	3	5
Aaa	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001
Aa	0.001	0.002	0.003	0.002	0.002	0.003	0.001	0.002	0.003	0.002	0.002	0.003
A	0.002	0.003	0.004	0.002	0.004	0.005	0.002	0.003	0.004	0.002	0.003	0.005
Baa	0.006	0.010	0.013	0.008	0.011	0.015	0.006	0.010	0.012	0.008	0.011	0.014
Ba	0.028	0.032	0.038	0.037	0.037	0.044	0.028	0.032	0.037	0.036	0.036	0.042
B	0.092	0.092	0.096	0.120	0.107	0.111	0.091	0.090	0.094	0.116	0.102	0.107
Caa-C	0.296	0.201	0.176	0.386	0.234	0.205	0.293	0.197	0.173	0.373	0.225	0.196

TRS' fair spread is computed by Equation (11), using 6-month swaplets. Reported values are the average of those spreads.

Table 5 Average TRS' spread (b.p.-yearly data, 1994–2004)

Sector	Index	Credit rating						
		Aaa	Aa	A	Baa	Ba	B	Caa-C
Maturity: 1 year								
All Property	Capital Growth Index	0.00	0.12	0.16	0.63	2.85	9.52	33.31
	Income Return Index	0.00	0.02	0.02	0.08	0.37	1.22	4.28
	Rental Value G. Index	0.00	0.12	0.16	0.61	2.73	9.10	31.83
	Total Return Index	0.00	0.12	0.16	0.61	2.77	9.24	32.35
Retail	Capital Growth Index	0.00	0.10	0.14	0.53	2.37	7.90	27.65
	Income Return Index	0.00	0.01	0.02	0.07	0.34	1.12	3.93
	Rental Value G. Index	0.00	0.08	0.10	0.39	1.77	5.91	20.69
	Total Return Index	0.00	0.10	0.13	0.51	2.31	7.70	26.96
Office	Capital Growth Index	0.00	0.15	0.20	0.78	3.54	11.80	41.29
	Income Return Index	0.00	0.02	0.02	0.09	0.43	1.42	4.97
	Rental Value G. Index	0.00	0.17	0.22	0.85	3.85	12.85	44.97
	Total Return Index	0.00	0.15	0.20	0.76	3.43	11.45	40.07
Industrial	Capital Growth Index	0.00	0.12	0.16	0.62	2.81	9.36	32.77
	Income Return Index	0.00	0.01	0.02	0.07	0.32	1.08	3.78
	Rental Value G. Index	0.00	0.11	0.14	0.55	2.47	8.22	28.78
	Total Return Index	0.00	0.12	0.16	0.61	2.77	9.24	32.32
Other Property	Capital Growth Index	0.00	0.09	0.12	0.48	2.15	7.16	25.04
	Income Return Index	0.00	0.01	0.01	0.05	0.23	0.78	2.73
	Rental Value G. Index	0.00	0.05	0.06	0.24	1.10	3.67	12.84
	Total Return Index	0.00	0.09	0.13	0.49	2.19	7.31	25.58
Maturity: 3 year								
All Property	Capital Growth Index	0.01	0.22	0.38	1.18	3.82	10.62	22.08
	Income Return Index	0.00	0.03	0.05	0.15	0.49	1.37	2.84
	Rental Value G. Index	0.01	0.21	0.36	1.12	3.65	10.13	21.06
	Total Return Index	0.01	0.22	0.37	1.14	3.71	10.31	21.43
Retail	Capital Growth Index	0.01	0.19	0.31	0.98	3.17	8.80	18.30
	Income Return Index	0.00	0.03	0.04	0.14	0.45	1.26	2.61
	Rental Value G. Index	0.01	0.14	0.24	0.74	2.40	6.67	13.86
	Total Return Index	0.01	0.18	0.30	0.95	3.09	8.58	17.84
Office	Capital Growth Index	0.02	0.28	0.46	1.45	4.72	13.11	27.25
	Income Return Index	0.00	0.03	0.06	0.18	0.58	1.60	3.32
	Rental Value G. Index	0.02	0.30	0.50	1.57	5.10	14.17	29.45
	Total Return Index	0.02	0.27	0.45	1.41	4.57	12.70	26.41
Industrial	Capital Growth Index	0.01	0.22	0.37	1.17	3.80	10.55	21.93
	Income Return Index	0.00	0.02	0.04	0.13	0.42	1.18	2.45
	Rental Value G. Index	0.01	0.19	0.33	1.03	3.34	9.27	19.27
	Total Return Index	0.01	0.22	0.37	1.15	3.74	10.39	21.60
Other Property	Capital Growth Index	0.01	0.17	0.28	0.88	2.86	7.94	16.50
	Income Return Index	0.00	0.02	0.03	0.09	0.30	0.85	1.76
	Rental Value G. Index	0.01	0.08	0.14	0.45	1.44	4.01	8.34
	Total Return Index	0.01	0.17	0.29	0.90	2.92	8.12	16.87
Maturity: 5 years								
All Property	Capital Growth Index	0.08	0.33	0.52	1.46	4.33	10.70	18.98
	Income Return Index	0.01	0.04	0.07	0.19	0.56	1.38	2.44
	Rental Value G. Index	0.08	0.32	0.50	1.40	4.13	10.22	18.13
	Total Return Index	0.08	0.32	0.51	1.42	4.19	10.36	18.39
Retail	Capital Growth Index	0.07	0.28	0.43	1.21	3.57	8.84	15.68
	Income Return Index	0.01	0.04	0.06	0.17	0.51	1.27	2.25
	Rental Value G. Index	0.05	0.21	0.33	0.93	2.74	6.78	12.02
	Total Return Index	0.07	0.27	0.42	1.17	3.48	8.60	15.25

Table 5 (continued)

Maturity: 1 year Sector	Index	Credit rating Aaa	Aa	A	Baa	Ba	B	Caa-C
Office	Capital Growth Index	0.10	0.41	0.64	1.80	5.33	13.18	23.39
	Income Return Index	0.01	0.05	0.08	0.22	0.65	1.61	2.86
	Rental Value G. Index	0.11	0.44	0.69	1.94	5.74	14.20	25.18
	Total Return Index	0.10	0.40	0.62	1.74	5.16	12.75	22.62
Industrial	Capital Growth Index	0.08	0.33	0.52	1.46	4.31	10.66	18.91
	Income Return Index	0.01	0.04	0.06	0.16	0.47	1.17	2.08
	Rental Value G. Index	0.07	0.29	0.46	1.28	3.79	9.36	16.61
	Total Return Index	0.08	0.33	0.51	1.43	4.24	10.49	18.60
Other Property	Capital Growth Index	0.06	0.25	0.39	1.09	3.22	7.96	14.12
	Income Return Index	0.01	0.03	0.04	0.11	0.34	0.84	1.49
	Rental Value G. Index	0.03	0.12	0.19	0.54	1.61	3.98	7.05
	Total Return Index	0.06	0.25	0.40	1.11	3.29	8.14	14.45

TRS' fair spread is computed by Equation (11), using 1-year swaplets. Reported values are the average of those spreads.

Table 5 reports estimates of TRS fair spreads (basis points) of IPD Annual office, retail and industrial sectors indices for different levels of default risk. The volatility of index returns is computed as before using a rolling window of the last 13 years of yearly observations. The spreads are computed assuming swaplets with one-year maturity. The results can be summarised as follows: TRS of Income Return Indices, for all sectors and maturities, have low spreads reflecting the low volatility of these indices; overall, the TRS of Office Indices have relatively higher spreads; and the pattern observed earlier for investment-grade and speculative-grade rated investors is also observed for these indices.

Tables 6 and 7 report the estimates of TRS fair spreads for IPD Annual Capital Growth and Rental Value Indices of Offices by region, respectively. Once again, TRS spreads are function of volatility, which is computed using a rolling window of the last 13 years of yearly observations. Overall, the Rental Value Indices have lower volatilities than Capital Growth Indices for the Office sector.

To the best of our knowledge, no market quotes on TRS spreads are available for IPD indices over the sample period studied here. Tullet Prebon Corporation has available indicative swap prices for a range of property derivative contracts, with different maturities. For example, the average spread, over the period 11/05 to 03/06, of a LIBOR–IPD UK All Property swap with 1 year of maturity, is around 400 basis points (bp). The lowest spread is around 100 bp and the average spread for several LIBOR–IPD swaps is around 300 bp. Although our sample period is different, Tullet Prebon market quotes are far greater than the average spread of around 65 bp observed in our results. As pointed out earlier, our results are derived from the low volatilities observed in Tables 2 and 3.

Under a scenario analysis of LGD equal to 100 percent and the index return volatility of around 30 percent, the fair spread of 1 year TRS done with a counterparty rated Caa-C is around 140 bp. Our estimates spreads are only a small fraction of the quoted market spread. There are a number of factors other than counterparty credit risk that can account for this apparent difference including illiquidity and high transaction costs in property

Table 6 Average TRS' spread on capital growth offices index by region (b.p.-yearly data, 1994–2004)

Region	Maturity	Credit rating						
		Aaa	Aa	A	Baa	Ba	B	Caa-C
All Office	1	0.00	0.15	0.20	0.78	3.54	11.80	41.29
	3	0.02	0.28	0.46	1.45	4.72	13.11	27.25
	5	0.10	0.41	0.64	1.80	5.33	13.18	23.39
City	1	0.00	0.18	0.24	0.93	4.19	13.98	48.91
	3	0.02	0.32	0.55	1.71	5.56	15.44	32.10
	5	0.12	0.48	0.76	2.12	6.27	15.51	27.52
Mid Town	1	0.00	0.20	0.26	1.02	4.59	15.32	53.61
	3	0.02	0.36	0.60	1.88	6.11	16.98	35.30
	5	0.13	0.53	0.83	2.33	6.90	17.06	30.27
West End	1	0.00	0.20	0.27	1.03	4.64	15.48	54.19
	3	0.02	0.36	0.61	1.90	6.17	17.16	35.66
	5	0.13	0.54	0.84	2.36	6.97	17.24	30.58
Central London Fringe	1	0.00	0.18	0.24	0.95	4.27	14.24	49.83
	3	0.02	0.33	0.56	1.74	5.66	15.72	32.67
	5	0.12	0.49	0.77	2.15	6.36	15.73	27.91
Outer London	1	0.00	0.14	0.18	0.70	3.18	10.59	37.06
	3	0.02	0.25	0.42	1.31	4.24	11.77	24.46
	5	0.09	0.37	0.58	1.61	4.78	11.81	20.95
South East	1	0.00	0.12	0.16	0.62	2.79	9.29	32.52
	3	0.01	0.22	0.37	1.14	3.71	10.31	21.43
	5	0.08	0.32	0.50	1.41	4.17	10.30	18.28
South West	1	0.00	0.13	0.17	0.67	3.02	10.06	35.22
	3	0.02	0.24	0.41	1.27	4.11	11.42	23.74
	5	0.09	0.36	0.56	1.58	4.68	11.56	20.51
Eastern	1	0.00	0.14	0.18	0.72	3.23	10.78	37.72
	3	0.02	0.25	0.43	1.34	4.33	12.04	25.02
	5	0.09	0.38	0.59	1.66	4.90	12.11	21.49
East Midlands	1	0.00	0.12	0.16	0.60	2.72	9.06	31.72
	3	0.01	0.22	0.37	1.15	3.72	10.33	21.48
	5	0.08	0.33	0.51	1.44	4.25	10.52	18.66
West Midlands	1	0.00	0.11	0.15	0.59	2.65	8.84	30.92
	3	0.01	0.21	0.36	1.12	3.63	10.08	20.95
	5	0.08	0.32	0.50	1.39	4.13	10.20	18.10
North West	1	0.00	0.10	0.13	0.52	2.33	7.75	27.13
	3	0.01	0.19	0.31	0.98	3.17	8.80	18.30
	5	0.07	0.28	0.43	1.22	3.60	8.90	15.79
Yorks & Humber	1	0.00	0.12	0.16	0.63	2.84	9.47	33.15
	3	0.01	0.23	0.38	1.19	3.86	10.74	22.32
	5	0.08	0.34	0.53	1.49	4.40	10.88	19.30
North East	1	0.00	0.11	0.14	0.54	2.46	8.19	28.66
	3	0.01	0.20	0.33	1.03	3.34	9.29	19.32
	5	0.07	0.29	0.46	1.28	3.79	9.36	16.61
Scotland	1	0.00	0.12	0.15	0.60	2.69	8.96	31.36
	3	0.01	0.21	0.36	1.12	3.63	10.09	20.98
	5	0.08	0.32	0.50	1.39	4.11	10.16	18.03
Wales	1	0.00	0.10	0.14	0.53	2.41	8.04	28.12
	3	0.01	0.19	0.32	1.00	3.24	9.01	18.73
	5	0.07	0.28	0.44	1.24	3.66	9.04	16.04

TRS' fair spread is computed by Equation (11), using 1-year swaplets. Reported values are the average of those spreads

Table 7 Average TRS' spread on rental value offices index by region (b.p.-yearly data, 1994–2004)

Region	Maturity	Credit rating						
		Aaa	Aa	A	Baa	Ba	B	Caa-C
All Office	1	0.00	0.17	0.22	0.85	3.85	12.85	44.97
	3	0.02	0.30	0.50	1.57	5.10	14.17	29.45
	5	0.11	0.44	0.69	1.94	5.74	14.20	25.18
City	1	0.00	0.22	0.30	1.16	5.23	17.43	61.00
	3	0.03	0.40	0.68	2.12	6.86	19.06	39.62
	5	0.14	0.59	0.93	2.60	7.70	19.04	33.78
Mid Town	1	0.00	0.24	0.32	1.23	5.53	18.43	64.50
	3	0.03	0.42	0.72	2.24	7.27	20.21	42.01
	5	0.15	0.63	0.98	2.76	8.16	20.17	35.78
West End	1	0.00	0.23	0.30	1.17	5.29	17.63	61.70
	3	0.03	0.41	0.69	2.15	6.98	19.39	40.31
	5	0.15	0.60	0.95	2.65	7.84	19.39	34.40
Central London Fringe	1	0.00	0.21	0.28	1.09	4.93	16.43	57.51
	3	0.02	0.38	0.64	2.00	6.49	18.04	37.50
	5	0.14	0.56	0.88	2.46	7.27	17.98	31.90
Outer London	1	0.00	0.15	0.20	0.78	3.51	11.70	40.94
	3	0.02	0.27	0.46	1.43	4.65	12.92	26.86
	5	0.10	0.40	0.63	1.76	5.22	12.90	22.89
South East	1	0.00	0.12	0.16	0.63	2.86	9.54	33.40
	3	0.01	0.22	0.37	1.17	3.79	10.53	21.89
	5	0.08	0.33	0.51	1.44	4.26	10.52	18.66
South West	1	0.00	0.13	0.17	0.65	2.93	9.78	34.21
	3	0.01	0.23	0.39	1.24	4.01	11.13	23.14
	5	0.09	0.35	0.55	1.54	4.56	11.27	19.99
Eastern	1	0.00	0.16	0.22	0.85	3.84	12.80	44.78
	3	0.02	0.30	0.50	1.58	5.11	14.21	29.53
	5	0.11	0.44	0.69	1.94	5.74	14.20	25.19
East Midlands	1	0.00	0.10	0.13	0.51	2.32	7.74	27.09
	3	0.01	0.19	0.32	1.00	3.23	8.98	18.66
	5	0.07	0.28	0.45	1.25	3.69	9.13	16.20
West Midlands	1	0.00	0.13	0.17	0.65	2.95	9.84	34.42
	3	0.01	0.24	0.40	1.26	4.09	11.37	23.65
	5	0.09	0.36	0.56	1.58	4.67	11.54	20.47
North West	1	0.00	0.09	0.13	0.49	2.21	7.38	25.82
	3	0.01	0.18	0.30	0.94	3.05	8.46	17.59
	5	0.06	0.27	0.42	1.17	3.46	8.54	15.16
Yorks & Humber	1	0.00	0.10	0.14	0.53	2.40	8.00	27.99
	3	0.01	0.19	0.33	1.03	3.33	9.26	19.24
	5	0.07	0.29	0.46	1.28	3.80	9.39	16.67
North East	1	0.00	0.09	0.11	0.44	1.99	6.62	23.18
	3	0.01	0.16	0.27	0.84	2.73	7.59	15.77
	5	0.06	0.24	0.37	1.04	3.08	7.62	13.53
Scotland	1	0.00	0.11	0.15	0.57	2.56	8.52	29.82
	3	0.01	0.20	0.34	1.07	3.48	9.68	20.11
	5	0.07	0.30	0.48	1.33	3.94	9.74	17.28
Wales	1	0.00	0.11	0.14	0.55	2.48	8.28	28.97
	3	0.01	0.20	0.33	1.05	3.39	9.43	19.60
	5	0.07	0.30	0.46	1.29	3.83	9.47	16.80

TRS' fair spread is computed by Equation (11), using 1-year swaplets. Reported values are the average of those spreads markets. Apparently, with illiquidity, high transaction costs, and relatively low turnover in real estate asset markets, brokers who trade IPD TRS most likely charge high liquidity premium in addition to the TRS fair spread. Our results are in line with the evidence presented in Buttimer et al. (1997), who reported the spread over LIBOR of 0.125 bp on real estate index TRS contract between Morgan Stanley and a pension fund trying to reduce its exposure to real estate assets in the USA.

Other factors can also account for the observed differences between the market and the predicted spreads. These are related to the market microstructure theory. Brokers, who trade property derivatives are required to cover their exposure to property through a hedging strategy. They incur high inventory holding and adverse selection costs[4], which are prevalent in property markets.

Conclusion

Two main types of property derivatives currently available in the UK are property index certificates and total return swaps based on IPD indices. ABN AMRO bank led the recent attempt to provide two-way prices on total return swaps based on IPD property indices. A TRS is a bilateral contract between a total return payer, who owns the asset, and a total return receiver, who will enjoy the asset's cash flows or returns without owning it. In this paper we extend the existing TRS valuation models to incorporate counterparty default risk and demonstrate that TRS spreads over the LIBOR increase with volatility of returns on IPD indices and with counterparty default risk. Surprisingly, our computed spreads on IPD indices are much lower than a sample of quotes we obtained from one of the traders in the market. This finding suggests that factors other than counterparty default risk are driving the observed TRS quotes in this early stage of market development. Factors such as low transparency, low market liquidity, and high transaction costs adversely affect investors' decisions to use these instruments to gain/offset property market exposure. TRS traders also incur additional exposures due to low transparency and high transaction costs. Progress on the property derivatives development front might well be dependent on the improvements in transparency in the underlying physical markets.

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[4] Inventory holding costs arise because dealers incur additional costs for carrying undesirable long or short inventory positions. This imbalance is due to temporal divergences between buy and sell orders and moreover due to the obligation to provide liquidity. The spreads inevitably arise as a mechanism to keep the inventory at a desirable level. Adverse selection costs arise because dealers might face traders with superior information, which force the dealer to set the spread in order to maximize the difference between the gains obtained from trading with liquidity motivated traders and the losses from trading with informed traders (see O'Hara (1995)).

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