YALE INTERNATIONAL CENTER FOR FINANCE

Yale ICF Working Paper No. 09-12

June 2009

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Hedging Real-Estate Risk

Real-estate assets represent more than one-third of the value of all the underlying physical capital in the United States and the world. The relationship between the level of interest rates and housing prices does not always follow one direction and a shock event in one market may trigger deep repercussions in the other. With the spread of the securitization process, the risks rooted in these two fundamental markets can have far reaching outcomes.

Prices in the residential housing market are determined by direct trade between buyers and sellers who are influenced by emotional involvement and other opaque social factors such as change of employment or change of school for children. Residential real-estate assets are naturally not diversified and are a combination of a consumption asset and a leveraged investment. As Shiller and Weiss [1999] point out, this characteristic poses greater risk for the financial stability of individuals due to geographic fluctuations in property prices. Ideally, homeowners could use derivatives on relevant real-estate indices to hedge this risk and stabilize prices. Although real-estate derivatives should be preferred to insurance-type contracts because of direct settlement, liquidity is very important and this can be established only after banks decide to participate more actively in the real-estate index futures and options markets, as advocated by Case, Shiller, and Weiss [1993]. Housing prices are sticky when they are going down, sellers being reluctant to sell at a price below the price at which the property was initially purchased. Hence, the market is localized, the information is asymmetric, and participants' price expectations are very much influenced by the recent series of prices.[1] While it would be difficult for homeowners to hedge directly the price of their homes, banks and building societies that have mortgage portfolios more diversified nationally should be enticed to hedge their exposure with derivatives written on local indices. The use of index-based futures contracts and options for hedging mortgage risk, default risk, and real-estate price risk

[1] This is discussed in more detail in Case, Quigley, and Shiller [2003]

has long been advocated by Case and Shiller [1996]. Fisher [2005] provides an overview of NCREIF-based swap products and Clayton [2007] examines various indices developed for derivatives trading

The introduction of derivatives in the real-estate market is not easy because liquidity is difficult to establish when returns are predictable. An extensive discussion highlighting the important psychological barriers that need to be passed for the establishment of real-estate derivatives is provided in Shiller [2008]. Carlton [1984] argues that if changes in market prices are predictable, then changes in prices cannot be perceived as risky. The major obstacle for the introduction of real-estate derivatives was that when returns follow trends at certain points in time, then market sentiment is in only one direction and it is difficult to find counterparties trading against the trend. Nevertheless, if a futures contract is already trading for a series of future maturities, then the shape of the forward curve on real-estate index becomes important. Trades may be executed on the curve, say short a futures with a long maturity and long a futures with shorter maturity, which would be impossible to execute otherwise. With futures and options on futures, an entire spectrum of trading strategies becomes available and market participants such as hedge funds, investment houses, and private equity funds may provide much needed liquidity.[2]

The exponential growth of the subprime mortgage market from 2002 to 2007 was driven by the exploitation of securitization as a process of ring-fencing the risks of a collateral portfolio on one side and the introduction of the real-estate collateralized debt obligation (RE CDO) concept on the other side. The ever-growing demand for credit risky bonds pushed the boundaries of this new market into new territory, residential mortgage-backed securities (RMBS) backed by home equity loans (i.e., loans to credit impaired borrowers) and

[2] For example, Alpha Beta Fund Management (ABFM) announced in July 2007 that it targeted pension funds and other investors that may benefit from access to British housing by dealing in an over-the-counter property derivatives market which tracked the Halifax House Price Index (HHPI)

commercial mortgage-backed securities (CMBS). The cash flows of a RMBS, CMBS, and RE CDO depend fundamentally on the performance of a pool of mortgage loans, which in turn depend on the behavior of individual homeowners and commercial borrowers. These real-estate structured products are radically different from a CDO where the collateral consists of corporate credits whose corporate names could be monitored and their balance sheet scrutinized regularly. Hence, the real-estate risk drivers ─ prepayments and defaults clustering and timing ─ as well as recovery rates, could influence the financial stability of companies and institutions not directly related to the spot real-estate market. Hedging the potential disruption of scheduled cash flows is not an easy task and there are only a few instruments available in the market.

The advances in futures markets on real-estate indices may improve efficiency in spot markets and improve price discovery. Since transaction costs are high and create a barrier for entry into spot markets, futures markets may also help indicate the level of spot prices in the future and current market volatility. Another benefit of real-estate derivatives is that they are useful tools that allow investors access to an important asset class that would be hard to access otherwise. Furthermore, due to the lack of correlation of housing prices with equity prices, expanding diversified portfolios to include real estate could be highly beneficial, particularly for insurance and pension-funds.[3] Englund, Hwang, and Quigley [2002] point out that there could be large potential gains from instruments that would allow property holders to hedge their lumpy investments in housing.

Obviously, the first step in hedging is the selection of a suitable hedging instrument. A primary factor in deciding which derivative contract will provide the best hedge is the degree of correlation between the factors that drive the price of the derivative instrument under consideration as the hedging vehicle and the underlying risk that investors seeks to eliminate.

[3] This is more extensively discussed in Webb, Curcio, and Rubens [1988] and Seiler, Webb, and Myer [1999]

Correlation is not, however, the only consideration when the hedging program is of significant size. If, for example, an investor wants to hedge a very large cash position, liquidity becomes an important consideration and it might be necessary to split the hedge among two or more different derivatives.

Real-estate derivatives are useful to several categories of end users. The first category consists of individuals who are property owners and private investors specializing in real estate. Although this category of users is very large, in practice, not many may employ property derivatives due to knowledge and transaction costs barriers. The second category consists of portfolio managers hedging their price risk exposure in both domestic and foreign real estate. An adjacent category contains dealers and portfolio managers in structured products seeking to hedge their positions. Finally, real-estate derivatives can be embedded by structurers into newly designed structured products. The risks that users in these categories are hedging with property derivatives may vary. For example, while the members of the first category will hedge price risk, the users in the other categories may also consider property derivatives in connection with interest-rate risk and, possibly, currency risk.

In this paper, we describe the real-estate derivatives available worldwide and discuss the issues related to the pricing of these instruments and to the managing of hedging instruments over time.

REVIEW OF INSTRUMENTS USED FOR HEDGING REAL-ESTATE RISK

In this section, we describe the development of real-estate linked derivatives worldwide. The most developed markets from a financial product innovation point of view are in the United States and the United Kingdom, although some activity has been noticed in other developed European countries as well. The instruments can be classified by the type of real-estate risk they are hedging (1) housing price risk, (2) commercial property price risk, and (3) mortgage loan portfolio amortizing risk.

Hedging Housing Price Risk

A major component of the real-estate asset class is represented by residential housing. Housing prices are determined by macroeconomic conditions and by the behavior of the individuals buying and selling properties. Housing price risk is mainly associated with the sharp downturn or fall in housing prices. In addition to the owner of the property, this risk is a major concern to banks and other lending institutions and investors in structured products backed by residential mortgage loans. Here we review the financial instruments that have been designed to be used for hedging this risk.

In May 2006, the Chicago Mercantile Exchange (CME) launched futures and options on futures trading on the Standard & Poor's/Case-Shiller Home Price Index, an index constructed based on repeated sales analysis. As of 2009, there are futures contracts with maturities extending out 18 months into the future, listed on a quarterly cycle of February, May, August, and November; futures contracts with maturities extending out 19 to 36 months into the future, listed on a bi-annual schedule May and November; and futures contracts with maturities extending out 37 months to 60 months into the future, listed on an annual schedule with November maturity. The futures contracts trade at $250 times the index with a tick of $50, while the options trade on one futures contract with a tick of $10, for a range of strikes at five index point intervals from the previous day close price of the futures on the Case-Shiller Index. There are futures for 10 U.S. cities and also an aggregate index

The RPX is a residential index developed by Radar Logic Incorporated[4] that captures owner-occupied housing in 25 U.S. metropolitan statistical areas (MSAs). There is a global

[4] More details and price fixings can be found at www.radarlogic.com

MSA 25 Composite index that reflects the top 25 MSAs, as well as indices for the individual MSAs. This index is based on rolling quarterly price fixings, measured by price per square foot,[5] and updated daily. Trading on derivatives contingent on the RPX index started in September 2007. The first RPX index-based derivative traded was a total-return swap. For this derivative, a fixed payment is periodically exchanged for the growth of the RPX index. Subsequently, RPX forward contracts began trading in May 2008 and they have become the most liquid contracts based on the RPX index.

In June 2009 the firm MacroMarkets LLC, has scheduled a launch of securities whose underlying value is linked by formula to the S&P/Case-Shiller Composite 10 Home Price index, an index of home prices in major metropolitan areas, on the New York Stock Exchange. There are two five-year securities, with ticker symbols UMM (for Up Major Metro) and DMM (for Down Major Metro). The securities are automatically created or redeemed in pairs by authorized participants, and the funds contributed at creation are invested in US Treasury Bills. Thus the pair together is fully collateralized and represents a balanced book for the issuer, so there is no counterparty risk. The elements of the pair trade separately, so there is price discovery for real estate five years after issue.

In the United Kingdom, real-estate derivatives are written on a house price index (HPI), the most common being the Halifax (HHPI) series. The HHPI is the longest running monthly housing price series in the United Kingdom with data available since January 1983. This index is based on the largest monthly sample of mortgage data, typically covering around 15,000 house purchases per month. This is a hedonic index.

In 2003, Goldman Sachs issued the first series of a range of covered warrants based on the Halifax All-Houses All-Buyers seasonally-adjusted index on the London Stock Exchange (LSE). More recently, based on the HPPI, in August 2007, Morgan Stanley agreed on an exotic

[5] This index can also be used to account for values paid in arms-length residential real estate transactions on a price per square foot basis.

swap with an undisclosed counterparty, worth more than £1 million. This is the UK's first residential property derivative trade that included an embedded exotic option, a "knock-in put" option. This derivative allows the counterparty to gain if the HHPI rises, subject to a maximum payout. The investor's capital is protected unless the HHPI falls below an initially specified value.

Hedging Commercial Property Price Risk

The other major component of real-estate asset class is commercial properties. Price risk for commercial properties is similar to housing price risk but it is not generally influenced by the behavior of the same participants as in the residential housing market. Commercial property prices are determined by supply and demand and specialized market participants. While some degree of correlation is expected between commercial price risk and housing price risk, there are sufficient differences to warrant a separate analysis and separate hedging instruments[6].

A major property index used as an underlying for property derivatives to hedge commercial property price risk in the United States is the NCREIF series and, in particular, the National Property Index. The NCREIF property index is based on an aggregation of appraised property values. This index is the underlying for two types of swaps that were traded to date. One is the total-return swap that allows an investor to synthetically reproduce the economic gains of the index return. The other is an instrument used to swap different NCREIF property sectors. In June 2008, the NCREIF Property Index Total Return Swaps changed from a quarterly to annually payment schedule, all contracts paying at the end of the fourth quarter.

[6] Although discontinued in early 2009, the first commercial property derivative was based on the Standard & Poor's and Global Real Analytics/Charles Schwab Investment Management developed the S&P/GRA Commercial Real Estate Index, SPCREX™. This family of indices comprised 10 commercial real estate indices: a national composite, five major U. S. regions (Northeast, Mid-Atlantic South, Midwest, Desert Mountain, and Pacific West), and four property sectors (apartments, office, retail, and warehouse). The indices were calculated monthly using a three-month moving average and published with a three month lag.

In addition, since June 2008, there are two new total-return swap indices traded, the four-year maturity NCREIF National and five-year NCREIF National.

Barclays Capital began issuing its Property Index Certificates in 1994 and Property Index-Forwards in 1996, with the index comprising UK commercial property only. The contracts are currently traded in the over-the-counter (OTC) market and are written on two monthly indices published by the Investment Property Database (IPD): the IPD Total-Return and IPD Capital-Growth indices. These contracts have maturities of three to four years.

The property derivatives market has expanded in the United Kingdom from £850 million in 2005, £3.9 billion in 2006 to £7.2 billion in 2007. The IPD Index Property Derivatives volume in 2008 was £7.73 billion, not far from £8.30 billion in 2007's record year. In Europe, in 2007 the trading volume on the IPD French All Office Index[7] was £787 million, compared to £283 million on the German All Property Index.[8] Other markets where property derivatives have been traded include Switzerland, Canada, Japan, Italy, Hong Kong, and Australia. Thirteen major investment banks acquired licenses for the IPD index family. In Europe, property derivatives written on IPD indices traded OTC with a notional over £18.8 billion in trades executed by October 2008.

Eurex began trading property futures on February 9, 2009. These futures contracts are annual contracts based on the total returns of the IPD UK Annual All Property Index[9] for individual calendar years. The futures contract aims to eliminate counterparty risk, to improve liquidity to the commercial property sector of the real-estate property market, and to attract a complete range of potential participants in this asset class. Further futures contracts are going

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[7] The first French property swap on the IPD France Offices Annual Index was traded in December 2006 by Merrill Lynch and AXA Real Estate Investment Managers.

[8] The first option on an IPD index outside the United Kingdom was referenced to the German IPD/ DIX Index and it was traded in January 2007 with Goldman Sachs acting as a broker.

[9] At the end of 2007, the IPD index covered 12,234 properties with a total value of £184 billion - equivalent to 49% of the UK investment market. The IPD UK Annual Property Index measures unleveraged total returns to direct UK property investments and it is calculated using a time-weighted methodology with returns computed monthly and thereafter compounded for the purposes of the annual index construction.

to be launched by Eurex on IPD property indexes, such as UK sector indexes (Offices, Retail, Industrial) and other European indexes (initially France and Germany) on a demand-led basis.

The Australian Stock Exchange introduced its ASX Property-Trust futures based on the S&P/ASX200 Listed Property-Trust index in 2002. This index is comprised of the 200 largest listed property investments by market capitalization and most liquid securities in Australia. Three years later, the Sydney Futures Exchange listed futures based on the Dow Jones Australia Listed Property-Trust index.

Proposal for improved commercial real estate indices and instruments based on them will find their way into the market. For example, Horrigan et.al [2009] demonstrate how to construct segment-specific indices of property market returns from real-estate investment trust (REIT) return data, bond data, and property holding data and use those indices to make pure, targeted investments in the commercial real estate market while retaining the liquidity benefits of the well-developed public market in REITs. It is possible to re-construct the indices at the daily frequency without significant increases in noise and at various levels of segment granularity. Moreover, it seems that these new indices suggested by the authors lead transactions-based direct property market indices during market turns. Thus, these REIT-based commercial property return indices have the potential to be used to develop hedging strategies in the real-estate market and support derivatives trading.

Mortgage loan portfolio amortizing risk

At the portfolio level, mortgage loans carry two intrinsic risks that require hedging tools: default risk and prepayment risk. Default risk is the risk of loss of principal and/or interest due to the failure of the borrower to satisfy the terms of the lending agreement. This risk is high for RMBS that are backed by mortgage pools containing subprime mortgages.

A prepayment is the amount of principal repayment that is in excess of the regularly scheduled repayment due. A prepayment can be for the entire amount of the remaining principal balance (i.e., complete payoff of the loan) or for only part of the outstanding mortgage balance (referred to as a curtailment). Prepayment risk is greater for RMBS than CMBS because commercial loans have provisions to mitigate prepayment risk (e.g., lockout periods, prepayment penalties, yield maintenance, and defeasance).

From an investor's perspective, prepayment risk is the risk that borrowers will prepay their loan (in whole or in part) when interest rates decline. This action by borrowers would force investors to reinvest at lower interest rates. Note that if borrowers prepay when interest rates rise, prepayments are beneficial to investors because proceeds received can be reinvested at a higher interest rate. From the perspective of a portfolio manager or risk manager who is seeking to hedge an RMBS position against interest rate risk, prepayment risk exists even if prepayments occur when interest rates rise. This is because in establishing a hedge, the amount to be hedged will vary depending on a projected prepayment rate. At the outset of a hedge, an amortization schedule is projected based on the projected prepayment rate. Actual prepayment experience of a hedged asset or can cause a deviation between the projected principal outstanding based on the amortization schedule designed at the outset for the hedging instrument and the actual principal. This can result in over or under hedging a position. This stochastic nature of the amortization scheduled due to stochastic prepayments that hedgers face might more aptly be described as "amortization risk".

Default and prepayment risks called for special hedging instruments. The rapid growth of the U.S. subprime mortgage market led to the introduction of home equity credit default benchmark indices, referred to as ABX.HE indices that started trading in January 2006.[10] One of the main roles of the ABX.HE indices is to discover the market view on the risk of the underlying subprime loans. This is a synthetic instrument that allows investors to identify macro hedges on the subprime sector of the residential housing market. In addition to

[10] The trading is offered by CDSIndexCo, a consortium of credit derivative desks. The members contribute to the ABX.HE indices, which are managed by Markit Group.

managing risk, CDO collateral managers use the index to take advantage of any temporary pricing discrepancies.

The ABX.HE indices consist of five separate sub-indices, one for each of the rating categories AAA, AA, A, BBB, and BBB–.[11] Each sub-index consists of 20 tranches (of the same rating as the rating category for that particular sub-index) from 20 home equity (i.e., subprime) deals, with each deal represented once in each sub-index. A new set of ABX.HE indices is launched every six months on January 19 and July 19, referred to as "Roll Dates." Closing mid-market prices are published daily for each set of ABX.HE indices. The administrator for the indices, Markit, employs a filtering process similar to that used by the British Banker's Association to calculate LIBOR. This entails taking the quotes received, discarding those in the top and bottom quartiles, then calculating an arithmetic mean of the remainder.[12] The key innovation in this product design is the "pay as you go" (PAUG) CDS to deal with the unique issues associated with credit events when dealing with CDS backed by residential real-estate loans.

Turning to commercial properties, for CMBS there is a synthetic index that can be used for hedging. CMBX is a synthetic family of indices, each index referencing a basket of 25 of the most recently issued CMBS tranches, sorted by rating class. It is a similar type of index to corporate CDS indices such as the CDX. Hence, the CMBX indices are rolled into a new "on-the-run" series twice a year with changes in the reference portfolio reflecting the current CMBS market. The payments follow the PAUG template. With the CMBX index investors can get synthetic risk exposure to a portfolio of CMBS. There have been five index series issued in

[11] Appropriately, the names of the five sub-indices are ABX.HE.AAA, ABX.HE.AA, ABX.HE.A, ABX.HE.BBB, and ABX.HE.BBB–.
[12] To calculate the official fixing value for a particular sub-index, the administrator must receive closing mid-market prices from the greater of (1) 50% of ABX.HE contributors, or (2*)* five ABX.HE contributors. If, on any date, the administrator receives fewer closing prices for a sub-index than the minimum fixing number, no fixing number is published for that date.

the market,[13] each index with seven tranches containing bonds rated AAA, AJ[14], AA, A, BBB, BBB-, and BB, respectively. To be included in the CMBX index, a reference CMBS must have a minimum size of $700 million, secured by at least 50 separate mortgages that are obligations of at least 10 unaffiliated borrowers, the underlying mortgages must have no more than 40% of the properties in the same state, and no more than 60% of the properties can be of the same property type.

With respect to interest rate risk, dealers holding inventory for whole loans waiting to be securitized or securitized products held in inventory, as well as asset managers, are exposed to interest rate risk linked to the amortization of mortgage loan portfolio dynamics. The amortization is stochastic and is driven mainly by prepayment and default speeds. As a response to this type of hedging problem, a set of financial instruments linked indirectly to real-estate risk drivers appeared in the market: structured swaps. These swaps have been used by building societies in the United Kingdom and ABS desks in major investment banks to hedge interest rate exposure on mortgage loan portfolios.

There are three types of structured swaps: (1) a balance guaranteed swap, (2) a cross-currency balance guaranteed swap, and (3) a balance guaranteed LIBOR-base rate swap. In a balance guaranteed swap, the collected coupons on a collateral portfolio of mortgage loans are exchanged for a reference LIBOR plus a spread. The notional is the total balance of surviving loans for the period. It is a complex swap because the notional is stochastic, being determined by the amount of prepayments, defaults, and arrears in the reference portfolio. The total coupon paid on an exchange date is also stochastic and, even if the notional was known, because of the different possible mixture of loans surviving in the reference portfolio, the coupon could differ for the same notional. The typical structure for a balance guaranteed

[13] The CMBX Series 6 originally planned for October 25, 2008, was postponed because of the lack of new issuance since the CMBX 5 launch. This issue will be revisited on April 27, 2009.

[14] The AJ tranche is the most subordinate of the AAA rated tranches. It has been added to CMBX in order to help institutional investors seeking exposure to an additional credit class.

swap[15] is shown in Exhibit 1. This swap became part of the securitization process because it use was mandated by rating agencies in order to hedge the interest rate risk mismatch between fixed coupons collectable from mortgage loans and floating coupon payments that have to be paid post securitization to investors. (Given the large volume of RMBS deals between 2005 and 2007, one can envisage that there are many institutions holding many positions in this type of swap.) A balanced guaranteed swap is not an instrument to hedge prepayment risk or default risk because it does not guarantee the balance of the reference pool; on the contrary, it is exposed to these two risks. The underwriter of a balance guaranteed swap is exposed to the amortization speed on the reference mortgage loan portfolio.

INSERT EXHIBIT 1 HERE

A cross-currency balance guaranteed swap is a more complex swap product that deals with cross-currency deals whereby the coupons on one leg of the swap and also the notional are determined in a foreign currency. This swap deals with an extra level of risk through its foreign-exchange exposure. All characteristics described above for a balance guarantee swap still apply but the notional is stochastic and in a different currency. One subtlety with this product is that it also has embedded some macroeconomic risk of the country where the obligors reside. This risk may resurface even if there are no changes in the currencies specified in the swap. For example, the ebbs and flows of the political and social environment in the borrowers' country may cause job losses or price inflation that may trigger in turn high default rates in the collateral portfolio.

[15] There are many problems related to the design of the balance guaranteed swap. One problem is that the collateral coupon leg is paid in arrears since mortgage payments are collected every day in the period. The tenor may also differ from deal to deal, the monthly one being more common because this is also the frequency of mortgage payments and consequently the calculation of defaults and prepayments. Quarterly is also used in the market on occasion. Since the usual reference floating rate is three-month LIBOR, there is a basis between three-month LIBOR collected monthly from the swap and three-month LIBOR paid quarterly to the investors. When the reference rate is one-month LIBOR there would be a basis too.

To understand our next swap — a balance guaranteed LIBOR-base rate swap — we need to review the linkages between the official base rate and the standard variable rate charged on mortgage accounts by lending banks. The official base rate is the rate at which the Bank of England lends to other financial institutions. The Bank of England's Monetary Policy Committee meets every month to determine what needs to be done in response to economic conditions. While the official base rate plays a very important role in these markets, banks have the freedom to use a different rate on their loans, which is the standard variable rate. The standard variable rate is linked directly to the official bank rate, but it is usually a little higher, reflecting factors such as the real rate at which they borrow from each other, the business costs associated with lending operations, the volume and maturity profile of loans, and the funding arrangements. The standard variable rate is likely to vary from bank to bank and is used to determine the cash flows linked to RMBS. In the United States there are variable rate mortgages that lend themselves to hedging in the same way.

While a balance guaranteed swap is useful for converting fixed-rate coupons into LIBOR-based coupons, there are situations when the collateral pool for RMBS and CMBS, will contain loans that pay variable coupons determined by the variable rate established by the lender. The level of the variable rate is determined by the lending bank in relation to both the base rate determined by the national or federal banks and other funding costs driven by LIBOR-swap rates. In general, the basis between the standard variable rate (or its proxy the official base rate), and LIBOR is almost constant and not very large during periods of low volatility of interest rates. However, in turbulent periods, such as the subprime crisis of 2008, the basis between the standard variable rate and LIBOR may increase dramatically. Mortgage traders therefore employ our third swap, a balance guaranteed LIBOR-base rate swap, to hedge this basis risk. One leg of the swap pays LIBOR plus a spread while the other leg pays the average official base rate during the period. For this type of swap, the LIBOR leg pays the coupon fixed at the beginning of the period but the official base rate leg payment is fixed at the end of the period. For practical market purposes, the notional can be any value within a pre-specified band. The buyer has the right to choose the size of the notional at the beginning of each period. This is a difficult economic decision as only the LIBOR coupon is known.

PRICING AND HEDGING ISSUES RELATED TO REAL ESTATE DERIVATIVES

Derivatives require homogeneity of the underlying for establishing liquidity in their trading. The lack of homogeneity in real-estate markets was one of the main obstacles to the development of property derivatives. The securitization mechanism, on the other hand, has brought a wider participation in these markets and an increased demand for hedging tools.

Case and Shiller [1989, 1990] point out that the housing market in the United States is inefficient due to serial correlation and inertia in housing prices, as well as in the excess returns. A possible explanation has been offered by Case, Quigley, and Shiller [2004] who argue that the price expectation of the majority of market participants is backward looking. The real-estate literature suggests that repeat-sales indices have three main characteristics: (1) they are not subject to the noise caused by a change in the mix of sales, (2) they are highly autocorrelated, and (3) they are predictable with a forecast R-squared roughly 50% at a one-year horizon. The hedonic indices are subject to model risk stemming from the multivariate regressions used to build those indices. The factors employed in hedonic regressions are those characteristics of properties that have been historically found to explain housing prices. The methods associated with hedonic indices inherit all the common problems known for regression analysis, namely spurious regression, multi-collinearity, and model selection.

When pricing or hedging various instruments, it should be remembered that short sales of real-estate properties is impossible and trading may not be feasible for fractional units. These unique characteristics of real-estate properties have profound implications regarding valuation principles. Applying the Black-Scholes framework to a market where the underlying assets have these characteristics would be inappropriate. Moreover, the predictability in housing prices makes it difficult to establish hedging procedures. However, one may argue that a well-established futures market may feed information into current prices and some balance can be achieved with a dual information transmission mechanism.

Given the characteristics of real-estate markets, the valuation of property derivatives is not straightforward. Neither is the pricing of credit-type instruments such as single-name ABS credit default swaps (ABCDS), ABS credit default swap indices (ABX.HE), or ABS CDOs, nor the new cash-flow driven hedging swaps such as balance guaranteed swaps or LIBOR-base rate swap discussed earlier.

The finance literature in this area is quite sparse and the models proposed are dichotomized into no-arbitrage models and equilibrium models.[16] No-arbitrage models focus on the relationship between a real-estate variable and an interest rate.[17] They also allow the calculation of counterparty risk, a very important consideration after the subprime mortgage crisis. Under the no-arbitrage framework, it can be demonstrated that the spread over a market interest rate such as LIBOR that a total-return swap payer must charge is highly dependent on the volatility of the reference index returns and on counterparty risk, with higher volatility of returns and counterparty risk implying a higher spread over market interest rate.[18]

The no-arbitrage argument is difficult to apply because of the impossibility of short selling and the non-homogeneity of the property as an asset. Moreover, the underlying index

[16] Geltner and Fisher [2007] describe the major ideas related to equilibrium modeling in real estate.
[17] Titman and Torous [1989], Buttimer, Kau, and Slawson [1997], Bjork and Clapham [2002] and Ciurlia and Gheno [2008] provide models using the no-arbitrage framework with complete markets models. Otaka and Kawaguchi [2002] take a step further and develop a model for incomplete markets that consists of a security market where stocks, bonds, currencies, and derivative securities that are traded without friction, a space market with the rents of buildings, and a property market where the prices of real properties are determined.
[18] See Patel and Pereira [2006] for a more detailed discussion.

is only an observable variable and not an asset that could be traded freely without any frictions, although real estate portfolios mimicking exactly the index are a possibility for a distinct class of investors. The new generation of products dependent on real-estate risks cannot be priced in a risk-neutral framework either. This is due to the relationship between interest rate risk along the term structure of interest rates and the risk triggers in RMBS space such as defaults, prepayments, and arrears. Hence, a real-world measure approach based on statistical calibration of historical data is required for pricing real-estate derivatives. A new method focused on the market price of risk as a modeling tool has been proposed by Fabozzi and Tunaru [2009]. Their models take into consideration the mean-reversion to a nonlinear long-run trend of real-estate indices.

Property derivatives markets are incomplete because the primary asset underpinning this market suffers from lack of homogeneity.[19] However, similar properties in close geographical proximity should have similar prices. This high correlation is helpful for cross-hedging spot real-estate portfolios with futures on local indices. Nevertheless, the lack of homogeneity implies that hedging with real-estate derivatives is always going to be less than perfect.[20]

An important characteristic to account for when modeling a real-estate underlying index is reversion to a long-run trend. Similar to commodity markets where the underlying asset is a consumption asset, the supply and demand forces on real-estate markets drive real-estate prices in a different way than a stock financial index.

Let $\{X_t\}_{t\geq 0}$ be a stochastic process representing a real-estate index. Then consider the process on the log-scale $Y_t = \ln(X_t)$. In Exhibit 2, the monthly series of the Case-Shiller Home Price Composite-10 Index is displayed on the log scale. There is a clear linear time

[19] Black [1986] emphasizes that for the smooth functionality of derivatives, a homogeneous underlying asset is helpful.

[20] Real-estate traders managing portfolios with assets worth individually a large amount of money have extra exposure to idiosyncratic risk that cannot be hedged away easily with property derivatives. See Baum [1991].

trend for this data series. The same can be said for the IPD UK Monthly Index[21] since 1986 as illustrated in Exhibit 3 using a log-scale and for the Halifax House Price Index in Exhibit 4 based on a quarterly historical series. For all indices, the log-index series fluctuates around a positive linear time trend and any model for pricing real-estate derivatives on these indices should account for this statistical property.

INSERT EXHIBIT 2 HERE

INSERT EXHIBIT 3 HERE

INSERT EXHIBIT 4 HERE

Therefore, we can assume that $\{Y_t\}_{t\geq 0}$ is a process that is mean reverting towards a deterministic linear trend. In other words, the log-index is the sum of a zero-mean stationary autoregressive Gaussian process and a deterministic linear trend. One could also fit nonlinear trends if necessary. It is possible then to calculate the solution of this equation in closed form which can be useful for pricing derivatives. Hence, a real-estate index can be modeled with a geometric Ornstein-Uhlenbeck process that always ensures positive levels. Because the real-estate market is incomplete, for pricing purposes one needs to specify exogenously the market price of risk. For example, an equilibrium model could be used to determine the forward price on an index and then the market price of risk inferred from there can be used to price other derivatives contingent on the same index.

The same methodology can be applied using a two-factor model where the de-trended log-index and a representative interest rate $(Y_t - \alpha - \beta t, r_t)$ are jointly normally distributed. The marginal distribution of $Y_t - \alpha - \beta t$ is therefore Gaussian and consequently the distribution of real-estate index X_t is log-normal. The bivariate process $(Y_t - \alpha - \beta t, r_t)$ has

[21] The IPD Monthly Index is based on an open market appraised valuations of real buildings and it covered 3,700 properties worth around £47 billion in September 2006. It includes commercial and other investment properties representing more than 90% of the combined value of the property assets held in UK unit trusts and other unit linked property investment funds.

three econometric characteristics that make it suitable for modeling a real-estate index: (1) it is trend stationary (i.e, the log-index may vary around a time trend); (2) the variance of index returns does not grow indefinitely with time, and; (3) the model implies autocorrelations that can be positive or negative.[22]

It is critical to be able to model real-estate indices as close as possible to reality since many mortgage-related securities are marked to model in the absence of a liquid market. A large bias in forecasting future levels of a real-estate index will be reflected say, in marking the profit and loss position of a real-estate position, and this could be extremely detrimental to banks holding positions in these securities.

SUMMARY

In this paper, we review the role of property derivatives and discuss the instruments available. Mortgage-backed securities require specialized interest hedging tools capable of handling the embedded prepayment and default risk. Given the special characteristics associated with the real-estate asset class, we emphasize the main points to be taken into account when pricing property derivatives, this being a typical situation of incomplete markets.

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[22] Detailed calculations of autocorrelations are provided in Lo and Wang [1995]. The capability of a model to reproduce a wide range of autocorrelations is important because then it is possible to match the empirical findings in Fama and French [1988a, 1988b] and Lo and Mackinlay [1988], that equity portfolios are positively autocorrelated at shorter horizons and negatively correlated at longer horizons.

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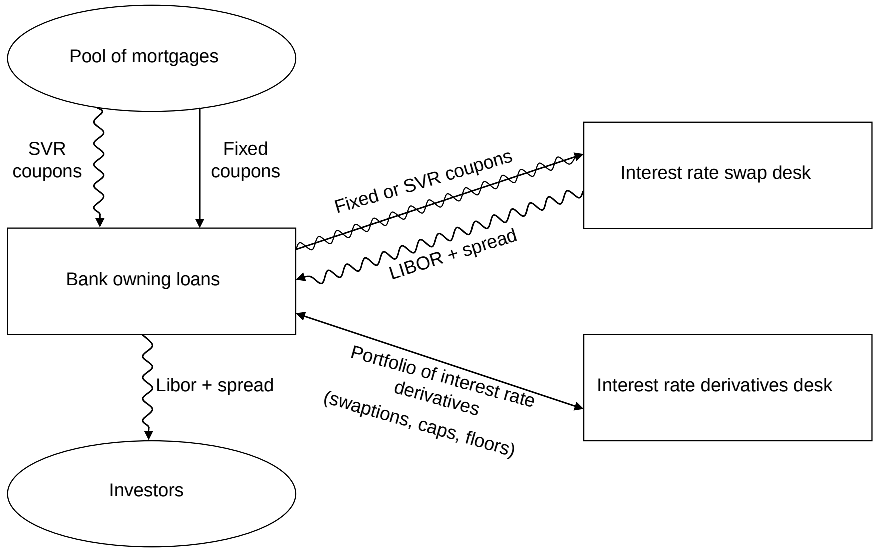

Exhibit 1. The main components affecting a balance guaranteed swap linked to a portfolio of mortgage loans. The SVR is the standard variable rate that banks charge their mortgage borrowers when their mortgage switches from fixed the floating. It is driven by the official base rate but its exact value is at the discretion of the bank.

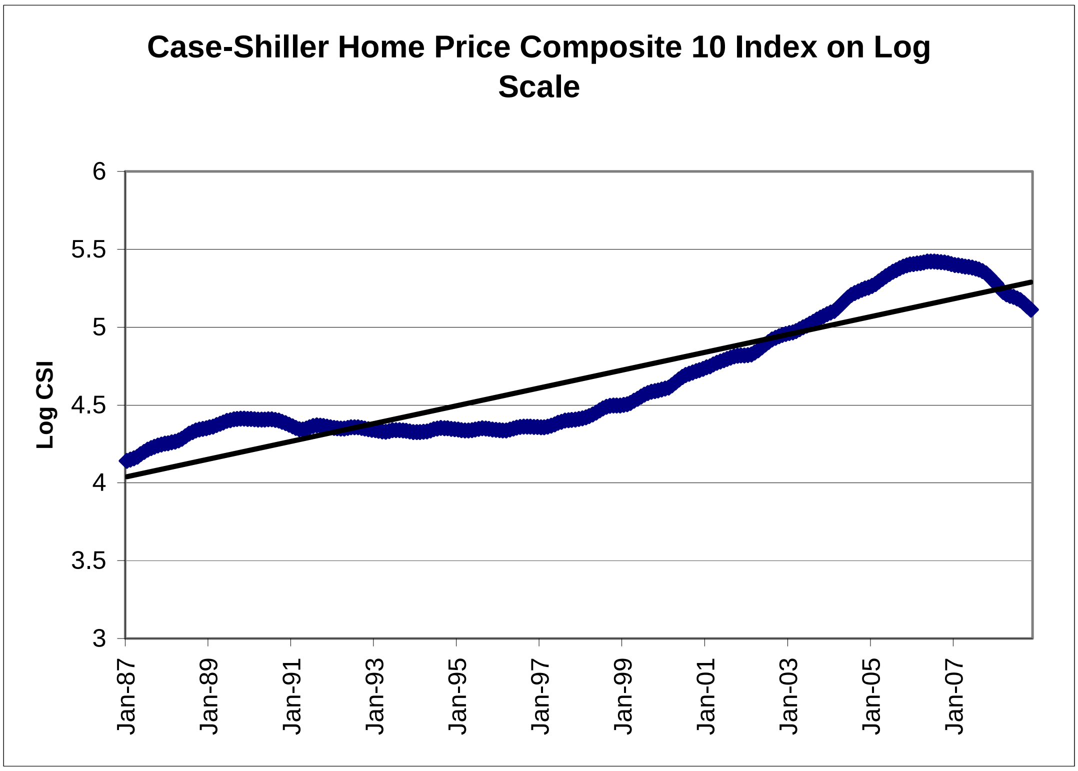

Exhibit 2. Historical monthly data of Case-Shiller Home Price Composite 10 Index, monthly on the log scale. The series displays a linear time trend.

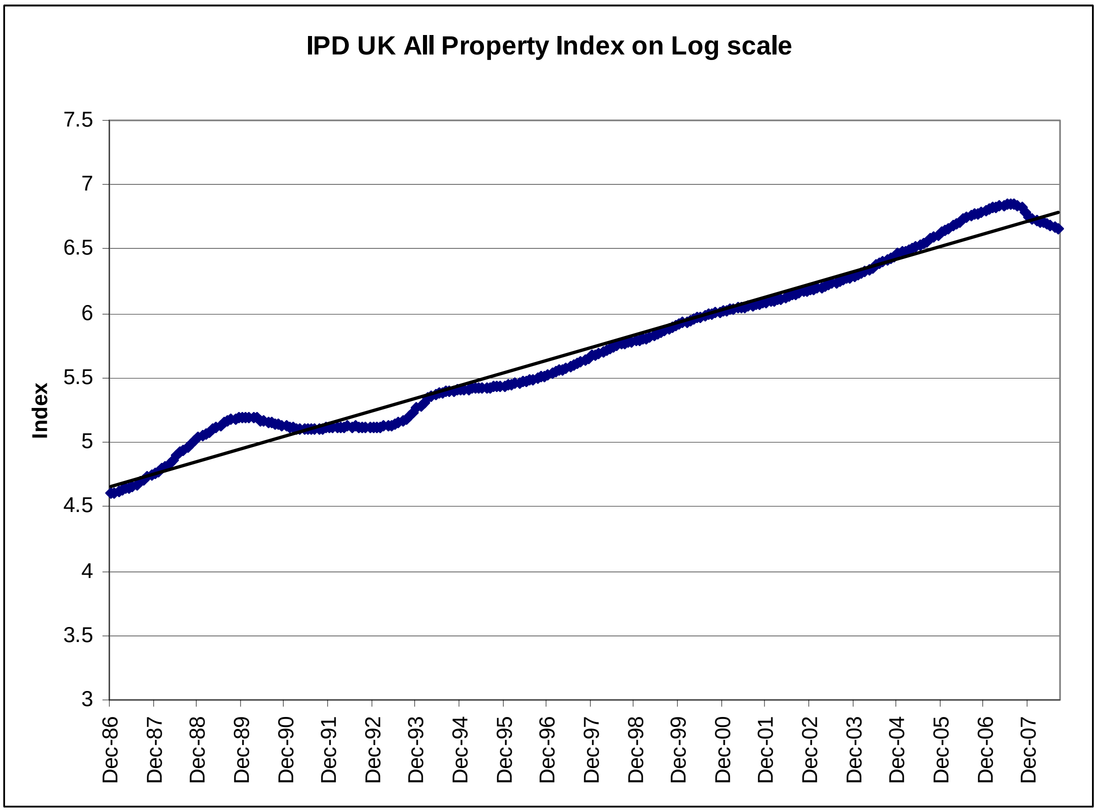

Exhibit 3. Historical monthly data of IPD UK Monthly Index on the log scale. The series displays a linear time trend.

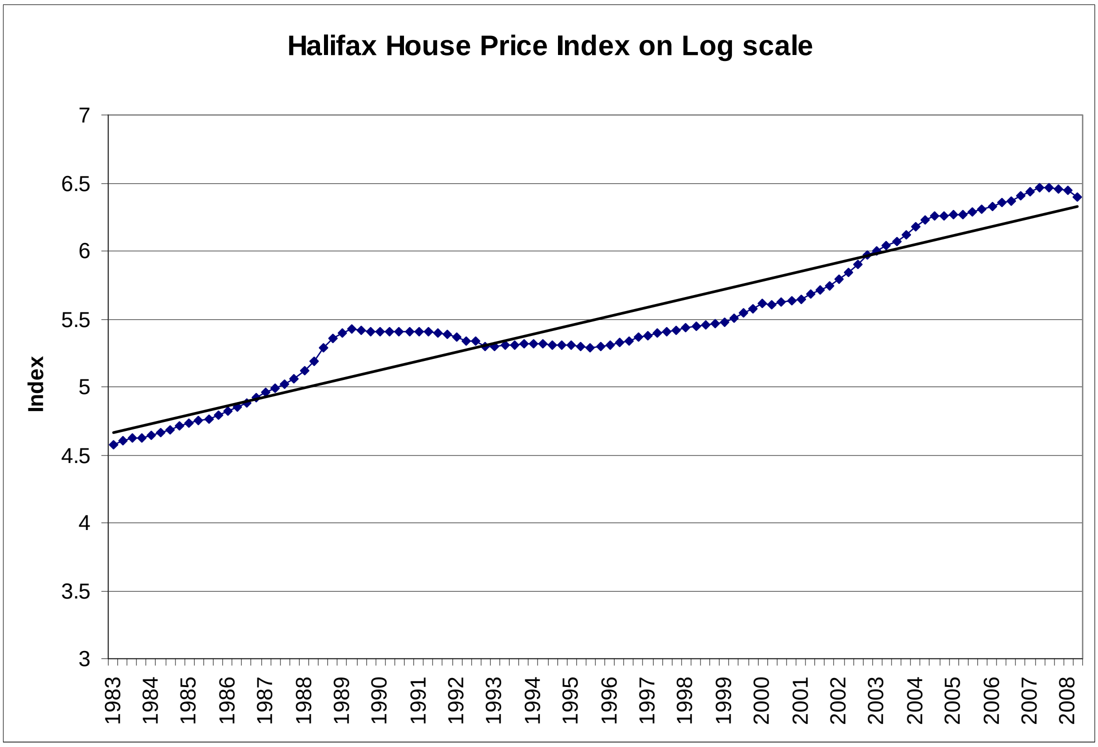

Exhibit 4. Historical quarterly data of Halifax House Price Index (HHPI) on the log scale.