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Introduction of Derivatives on Residential Real-Estate in the UK

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Introduction

Derivatives markets have enjoyed huge increases in turnover recently and at the same time UK housing-wealth and house-leverage has risen to new highs driven by returns not seen by similarly-sized asset-classes. Nevertheless, the combination of both, residential real-estate derivatives-markets, have not been successful despite clear arguments for such markets and their likely substantial beneficial economic impact.

Property derivatives have been launched before, some of which still exist. However, the only trial which most closely resembles the market envisaged here failed due to lack of interest in 1991. Several things have moved on since, not just house-prices, and important lessons can be learnt to make the product successful.

Analysing these case-studies and the unique house-market characteristics as well as the likely market-participants and their motivations, this paper argues that exchange-traded futures and options with contract specifications close to those of standard commodity derivatives, probably with longer maturities of up to 2 years, would most likely succeed and would be most beneficial. Candidates for underyling instruments are existing UK house-price indices with the largest data-base and the smallest data-bias, published by independent vendors.

Pricing of the derivatives is not trivial mainly because of the inability to trade the underyling, an average UK house. Little literature exists and the only specific valuation-model developed for house-price options is of doubtful value. Therefore, three theoretically robust approaches are shown, the Cox/Ross framework using the market-price of risk, Huang/Litzenberger's equilibrium model and valuation in the Merton investment-model via a traded-asset which is correlated with the non-traded underlying. All three have some practical drawbacks, solutions of which are discussed.

Finally, the economic impact is analysed. While risk-sharing by households and mortgage-banks, as well as price-finding and its influence on house-market efficiency are obvious benefits, business-cycles could be reduced due to the stabilising effect on consumption and construction-expenditure. At the same time, social risks and opportunities exist.

1. The UK house-market

1.1 Importance

The house-market is substantial and important for the UK economy, not just as a transmission mechanism from monetary-policy to consumption, but also as an asset class and, importantly, as a risk to the financial system.

In 2001, total gross personal house-wealth in the UK was £2,117bn(214% of GDP), of which £1,525bn was net-equity(154% of 2001 GDP)[1]. This compares to a total market-capitalisation of UK domestic equities on the London Stock Exchange of currently £1,580bn(136% of 2004 GDP) and the amount of outstanding gilts of £355.5bn(31% of 2004 GDP). There were 1.3mn house-transactions with a total value of £135bn in 2001 compared with £1,218bn in domestic equities and £1,061bn in gilts. Net-equity withdrawal from houses amounted to £25.9bn in 2001, accounting for 4.1% of consumer-spending. Of the 5.5% nominal increase in consumer-spending in 2001, a third was due to the increase in net-equity withdrawal, which almost doubled that year.

Worrying is the amount of outstanding debt and household-leverage. The house-loans/house-equity ratio has increased to 39% in 2001, higher than 1990(34.7%) but off its peak after the last house-market bust in 1993-1994(48-50%). For households which took out building-society advances in 2001 leverage reached 2:1. For first-time buyers it reached 4:1. A 20% decrease in house-prices would wipe out their entire equity.

As an asset-class residential property is not just attractive due to its size, but because its returns are uncorrelated with equities. Substantial diversification effects can be expected from adding residential property to multi-asset portfolios, reducing risk/enhancing returns(Pagliari/Webb/Canter/Lieblich,1997)

1.2 Characteristics

The house-market has largely been closed to institutional investors with the exception of few small investment-trusts. Partly responsible are the market characteristics, in particular the nature of transactions and the type of contracting,

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[1] Source for all figures for the housing market: Housing Review 2002/2003, Chartered Institute of Housing

which make it unique among commodity-markets(Gemmill,1990). Millions of participants put a large part of their wealth into one single asset, often with high leverage. Participants trade infrequently, sometimes only once in their life. The asset is very inhomogeneous and is traded in an intransparent market in which no single market-price exists.

Owner-occupiers, the majority of participants, perceive the asset as a hybrid between financial asset and consumption-good. Valuation by buyers/sellers is not just equal to financial value, but also includes personal and emotional factors(Alhashimi/Dwyer,2004). The market is not competitive and while demand can change quickly, supply is fixed in the short-term causing price-cyclicality(Chinloy,1996). Buyers and sellers have pricing-power because they trade by negotiation rather than at arms' length in thin local markets, not a national market. Information is asymmetric, transactions interdependent because of simultaneous buying/selling(trading-up), and substantial transaction costs prevent free entry and exit. Participants' price expectations are backward-looking(Case/Quigley/Shiller,2003).

It is consequently not a surprise that Case/Shiller(1989,1990) find positive serial-correlation as well as inertia in house-prices and excess returns. They show that prices can be forecasted and conclude that "the market for single-family homes [in the US] is inefficient"(Case/Shiller,1989). A similar regression has been run here for UK data confirming these findings.[2]

[2] See section 7.1

2. Case-studies of existing/previous real-estate derivatives

Before dealing with the theoretical details of house-price derivatives, case-studies of previous/existing real-estate derivatives both in the UK and globally are discussed to gain insights into the practical issues involved in launching such products and the relative merits of exchange-traded contracts vs. OTC-issues.

While the only ever exchange-traded house-price derivatives failed, the currently listed contracts in the UK, covered warrants and spread-bets, are retail products only and are not suitable at all for institutional-investors. OTC-derivatives on UK commercial property exist and derivatives on REITs indices have been launched in Australia and the US. However, both have substantial drawbacks.

2.1 FOX Residential Property Futures

The so far largest trial of house-price derivatives was the listing of futures based on the Nationwide house-price index on the London Futures and Options Exchange(FOX, now merged into Euronext-LIFFE) in 1991, together with three other futures based on commercial property capital and rent indices, and on mortgage interest rates. The introduction coincided with a collapse in UK house-prices and trading was suspended only 6 months after launch due to insignificant turnover leading to misleading prices being quoted. All four futures were cash-settled and had four expiry-dates per year.

One of the reasons for failure was that FOX did not have a clear marketing campaign for the products and little was spent on investor-education. This however is essential to attract interest and sufficient turnover. Market participants where unfamiliar with the contracts, which were very different from existing derivatives. The products were complex, traders were unable to price them and the fact that four contracts were launched at the same time split attention.

Institutional investors have up to then ignored the residential property-market because of its mentioned shortcomings. The Nationwide-index was not being followed by the City. This has certainly changed after the property crash in 1991-1992 and house-prices are now considered major economic indicators in the UK. In

1991, property portfolio managers and real-estate companies did not know enough about derivatives to be comfortable trading them.[3]

Case/Shiller/Weiss(1993) note that to their knowledge no intermediary started to develop retail products based on these futures. This however, as shown in chapter 4, is crucial in order to attract turnover for house-price futures given that most participants in the cash-market are private home-owners.

Roche(1995) adds further reasons:

- Mismatch between cash-position and property-index, therefore limited use as hedging-instrument
- Limited interest in hedging due to little perceived risk in property
- One-sided market-expectations
- Only monthly updating of the index
- Limited use for arbitrage
- High risk due to long contract durations(up to 3 years)
- Recession and technical problems

Patel(1994) argues that the failure of the FOX property future was partly due to the problems in the index-construction causing lag dependence, and partly due to cash-market illiquidity which caused substantial time basis-risk.

2.2 Barclays Property Index Forwards and Certificates

Only several years after the failure of the FOX contracts, Barclays started issuing its Property Index-Certificates in 1994 and Property Index-Forwards in 1996. Both exist to date and are somewhat successful, though comprise commercial UK property only. The contracts are over-the-counter issues based on the Investment Property Databank(IPD) Total-Return and IPD Capital-Growth indices, respectively, with maturities of 3-4 years. Up until mid-2004, less than £2bn of the two contracts have been issued in the UK by Barclays jointly with Protego Real-Estate Investors, indicating that the market remains very thin.[4] All contracts are based on the all-property IPD index thus far, but new issues are expected to be priced on sub-sector IPD indices in the future.[5]

[3] See also “BZW relaunches UK real estate derivatives” in Euromoney, January 1997
[4] Additionally, one contract was issued in Sweden jointly with Aberdeen Property Investors
[5] See Nabarro Property Edge, Issue 19, Summer 2005

2.3 Goldman Sachs Covered Warrants

In 2003, Goldman Sachs issued the first range of “covered warrants”(retail-options) based on the Halifax All-Houses All-Buyers seasonally-adjusted index on the London Stock Exchange(LSE). The current issue expires in August 2006 and is made up of 20mn securities each of three European calls and three European puts with different strike-prices. As table 1 shows, one of the calls has a zero strike-price and one put has a strike of almost double the current index-value. Both mirror a futures contract’s payoff without the leverage. In order to make the securities attractive for retail investors, all contracts have a denomination of 100,000:1.[6]

No turnover-data is published, but trading is thin given that the spreads for at-the-money options are 5-9% of the bid-price compared with about 1% for the most active GS covered-warrants on the FTSE100 and NASDAQ100. Spreads for the far in-the-money options are 1% compared with 2bps for the corresponding FTSE100 securities. According to LSE rules, issuers have to maintain liquidity of 10,000 contracts for bid/ask throughout the trading day, which is small given the contract’s denomination.

Table 1: Current market-prices for the GS covered-warrants

Prices as of 15/7/2005, last available price of the underlying:£162,605(Jun-05),source:GS

	Style	Strike (£)	Expiry	Bid (p)	Ask (p)	Leverage	Impl. Vola. Ask	Spread % of bid price.
G894	Call	-	Aug. 06	157.25	159.25	1.00	121.3%	1.3%
G899	Put	140,000	Aug. 06	7.90	8.70	3.33	31.9%	9.2%
G895	Call	160,000	Aug. 06	15.40	16.20	6.39	19.3%	4.9%
G898	Put	160,000	Aug. 06	12.80	13.60	3.67	26.5%	5.9%
G896	Call	180,000	Aug. 06	9.60	10.40	6.23	23.2%	7.7%
G897	Put	300,000	Aug. 06	139.00	141.00	0.75	64.8%	1.4%

It is not clear how GS hedges its positions other than crudely using interest-rate derivatives. The two futures-like contracts offset each other if issued in same quantities. For the other securities, GS is the seller of a straddle when looking at them in pairs. Therefore GS effectively sells volatility earning the option-premia if the index remains relatively stable plus any profits from market-making.

[6] Buying 100,000 securities gives the full exposure to the average UK house

All contracts are automatically executed on expiry. They are cash-settled and holders are not liable to UK stamp duty.

2.4 Spread Betting

Spread betting on house-prices was first introduced by City Index, though the company has suspended trading. Spreads were based on the Land Registry figures, which are simple averages of all property transactions completed in the previous quarter. The figures are not mix-adjusted and seemed to exhibit seasonality with prices staying constant in some quarters while always rising in others. These limitations meant that the index trend was at times detached from the perceived price-trend.

IG Index offers spreads on national and regional house-prices using the Halifax monthly seasonally-adjusted national index and 12 quarterly regional indices. Expiry is quarterly and the next four quarters are available for trading. The products have been somewhat successful given that the broker had to suspend trading on from September-2004 to April-2005 because its internal exposure-limit was reached after substantial betting on house-price declines in autumn-2004. The company does not seem to be hedging its exposure fully. As with all spread-bets, gains are tax-exempt.

2.5 Other trials globally

Two Australian exchanges offer property-futures, both based on property trust indices. The Australian Stock Exchange listed its ASX Property-Trust futures based on the S&P/ASX200 Listed Property-Trust index in 2002, while the Sydney Futures Exchange introduced futures based on the Dow Jones Australia Listed Property-Trust index in June 2005.

The obvious advantage of the two contracts is the tradability of the underlying instruments, eliminating one of the major problems of other property-futures. The S&P index is based on 23 constituents and has a market capitalisation of A$77bn while the Dow Jones index focuses on the 15 most liquid trusts. On the ASX, only the nearest expiry seems to be traded actively.

Similarly, the CBOT has listed options based on the Dow Jones Equity REIT index, which has a market capitalisation of almost $300bn.

HedgeStreet, a US online-broker, introduced so-called Hedgelets in October-2004 which are very similar to UK spread-bets. HedgeStreet allows bets on house-prices in six metropolitan areas based on the Median Sales-Prices of Existing Single-Family Homes released quarterly.

3. Conditions for success

From the discussion in the previous chapter and theoretical arguments(e.g. Black,1986) conditions for successful property-derivatives markets can be derived, which are assessed here with respect to the UK housing-market.

3.1 Cash-market

Size/liquidity

A large, liquid cash-market is of vital importance for the success of derivatives market(Black,1986). With larger cash-markets more participants are likely to have an interest in hedging and speculation, the main motives for derivatives trading. Liquidity/market-depth is relevant because the actual tradable proportion of the market has to be taken into account. This is the case particularly for real-estate markets(see section 1.1): the UK house-market traded 6.4% of its value in 2001, while the equity-market traded 82.8% of its market-capitalisation last year.

The UK house-market is certainly large enough to support a derivatives market considering its size relative to that of the UK equities and gilts, though doubts remain about its liquidity(Gemmill,1990). No definite cut-off for liquidity exists obviously and derivatives have been established successfully on narrow indices and single stocks with much smaller liquidity.[7]

Buyers/sellers in same quantity

Derivatives-markets are successful if a diversity of opinion exists such that a sufficient number of buyers and sellers want to trade creating a liquid market(Geltner,Miller,Snavely,1995). Therefore, the contracts need to be relevant and appealing to potential users(Patel,1994). In a one-sided market risk-tolerant investors are attracted as counterparties by the price, similar to insurance markets.

There are many natural sellers of UK house-price exposure: mortgage banks, construction companies, estate agents and home-owners. However, it is unclear whether sufficient natural interest exists for buying house-price exposure. Aspiring house-buyers and people currently involved in house-buying will seek exposure, but are probably not significant. Asset managers, real-estate investors, pension-funds

[7] see e.g. Euronext LIFFE press release 8.5.2003

and life-companies could be more important. Some hurdles remain for their involvement, e.g. the unfamiliarity of real-estate funds with derivatives and the unfamiliarity of traditional asset-managers with residential real-estate, but legal obstacles have been removed. In 2003 the FSA has overturned a rule preventing life-companies from trading property-derivatives.[8] The letter to the FSA by the Property-Derivatives Users-Association supporting a favourable ruling was backed by life-companies with total assets of £40bn, which shows their substantial interest.

Unpredictable returns

The difficulty of finding buyers and sellers in sufficient quantities is related to the question of predictability of returns. Ideally, returns of a derivative's underlying should be unpredictable creating a need for hedging. Changes in market-prices can only be perceived as risky if price-fluctuations happen unexpectedly(Carlton,1984). If returns show clear trends at certain points in time, it will be difficult to find market-participants willing to take positions against the trend, other than risk-tolerant traders attracted by price.

As argued in chapter 1, the house-market is generally seen as inefficient with its returns exhibiting serial correlation. The increased involvement of institutional investors and speculators through a traded derivatives market could make prices less trending and the market more efficient. However, a substantial initial hurdle remains until enough liquidity is reached.

Volatility

Cash-market volatility is important because it creates the need for hedging and attracts speculators supplying vital liquidity(Black,1986).

It is often argued that house-markets are attractive investments just because prices are not very volatile. This makes it unattractive for short-term investors, in particular speculators providing liquidity(Geltner/Miller/Snavely,1995). Using the Nationwide house-price index as a proxy, volatility of the UK house-price returns was 1.7%(3-months) and 6.7%(12-months) in the most recent periods. This compares with the volatility of the FTSE100 of 9.3%(1-month) and 8.9%(12-months).

[8] They are now allowed to trade in regulated markets or off-market with approved counterparties if the derivatives are held for 'efficient portfolio management' or 'reduction of investment risk' and the position is covered such that any payment requirements can be met.

There seems to be a positive, but insignificant relationship between volatility of the underlying and futures-contract turnover. Fluctuations in volatility coincide with fluctuations in futures-turnover, but the absolute turnover cannot be explained by the volatility of the underyling(Holland,Fremault Vila,1997).

Homogenous underlying

Homogeneity of the underlying asset is beneficial for derivatives because it makes settlement easier by removing uncertainty regarding the quality of the asset delivered under the contract(Black,1986). It makes the contract more attractive and relevant for different market-participants(Garbade,Silber,1983).

Futures have been issued on inhomogeneous assets and notional underlyings, such as 10-year government debt, with pricing based on the cheapest-to-deliver(CTD) asset from a range of admissible assets. This is impossible with residential real-estate given that the asset cannot be objectively valued, and so no CTD can be specified. Instead, the contract would have to be cash-settled like index-derivatives.

A homogeneous underlying makes derivatives more relevant for traders. Close correlation between different types of the underlying, in this case for example house-prices in different regions, means that the contract can be used for hedging even though there is no exact match between a specific cash-market exposure and derivative(Carlton,1984). Given its inhomogeneity, derivatives on residential real-estate provide an imperfect hedge and they are inadequate as hedging instruments for portfolios with a high amount of specific/unsystematic risk, which probably applies to most investors in residential real-estate(Baum,1991).

Arbitrage

Closely connected is the issue of arbitrage. The more homogeneous the underlying asset, the easier it is to perform arbitrage between cash and derivatives-market. Clearly, arbitrage is not possible in the case of residential real-estate derivatives given the average UK-home cannot be replicated[9]. An exception to this would be using swaps on the return of residential property-portfolios for arbitrage, or having derivatives based on listed residential-property companies that are sufficiently

[9] Trying to replicate the average home would involve substantial transaction costs and time-risk (due to long completion times of transactions in the house-market), and it would exclude owner-occupied houses, 69% of the UK house market.

diversified. This is not feasible in the UK, however, given the small capitalisation of this sector.[10] Arbitrage is relevant because traditional pricing models for derivatives rely on continuous arbitrage and because arbitrageurs provide important liquidity. The former can be solved theoretically(see chapter 7) or practically by speculators which provide a much looser link between cash-prices and derivative.

Alternative hedging instruments

Gemmill(1990) shows that an important success-factor for new derivatives is the absence of alternative hedging-instruments. He argues that this is the case for the UK housing-market, ignoring imperfect instruments such as interest rate derivatives. There have been plans by MPs to offer insurance schemes for home-owners, but these have never been realised. Leaving the differences in underlyings aside, OTC contracts such as Barclays' PIFs/PICs are not substitutes for traded property-futures given the counterparty risk for OTC contacts and their non-standardised nature.

3.2 Underlying instruments

Independent provider

The price of the underlying has to be accepted by all market-participants, it has to be objectively verifiable and no one should be able to manipulate it. In the case of the UK house-market this means that in order to avoid conflicts-of-interest, none of the mortgage-banks' and building-societies' indices can be used, as they and their customers are expected to be major market-participants.

Tracking the cash-market

An index used as underlying should track the price-trend in the UK house-market closely, meaning that it has to cover as much of the market as possible. This poses several problems for the construction of the index(see chapter 5) and in particular makes several of the UK house-market indices unusable. Importantly, the index has to include all house-transactions not only those involving a mortgage. Cash-only transactions have become more significant and they concern different

[10] Grainger Trust, the largest listed residential property company in the UK has a market cap of only £500mn

price-segments. The average house-price for transactions involving a mortgage was £99,710 compared with the average house-price for all transactions of £112,867.[11]

Regional indices vs. liquidity

There is an obvious trade-off between introducing regional contracts and liquidity(e.g.Gemmill,1990). Having several contracts based on regional indices increases the relevance to hedgers and offers more flexibility to asset-managers, but splits liquidity between several contracts. Given that previous trials of property-derivatives failed due to iliquidity it is probably advisable to start with the introduction of national contracts.

Other requirements

As with other derivatives, the success of property-derivatives will also depend on the actual market structure, on having low transaction costs and a clearing-house guaranteeing the contracts. The latter rules out OTC markets in favour of exchange-traded markets, which is also supported by the need for high liquidity and central price-finding.[12]

[11] Source: Housing Review 2002/2003, Chartered Institute of Housing
[12] See section 8.2

4. Market-participants and their motivations

4.1 Market-participants

Home-owners

In 2001, 17mn UK households owned their own home(69% of all households) 11.5mn had mortgages, some involving substantial leverage.[13] 1.3mn houses changed owners in 2001 and more than 500,000 people bought a home for the first time.[14]

Highly leveraged home-owners could hedge their exposure to house-prices directly using property derivatives or indirectly buying insurance-contracts from intermediaries. Buyers and sellers of houses are exposed to price changes because transactions take long and initial agreements are non-binding. Tailored insurance contracts could help to hedge this risk, but in this case trading the derivatives directly would be inadequate due to their fixed(usually quarterly) expiry dates. Aspiring home owners could enter the property ladder cheaply by buying exposure to the house-market via options or futures, avoiding the risk of being priced-out.

Retail-customers

Retail customers wishing to speculate on house-prices are potential market-participants. They already provide most of the turnover in the GS covered warrants and the spread-bets, which are specifically tailored to them.

Intermediaries

Given the novelty of the house-price derivatives and households' unfamiliarity with financial derivatives, intermediaries have an important role in the property derivatives-market. It is probably unrealistic to expect households and retail-customers to trade derivatives directly. Intermediaries can re-package the derivatives and create products the customers are already familiar with, such as insurance contracts and GS-style retail options(Gemmill,1990 and Case,Shiller,Weiss,1993).

Importantly, insurance companies cannot diversify away the risk of exposure to the house-market when writing contracts for retail-customers, unlike life, health or

[13] See section 1.1
[14] Source: Housing Review 2002/2003, Chartered Institute of Housing

car insurances for example. Pooling the contracts would actually increase the risk, which then has to be hedged in derivatives-markets(Thomas,1996).

Mortgage-banks/building-societies

Net outstanding mortgages held by the 30 largest lenders amounted to £842bn(72.5% of GDP) in the UK in 2004 with 60% of the exposure concentrated among the top-5 lenders and 80% among the top-10.[15] So far there has been no instrument for hedging this substantial risk(Case/Shiller/Weiss/1993) except for passing on the returns in mortgage-backed securities. The Barclays PIC/PIF issues have been tiny relative to the total UK mortgage-book, though their increased issuance highlights the desire of institutions to sell real-estate exposure.

Asset-managers

In an environment of low bond-yields and equity-returns, the high returns of UK house-prices paired with their uncorrelatedness with equities and the use as an inflation-protection has attracted the interest of institutional-investors (Pagliari/Webb/Canter/Lieblich,1997).[16] It has been difficult for them to invest in the house-market for practical reasons(lack of suitable investment vehicles, management costs in case of direct investments) and legal reasons(liquidity requirements). This led to an exodus of institutions from the UK house-market with the average weighting of property declining to only 6-8%. Formerly significant investors such as Prudential and Norwich Union have sold most of their holdings.[17] A derivatives market can remove the obstacles by providing liquid contracts which can be traded quickly and cheaply.

Real-estate investors are so far not able to hedge their portfolio against declines in the general house-price level. Taking short-positions in national house-prices derivatives allows them to extract the specific returns (and risk) of their portfolio while being neutral to overall trends in the house-market.

Construction industry

Industries such as the oil industry, gold and silver mines and agricultural producers have long benefited from liquid derivatives markets in which they are able

[15] Source: Council of Mortgage Lenders Statistics, 2005
[16] On inflation-protection see e.g. Downs(1996) and Schofield(1996)
[17] See also Financial Times, 12.7.2005, "Residential: Institutional appetites are still hungry for houses and flats."

to hedge their exposure to future commodity-prices. The construction-industry would benefit equally by passing-on price-exposure in building-projects which take several years to complete, resulting in more planning-security and return-stability.

Market-makers

Market-makers are essential for the successful launch of any derivatives market because they continuously provide binding quotes and therefore liquidity at a time when only few market-participants trade on the market.

Arbitrageurs

Arbitrageurs usually enter the market at a later stage once some liquidity has been established. In the case of derivatives based on house-price indices, their role will be limited however until liquid and diversified residential REITs exist.[18]

4.2 Motives

Hedging

Hedging strategies try to eliminate price-risk by fixing the future transaction-price. If no perfect hedge is possible, basis-risk arises which is defined as the difference between futures-price and cash-price. A hedge creates cross-hedge basis-risk due to imperfect correlation between cash-asset and the futures' underlying and time-basis risk due to timing differences between cash-transaction and contract expiry(Patel,1994).

As Gemmill(1990) shows, cross-hedge basis-risk can be substantial for an investor's regional property-portfolio when using futures based on national UK house-price indices. A hedging strategy would reduce the risk of the portfolio by only 25-64% depending on the region. For individual house-owners the correlation with a regional index will be imperfect, increasing cross-hedge risk further.

Following Newbery/Stiglitz(1981), it is possible to calculate the maximum benefit(B) of risk-reduction for different correlations(r) between individual house-price and national house-prices according to

$$B \leq 0.5 r^2 C^2 RG$$

where C is the coefficient of variation of returns, R is the coefficient of relative risk-aversion and G is the average quarterly return. For the UK, Gemmill(1990)

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[18] See section 3.1

calculates risk-benefits of 1-8% of the average house-price depending on the region, assuming imperfect correlation between an individual's house-value and the regional index(R=3). This exceeds transaction costs in futures markets substantially.[19]

Diversification, asset allocation and synthetic portfolios

Patel(1994) argues house-markets are influenced by factors that are different from those influencing financial markets and quotes several studies which have suggested that the addition of property to financial assets can yield significant diversification gains. Using UK data, Howells/Rydin(1990) and Lee(1989) concluded that the optimal weighting of property in a multi-asset portfolio should be substantial.

In addition to diversification across asset-classes, diversification can also be achieved within asset-classes, for example across regions and across different property-types. Very regional-specific investors could use derivatives markets to diversify nationally, though the high correlation between regional house-prices in the UK(Gemmill,1990) would probably reduce the need for such a strategy. More importantly though, investors in certain kinds of property, e.g. commercial property, could diversify into residential real-estate using derivatives-market, given the low correlation of returns between the two sectors(Geltner/Miller/Snavely,1995).

Liquidity

An important attraction of derivatives-markets is their liquidity, which can often be substantially higher than in the cash-market. One reason for the muted interest in residential property by professional investors is its iliquidity, preventing rapid changes in asset-allocation within and across asset-classes(McAllister,Mansfield,1998). Baum(1991) notes that derivatives would allow asset managers to change their exposure to residential real-estate quickly and cheaply.

Speculation, Leverage, Arbitrage, Transaction-costs

The motivations with respect to other aspects of derivatives markets, speculation, leverage, arbitrage and lower transaction-costs apply equally to house-price derivatives with the exception of arbitrage as noted above. In the case of speculation, the additional aspect of short-selling becomes a motivation for using house-price derivatives given that real-estate cannot practically be sold short.

[19] Compare Euronext.LIFFE "SUBSCRIPTIONS, FEES AND CHARGES FROM 1 JANUARY 2005"

International investment and Tax

Baum(1991) notes that international investors benefit from residential property-derivatives because they can gain exposure to the UK house-market using the derivatives rather than buying UK-property outright.

Trading the derivatives is also tax-efficient as the contracts are cash-settled and are therefore exempt from UK stamp-duty.

5. Underylings

5.1 Indices

Fundamental and mathematical criteria

The questions of an optimal index can be treated very technically and a large literature deals with the requirements for optimal indices. However, they will only be mentioned here briefly while concentrating the discussion on the relative merits of different available UK house-price indices instead.

According to the fundamental requirements, an index has to be representative of the cash-market, it should be replicable, its construction should be transparent, it should have sufficient historical data, and it should be timely, maintained by a neutral party and publicly available. Additionally, the mathematical requirements are monotonicity, linear homogeneity, dimensionality, commensurability, and the ability to aggregate from sub-indices.

Most existing UK house-price indices will not fulfil the requirements of financial indices because they were created to show the performance of the house-market without considering investability. They particularly struggle with the requirement to be replicable and timely.

Transactions-based/valuation-based

Fisher/Geltner/Webb(1994) distinguish transactions-based indices, based on actual transaction-prices over the period, and valuation-based indices, which are calculated using valuation-models and continuously updated property-characteristics. Given that transactions-based indices use actual market-data and valuation-models can only approximate house-prices[20], transactions-based indices are to be preferred unless insufficient transactions-data exist.

A natural basis for UK house-price indices are the property prices published by HM Land Registry, a government agency holding the register on all UK house-transactions. It calculates simple unadjusted averages of all house-transactions, which have the attraction that they are based on the largest possible data-base. But

[20] see discussion in chapter 1.2

given the averages are not mix-adjusted, a change in composition of the traded house stock can change the index-level despite a constant underlying price-level.

Hedonic indices

Hedonic/constant-quality price indices introduced by Griliches(1961) solve this problem by keeping the quality of the index constituents constant during the period under observation. This is achieved by running a multivariate regression of a number of house-characteristics on the actual transaction-price. It is assumed that despite the complexities of valuing residential homes[21], a relatively small number of characteristics explain a majority of the fluctuation in value(Ferri,1977).[22] The regression coefficients can be interpreted as the implicit prices of the characteristics(Case/Shiller,1987).

Two variants exists. The intertemporal method assumes that prices of different characteristics stay constant but that transaction-timing explains the change in price(Knight/Dombrow/Sirmans,1995). In this method, characteristics and time-dummies are regressed on the transaction-price in a univariate regression, with the coefficients of the characteristics being updated infrequently. The “Varying Parameter Approach” updates the implicit prices of the characteristics for each period, running a new regression whenever the index is re-priced(Knight/Dombrow/Sirmans,1995). While both variants show the same trend, the actual returns can vary substantially. No consensus exist with respect to the functional form.

A house-price index can be derived from the coefficients of the intertemporal method’s time-dummies as they explain the impact of time on the transaction-price controlling for changing characteristics. Alternatively, a notional average house can be constructed and valued using the regression coefficients from the Varying Parameter Approach.

The most prominent examples of hedonic indices for UK house-prices are the HBOS/Halifax, Nationwide and FT House Price indices. The former two are based on the banks’ own mortgage deals and thus only account for their own mortgage market-share(22% for HBOS and 9% for Nationwide in 2004) and exclude cash-transactions(8% of all transactions in 2001)[23], possibly contributing to the divergence

[21] See section 1.2
[22] Characteristics could be location, size, type and age of building, availability of a garden etc.
[23] see also section 3.2

in trend shown by the two indices since 1997[24]. The FT House Price index is a hedonically mix-adjusted index based on all transactions reported by HM Land Registry.

Repeated Sales Price model

An alternative to hedonic indices is the repeated sales price(RSP) model, which tracks the price of individual houses over multiple transactions(Shiller,1991). However, only about 3% of all transactions are repeated transactions(Clapp/Giacotto,1992) and the methodology therefore suffers from small-sample bias and fails to account for quality-changes(Case/Quigley,1991). Adjustments have been developed to solve these problems(Cho,1996), though no efficiency improvement has been found when applying them(Leishman/Watkins,2002). Therefore, RSP models seem unsuitable as underlying instruments for derivatives.

Valuation-based indices

Examples of valuation-based indices are the indices released by the IPD for UK commercial properties. The indices are calculated on the basis of various property-characteristics and regular valuations by Chartered Surveyors. Brown/Matysiak(1995) find several problems with performance-measurement using valuation-based indices, in particular autocorrelation introduced into the indices due to temporal aggregation. Additional problems are smoothing because of timing-differences between valuations, temporal lag-bias and inertia, though these can also affect transaction-based indices(Geltner,1993).

Automated Valuation Models(AVMs)

The problems arise because the indices are aggregated from data which was not generated for the purpose of showing the general house-price level at a certain point in time but rather to value a specific house or to price a specific transaction in the period. Therefore, delays and moving-average effects are inevitable (Fisher,2002). More sophisticated methods such as AVMs, which have appeared mainly in the US since the mid-1990s, try to solve this problem(Fisher,2002).

[24] see Mervyn King "The UK Economy and monetary policy - looking ahead", Bank of England Quarterly Bulletin August 1998

AVMs generate reliable property-valuations instantly at much lower costs by applying different valuation-methods to a range of input-data such as property-characteristics and transaction-prices of similar properties in the same area. If a large amount of high-quality data exists, their accuracy can surpass that of manual appraisal-techniques.[25] If a sufficient part of a region or country is covered, a property index can be calculated by valuing a representative house-portfolio at a certain point in time. Importantly, such an index can be re-calculated frequently.

The strength of AVMs lies in valuing typical properties, which is exactly what is required for property indices(Pace/Sirmans/Slawson,2002). However, none of the AVMs currently in use in the US have published their underlying proprietary algorithms therefore violating the key requirement of transparency of index composition and calculation.

5.2 REITs

Real-estate investment trusts(REITs) are expected to be introduced in the UK in 2006 and it will take some time for a broad and liquid market for residential REITs to develop. Case/Shiller/Weiss(1993) argue that even then REITs are not suitable underlying instruments for house-price derivatives because REITs are highly correlated with the equity market, although house-prices are not (Goetzmann/Ibbotson,1990). Furthermore, REITs cannot diversify over certain properties such as owner-occupied houses and cover only a small fraction of total real-estate. REITs are promoted as investment vehicles not hedging media and in general there are not enough shares available for short-selling due to their small size.

[25] Freddie Mac claims that its Home Value Explorer is more accurate in 70% of cases, see “Freddie Mac calls HVE more accurate than traditional method”, National Mortgage News, 24.6.2002.

6. Contract design

In order to be attractive for market-participants the contracts need to be designed to suit their specific requirements. The case for cash-settled, exchange-traded derivatives has already been made[26]. It also follows from chapter 4 that there is a need for futures and options, as they are complementary(Gemmill,1990). The standard features of futures and options are not discussed in detail, only some important characteristics are highlighted.

6.1 Traded futures

The most important parameter to be set for futures is the maturity-date and it is crucial to decide which maturities should be tradable at any point in time. Trading-volume varies with time-to-maturity and it has an impact on correct pricing and attractiveness for traders. Trading-volume is generally larger for shorter time-to-maturity and positions are rolled-over onto the next maturity once the contract nears expiry.[27] However, most futures contracts have quarterly maturities implying that the closest expiry is at most 3-months away. For equity and bond markets this coincides with a need for short-term hedging given their high short-term volatility.[28]

In contrast, UK house-prices show less short-term volatility and most market-participants have medium to long-term interest.[29] Using futures with quarterly maturities in a roll-over strategy would not work given the sluggishness and inefficiency of the UK house-market which makes short-term prices forecastable. Case/Shiller/Weiss(1993) show that because the one-year ahead variance only accounts for about half of total return-variance, short-term futures are an ineffective hedge against house-price risk. Therefore substantial trading is also expected in the distant maturities.

6.3 Perpetual futures

In order to bundle liquidity, Shiller(1993) and Thomas(1996) suggest perpetual futures based on perpetual claims. A perpetual claim pays, in perpetuity, a yield proportional to an index of income on property, such as income-streams from letting

[26] See section 3.1
[27] as in the case of the ASX Property futures, often only the nearest maturity is actively traded
[28] See section 3.1 on short-term vs. long-term volatility comparison for UK house-prices and equities.
[29] See chapter 4

residential property.[30] Its price is non-zero and equals the discounted future cash-flow(Thomas,1996). The perpetual futures written on these claims involve daily cash-settlement which adjusts for the change in price and the difference between yield of the underyling and return on an alternative asset:

$$s_{t+1} = (f_{t+1} - f_t) + (d_{t+1} - r_t f_t)$$

where s is the settlement-amount, the first bracket adjusts for the change in futures price, d is the payment under the perpetual claim and r is the return on an alternative asset(Shiller,1993). For the future's long-side, settlement equals for example the return on a one-period investment in the perpetual claim financed by borrowing at r.[31] The second bracket corresponds to the adjustment in the cost-of-carry model(Thomas,1996) and ensures that the futures-price tracks the price of the perpetual claim, which does not have to be tradable and can remain notional (Shiller,1993). Thomas(1996) argues that the perpetual futures can be used to create finite-maturity futures involving a long-position in the perpetual future and a forward to sell a perpetual future at a certain point in time.

While the proposal of Shiller(1993) and Thomas(1996) is of some academic interest, it is difficult to see how these contract work in practice. There is likely to be a shortage of writers of perpetual futures because usual hedging requirements have finite horizons, and marketing of the product will be difficult given there are no comparable widely-used products.[32]

6.4 Retail products

Insurance contracts

Home Equity Insurance(HEI) proposed by Case/Shiller/Weiss(1993) insures home-owners against a drop in house-prices, either nominal or real, below a specified floor at a fixed date. To avoid moral hazard the contract should be based on a local or regional index, not the actual house-price, leaving policy-holders with some uninsurable basis-risk. To avoid adverse selection, the policy could offer part-insurance or involve a deductible amount, just like conventional insurance contracts. The insurance company can pool many policies nationally such that the exposure to

[30] Similar to Barclays' PICs, but without maturity
[31] The actual choice of alternative asset can be shown to be irrelevant to the futures price as long as it is liquid and there are no transaction costs (Thomas,1996).
[32] The only similar contract exists at the Chinese Gold & Silver Exchange Society (Shiller,1993)

house-prices is diversified enough to be hedgable using national house-price derivatives.

HEI can take several forms, with up-front premia for a fixed contract-lenght, annual premia fixed at the start of the contract with the price-floor adjusted by an appropriate house-index(Shiller/Weiss,1999), or a rolling policy with annual payments depending on recent house-price trends and the required price-floor(Case/Shiller/Weiss,1993). Several features could be added, e.g. the ability to cancel, to pass it on to buyers of the house, or to transfer it to a newly-bought house. Cancelability introduces a risk similar to prepayment risk known from mortgages and it can be modelled in a similar way although there is no hedging instrument.

Short-term policies can be constructed for people involved in house-transactions. Buyers can insure against a price-rise during the transaction and sellers can insure against a price-drop. The premium could be paid to the mortgage bank upon taking-out/paying-back of the mortgage, avoiding up-front costs for customers. As above, the relevant house-price would be a local or regional index.

Marketing of both insurance policies would probably best be done by mortgage-banks as they can bundle the products with their mortgages. In fact, mortgage-rates should be lower for people taking out HEI.

Retail-options

For speculation, banks can turn the traded options into retail options with smaller denominations like the GS covered warrants. This would also allow aspiring home owners to get exposure to the house-market ahead of a house-purchase.

Reverse mortgages

Reverse mortgages have been introduces by US congress in 1989 as a scheme for home-equity conversion, offering loans to qualifying households which can be taken as lump-sums, income-streams over a fixed period, annuities or lines of credit. The amount depends on house-value and interest-rates, and rises with borrowers' age(Caplin,2000). No interest-payments are due and the amount only becomes due on sale of the house or upon death.

The program has been guaranteed by the Federal Housing Administration, but the scheme has not been successful, partly due to the high costs of almost 14% of the initial loan on average, including taxes and insurance fees(Caplin,2000).

Reverse mortgages could be offered by private banks, which use property derivatives for hedging, therefore driving down the costs for customers. As Caplin(2000) argues, “in a thick market, transactions costs would be lower”.

7. Pricing

A house can be thought of as an asset plus a stream of consumption/“housing services”(Alhashimi/Dwyer,2004). This, however, does not capture the psychological/personal value attached by the owner. The pricing of derivatives based on house-price indices is consequently far from trivial, also considering section 1.2, and apart from Shiller/Weiss(1999) no specific literature exists. The different approaches will be sketched only and where possible formulae for futures and options will be derived for illustration.

7.1 Issues in pricing real-estate derivatives

Tradability

Standard models for the valuation of derivatives(e.g. Hull,1997) rely on tradability of the underlying asset. However, house-price indices cannot be traded given that in practice no portfolio can be constructed which is suitably diversified over all residential property classes, including owner-occupied houses.[33] Consequently, the contracts cannot be priced under the assumption of no-arbitrage and therefore the risk-attitude of investors can become relevant(Hull,1997).

Furthermore, the assumption of absence of transaction costs is violated given that that stamp duty alone accounts for 1-4% of the property value in the UK, ignoring legal costs and estate-agent fees.

Predictability

Shiller/Weiss(1999) show that annual log-returns for single-family homes in Los Angeles based on the proprietary Case/Shiller Home Price Index exhibit serial-correlation, making house-prices predictable. Therefore the option prices depend not only on the current price of the underlying, but also on the recent trend in prices(Shiller/Weiss,1999). The same equation has been estimated here for the UK using the quarterly Nationwide House-Price Index from 1952 to 2004:

$$(1)\quad \begin{aligned} &\Delta \ln(P_t) = \underset{(0.0016)}{0.00629} + \underset{(0.0495)}{0.70312} * \Delta \ln(P_{t-1}) + \varepsilon_t \\ &R^2 = 0.495, n = 208, \sigma_\varepsilon = 0.0174 \end{aligned}$$

[33] See chapter 5

Standard errors are given in brackets. The coefficient for the lagged dependent variable is significant and the Shiller/Weiss(1999) findings can be confirmed for the UK.

This implies that Black/Scholes(1973) is not directly applicable to value house-price options even ignoring the above points about tradability and transaction-costs. Lo/Wang(1995) show that although the Black/Scholes formula is unaffected by changes in predictability of the underlying, the option-prices will be significantly affected because ignoring serial-correlation results in a specification error leading to incorrect prices. This can be seen from the input-parameters for Black/Scholes, μ and σ^2. For the Brownian motion $r_T(t)$, they must satisfy the following relations according to Lo/Wang(1995):

$$\bar{r}_\tau = \mu\tau$$
$$s^2(r_\tau) = \sigma^2\tau$$
$$\rho_\tau(1) = 0$$

where r-bar, s^2 and p(1) are the τ-period unconditional mean, variance and first-order autocorrelation, respectively. σ^2 can therefore be estimated by the sample-variance of continuously compounded returns r. However, if the underlying process is a trending autoregressive process, e.g. a trending univariate Ornstein-Uhlenbeck process with parameter γ, this is no longer the case because then μ and σ^2 need to satisfy:

$$\bar{r}_\tau = \mu\tau$$
$$s^2(r_\tau) = \frac{\sigma^2}{\gamma}\left[1 - e^{-\gamma\tau}\right]$$
$$\rho_\tau(1) = -\frac{1}{2}\left[1 - e^{-\gamma\tau}\right]$$

Clearly, the sample variance is no longer an appropriate estimator for σ^2(Lo,Wang,1995). Using the sample-variance as an estimator in the case of serially correlated asset returns would result in biased input-parameters for the Black/Scholes formula and therefore in incorrect option-prices. In the case of the OU-process, option-premia increase for higher (negative) autocorrelation and are always at least as high as premia under the standard specification.

For the generally applicable case of positive autocorrelation in asset prices[34], Lo/Wang(1995) show that under bivariate trending OU-processes, option premia fall with higher predictability as measured by R^2.

7.2 Discounting Expected Payout

Shiller/Weiss(1999) value house-price options as the NPV of expected payout under the assumption of log-normal prices, avoiding the construction of continuous hedge-portfolios. This follows the option-valuation approach by Sprenkle(1961), Boness(1964) and Samuelson(1967), which was later abandoned and superseded by Black/Scholes(1973) because of severe practical and theoretical problems. The theory lacked a coherent framework for deriving an appropriate discount-rate, the choice of return-distribution was subjective and it failed to derive option prices to satisfy put-call parity. The approach is shown here merely as a reference and applied to the Nationwide UK house-price index for illustration.

The price of put-options is the discounted strike-price multiplied by the probability of exercise less the discounted price of the underlying in case of exercise(Shiller/Weiss,1999). Using the formula for the truncated mean of the log-normal distribution, Shiller/Weiss derive the European real-estate put-option price as:

$$(2)\quad p(t, X, P, \mu, \sigma, r) = Xe^{-rt} N\left[\frac{\ln(X/P) - \mu}{\sigma}\right] - Pe^{(\mu + \frac{\sigma^2}{2} - rt)} N\left[\frac{\ln(X/P) - \mu}{\sigma} - \sigma\right]$$

where t=time-to-expiry, X=strike-price, P=current price of underlying, μ=expected log-price change until time t, σ=variance of μ and r=discount rate. The expected log-price change and its variance are derived from an autoregressive process such as (1). Rearranging (1) to derive the expected log price-change and its variance for 3-months ahead in terms of the most recent quarterly price-change results in:

$$(3)\quad \begin{aligned} \mu &= E(\ln P_{t+1} - \ln P_t) = \Delta \ln P_{t+1} = c + \rho \Delta \ln P_t \\ \sigma^2 &= Var(\Delta \ln P_{t+1}) = Var(\varepsilon_{t+1}) = \sigma_\varepsilon^2 \end{aligned}$$

where c=0.00629, ρ=0.70312, σ_ε=0.01738. Similarly, for the 12-month ahead expected log-price change and variance:

[34] See e.g. Lo/MacKinlay(1988,1990)

$$\mu = E(\ln P_{t+4} - \ln P_t) = \Delta \ln P_{t+4} + \Delta \ln P_{t+3} + \Delta \ln P_{t+2} + \Delta \ln P_{t+1}$$

$$(4) \quad = c(4 + 3\rho + 2\rho^2 + \rho^3) + \Delta \ln P_t(\rho + \rho^2 + \rho^3 + \rho^4)$$

$$\sigma^2 = Var(\ln P_{t+4} - \ln P_t) = \sigma_\varepsilon^2((1 + \rho + \rho^2 + \rho^3)^2 + (1 + \rho + \rho^2)^2 + (1 + \rho)^2 + 1)$$

Using (3) and (4) in (2) results in the theoretical put-option prices shown in tables 2 and 3 with the Nationwide UK house-price index as the underlying. At-the-money put-options on the Nationwide index would cost approximately £634(3-month) and £1,385(12-month) given that the index was almost unchanged in the most recent quarter at an index value of £154,107. Potential uses as retail products are discussed in section 6.4.

Table 2: 3-month European put-option prices for a £154,000 house (r=4.75%)[35]

Δln(Pt)	Strike Price (X)				
	£134,000	£144,000	£154,000	£164,000	£174,000
-5.0%	£0	£12	£4,360	£14,190	£24,072
-2.5%	£0	£0	£2,096	£11,568	£21,450
0.0%	£0	£0	£634	£8,899	£18,781
2.5%	£0	£0	£100	£6,195	£16,065
5.0%	£0	£0	£7	£3,564	£13,301

Table 3: 12-month European put-option prices for a £154,000 house (r=4.5%)

Δln(Pt)	Strike Price (X)				
	£134,000	£144,000	£154,000	£164,000	£174,000
-5.0%	£288	£2,177	£7,470	£15,660	£24,974
-2.5%	£56	£713	£3,655	£10,009	£18,650
0.0%	£7	£170	£1,385	£5,351	£12,479
2.5%	£1	£28	£388	£2,263	£7,112
5.0%	£0	£3	£78	£721	£3,264

7.3 Derivation of the market-price of risk

Hull(1997)[36] derives a differential equation for the valuation of derivatives based on non-traded assets which is structurally very similar to Black/Scholes(1973). Hull assumes that the underlying (non-traded) asset follows $d\theta / \theta = mdt + sdz$, where dz is a Wiener-process and m and s are time-drift and volatility, respectively. Two derivatives f_1 and f_2 are priced on this asset, whose discrete-time processes are

(5) $\Delta f_i = \mu_i f_i \Delta t + \sigma_i f_i \Delta z$ for i=1,2.

[35] The 3-months and 12-months Sterling interest rates published by the FT were used as risk-free rates.

An instantaneously risk-less portfolio π can now be constructed consisting of $\sigma_2 f_2$ of f_1 and $-\sigma_1 f_1$ of f_2.

$$\Pi = (\sigma_2 f_2) f_1 - (\sigma_1 f_1) f_2$$

$$\Delta\Pi = (\sigma_2 f_2)\Delta f_1 - (\sigma_1 f_1)\Delta f_2 = (\mu_1 \sigma_2 f_2 f_1 - \mu_2 \sigma_1 f_1 f_2)\Delta t = r\Pi\Delta t$$

where the last equality follows from the fact that π is risk-less. Substituting for π results in the measure for the market-price of risk,

(6) $$\lambda = \frac{\mu_1 - r}{\sigma_1} = \frac{\mu_2 - r}{\sigma_2}$$

which generally depends on θ and t, but not on the nature of the derivative f_i (see Hull,1997). Using Ito's lemma in the continuous-time version of (5), Hull derives the differential equation which has to be satisfied by f as

$$\frac{\partial f}{\partial t} + \theta \frac{\partial f}{\partial \theta}(m - \lambda s) + \frac{1}{2} s^2 \theta^2 \frac{\partial^2 f}{\partial \theta^2} = rf$$

which is similar to the Black/Scholes differential equation.

7.4 Pricing within the Cox/Ross framework

The above derivation of the market-price of risk for non-traded assets can be utilised to price derivatives under risk-neutrality in the Cox/Ross(1976) framework without employing no-arbitrage arguments between derivative and underlying.

Following Cox/Ross(1976), derivatives can be valued according to the discounted expected payoff at expiry T, using the risk-free rate as discount-rate given the assumption of risk-neutrality. Therefore, the current price $X_P'(t)$ of the derivative with underlying process $dP_t = a(P_t, t)dt + b(P_t, t)dz$ can be obtained as [37]

(7) $$X_P'(t) = e^{-r(T-t)} E_{Q,t}(X_P'(T)) = e^{-r(T-t)} \int_{-\infty}^{+\infty} X_P'(T) dQ'(P_T)$$

where $Q(P_t)$ and $Q'(P_t)$ are the cdf and pdf of the underlying asset-price in the risk-neutral economy, respectively. Neftci(1996) shows that $Q(P_t)$ can be obtained from the corresponding cdf in the real (i.e. non-risk-neutral) economy, $R(P_t)$, using the market-price of risk λ:

(8) $$dQ(P_t) = \lambda dR(P_t)$$

[36] See Hull(1997), p.288-291

[37] see Cox/Ross(1976),p.153; Harrison/Pliska(1981),p.220

which can be understood as the transformation of the real probability-measure $R(P_t)$ to its equivalent risk-neutral probability-measure $Q(P_t)$. A risk-neutral valuation using (7) is therefore possible given that discounting the expected payoff of the derivative yields identical prices in both worlds, i.e. taking expectations of the payoff with respect to $Q(P_t)$ and discounting by r equals taking expectations with respect to $R(P_t)$ and discounting by $\mu_i = r + \sigma_i \lambda$ (which follows from (6)):

(9) $e^{-r(T-t)} E_{Q,t}(X_P'(T)) = e^{-\mu_i(T-t)} E_{R,t}(X_P'(T))$

Assuming normally distributed prices, i.e. Q(.) and R(.) follow $N(m_Q,\sigma)$ and $N(m_R,\sigma)$, respectively, Schirm(2001) finds a closed-form solution for the valuation of European puts at time t with strike price K and maturity T:

(10)
$$\begin{aligned} p(t,T,K) &= e^{-r(T-t)} \int_{-\infty}^{+\infty} \max(K - P_T, 0) dN_Q'(P_T) \\ &= e^{-r(T-t)} \left(K\Phi\left(\frac{K - m_Q}{\sigma}\right) - m_Q \Phi\left(\frac{K - m_Q}{\sigma}\right) + \sigma\phi\left(\frac{m_Q - K}{\sigma}\right) \right) \end{aligned}$$

where Φ and *Φ* are the cdf and pdf of the standard-normal, respectively.

Discussion

The difficulty with this valuation approach is the identification of the market-price of risk and therefore the identification of the risk-neutral martingale-measure. Finding the latter can be shown to require a complete and arbitrage-free market for the derivatives("Fundamental Theorem of Asset Pricing"), which could be fulfilled by a liquid exchange-traded futures and options market exhibiting the spanning-property (Schirm,2001)[38].

From the derivatives prices of such a market, the implied mean m_R can be obtained in the same way as implied volatilities are obtained from option prices, and consequently the risk-neutral mean m_Q can be calculated from (7). Substituting into (9) for two derivatives separately yields the discount rate μ_i (i=1,2), which can then be used in (6) to determine the market-price of risk, λ.

While this seems to solve the problem of applying (10), it is a somewhat circular argument basing the prices of derivatives on the observed market prices of those derivatives. A further issue is that the underlying price is assumed to follow an Ito-process, implying that past returns do not affect future returns. This, however, is

[38] see Duffie(1988) for a technical exposition of the spanning property.

contrary to the discussion in 7.1 regarding the process house-price indices seem to follow.

Furthermore, the specific solution (10) assumes normally distributed returns, which is probably inadequate, though a closed-form solution can also be obtained for log-normal prices.

7.5 Equilibrium-valuation

An alternative to risk-neutral valuation is an inter-temporal consumption-based capital asset pricing model such as Huang/Litzenberger(1988) in discrete time, which does not require complete markets and no-arbitrage conditions.[39,40]

Model Set-Up

A representative individual, i, is assumed to have an infinite planning-horizon over a single consumption-good. The individual maximises future expected utility according to an additively separable, strictly concave and differentiable utility function:

$$U\left(\underline{c}^i\right) = E_0\left(\sum_{t=0}^{\infty} U\left(c_t^i, t\right)\right) = U\left(c_0^i, 0\right) + E_0\left(\sum_{t=1}^{\infty} U\left(c_t^i, t\right)\right)$$

$\underline{c}^i$ is the multi-period consumption plan $\underline{c}^i = \left\{c_t^i, t = 0,1,...\infty\right\}$ of random consumption c_t at time t. There are N companies producing the single consumption-good and issuing shares in the market. The shares of all companies can be summarised without loss of generality by a single market-portfolio. Furthermore, there are risk-less zero-coupon bonds with unit nominal value, and derivatives on stocks, bonds and a real-estate index. The net outstanding amount of derivatives is zero. The individual finances consumption through a multi-period trading-strategy which is subject to uncertainty due to the stochastic processes of dividends and the real-estate index.

Stochastic discount-rate

Huang/Litzenberger(1988) define the maximisation problem and the conditions and constraints resulting from the above assumptions. The solution is obtained via dynamic optimisation using the Bellman-equation, which will not be shown here.

[39] However, the notation of Cao/Wei(1999) is followed here
[40] Due to constraints on space, only the construction of the model is set out while the solution is just sketched rather than derived in detail. See Huang/Litzenberger(1988), p.193-203 for details

Given all individuals are identical and in particular have identical utility-functions, their consumption can be aggregated:

(11) $C_t = \sum_{i=1}^{I} c_t^i$

From the first-order conditions of the maximisation-problem, Huang/Litzenberger(1988) derives the following condition for the ex-dividend price S(t) of a complex security at time t:[41]

(12) $S(t) = E_t\left(\sum_{\tau=t+1}^{\infty} \frac{U_c(c_\tau^i,\tau)}{U_c(c_t^i,t)} d(\tau)\right) = E_t\left(\sum_{\tau=t+1}^{\infty} \frac{U_C(C_\tau,\tau)}{U_C(C_t,t)} d(\tau)\right)$

where U_c and U_C are the first derivatives of the individual and aggregate utility-function, respectively, and the last equality follows from (11). d(τ) is the random dividend or payoff paid at time τ. The stochastic discount-factor equals the inter-temporal marginal rate of substitution between time t and τ and depends on investors' preferences(Campbell/Lo/MacKinlay,1997,p.294).

Equilibrium

In equilibrium, markets are required to clear, which given the net-zero supply of bonds and derivatives means that aggregate consumption C_t must equal aggregate dividends D_t paid in the economy at every t.

(13) $D_t = \sum_{n=1}^{N} d^n(t) = \sum_{i=1}^{I} c_t^i = C_t$

Huang/Litzenberger(1988) show that the resulting equilibrium-prices and allocations are pareto-efficient. Substituting into (12) and restricting the formula to prices X'(t) of derivatives which generally only have a single payoff X'(T) at expiry T (e.g. options), results in:

(14) $X'(t) = E_t\left(\frac{U_C(D_T,T)}{U_C(D_t,t)} X'(T)\right) = \frac{E_t\left(U_C(D_T,T)X'(T)\right)}{U_C(D_t,t)}$

An explicit solution can be obtained by making an assumption about the individual's utility function, e.g. CRRA utility:

(15) $U(c_t^i,t) = e^{-\delta t} \frac{\left(c_t^i\right)^{\gamma+1}}{\gamma+1}$

[41] Huang/Litzenberger(1988), p.202

where δ is the rate of time-preference and γ is the coefficient of risk-aversion.[42] Substituting the utility-function (15) and the equilibrium-condition (13) into (14) results in the equilibrium-price of the derivative:

$$X'(t) = E_t\left(\left(\frac{e^{-\delta T} C_T^{\gamma}}{e^{-\delta t} C_t^{\gamma}}\right) X'(T)\right) = E_t\left(\left(\frac{e^{-\delta T} D_T^{\gamma}}{e^{-\delta t} D_t^{\gamma}}\right) X'(T)\right) = e^{-\delta(T-t)} D_t^{-\gamma} E_t\left(D_T^{\gamma} X'(T)\right)$$

which depends on the rate of time-preference, the time-to-expiry, aggregate dividends and the final payoff.[43] This can then be applied to put-options on a real-estate index P_t with strike-price K:

(16) $p(t,T,K) = e^{-\delta(T-t)} D_t^{-\gamma} E_t\left(D_T^{\gamma} \max(K - P_T, 0)\right)$

As Schirm(2001) notes, a closed-form solution cannot generally be obtained for given stochastic processes of P_t and D_t if the two processes are correlated. This should generally be assumed, however, in the case of house-price derivatives[44] and therefore simulation methods have to be used to determine the option-premium.

7.6 Derivation of the C-CAPM

As Huang/Litzenberger(1988) show, (12) can be written as

$$S(t) = E_t\left(\frac{U_C(C_{t+1}, t+1)}{U_C(C_t, t)} (d(t+1) + S(t+1)\right)$$

which can be re-arranged using the one-period holding return $r_{S,t+1}$

(17)
$$\begin{aligned} 1 &= E_t\left(\frac{U_C(C_{t+1}, t+1)}{U_C(C_t, t)} (1 + r_{S,t+1})\right) \\ &= E_t\left(\frac{U_C(C_{t+1}, t+1)}{U_C(C_t, t)}\right) E_t(1 + r_{S,t+1}) + \operatorname{cov}_t\left(\frac{U_C(C_{t+1}, t+1)}{U_C(C_t, t)}, r_{S,t+1}\right) \end{aligned}$$

Using the fact that a zero-coupon bond with one period to expiry returns the risk-free rate r_{t+1}, (17) can be simplified and re-arranged into the equation for the Consumption-based CAPM[45]

$$\begin{aligned} E(r_{S,t+1}) - r_{t+1} &= -(1 + r_{t+1}) \operatorname{cov}_t\left(\frac{U_C(C_{t+1}, t+1)}{U_C(C_t, t)}, r_{S,t+1}\right) \\ &= -(1 + r_{t+1}) \operatorname{cov}_t\left(e^{-\delta}\left(\frac{C_{t+1}}{C_t}\right)^{\gamma}, r_{S,t+1}\right) = -(1 + r_{t+1}) \operatorname{cov}_t\left(e^{-\delta}\left(\frac{D_{t+1}}{D_t}\right)^{\gamma}, r_{S,t+1}\right) \end{aligned}$$

[42] see Huang/Litzenberger(1988), p.207 for a solution with quadratic utility
[43] see also Schirm(2001)
[44] See section 8.3

where the two last equalities follow from (15) and (13).

7.7 Pricing futures/forwards

The valuation of call-options follows straight from the above discussion on put-options by adjusting the payoff structure appropriately. Given the prices for call and put-options, the payoff structure of forwards can be obtained by a long call and a short put with same exercise-prices. The quoted price of a forward is the strike price of the two options which sets the value of the forward equal to zero at the beginning of the contract.

In the Cox/Ross framework, given the convenient properties of the pdf and cdf of the normal distribution, the forward-price can be easily shown to equal m_Q, which as Schirm(2001) comments is an intuitive results given the absence of cost-of-carry.

In the equilibrium valuation-model, (16) can be manipulated directly to result in the value f of a future on a real-estate index P_t:

(18) $f(t,T,K) = e^{-\delta(T-t)} D_t^{-\gamma} E_t\left(D_T^{\gamma}(P_T - K)\right)$

Again, at the beginning of the contract, the price F of the forward equals the strike price K at which the value f of the forward is zero. Setting (18) equal to zero and solving for K results in the price F of the forward:

$$F(t,T,K) = \frac{E_t\left(D_T^{\gamma} P_T\right)}{E_t\left(D_T^{\gamma}\right)}$$

If one were to assume that aggregate dividends and the real-estate index are uncorrelated, the forward price would reduce to the expectation of P_T, which equals m_Q(Schirm,2001).

7.8 Merton investment model with correlated assets

Hobson(1994), Henderson/Hobson(2002) and Henderson(2002) derive prices for derivatives based on non-traded assets within the Merton(1969) investment-model. Introducing a non-traded asset which is correlated with the traded asset into the Merton-model allows hedging of the derivative-position using the traded asset, albeit imperfectly, resulting in so-called ‘basis risk’.

Henderson(2002) derives option-prices based on this approach both under the assumption of constant-relative and constant-absolute risk-aversion. However, the

[45] see Huang/Litzenberger(1988), p.204

derivation is somewhat involved and an explicit solution can only be found for CARA due to the separability properties of the exponential utility-function.

Model Set-Up

The non-traded asset S and traded asset P follow exponential Brownian motions:

(19)
$$\frac{dS}{S} = vdt + \eta dZ$$
$$\frac{dP}{P} = \mu dt + \sigma dB$$

where Z and B are correlated Brownian-motions, with correlation ρ. Z can also be represented by a linear combination of two independent Brownian-motions, B and W: $Z_t = \rho B_t + \sqrt{1-\rho^2} W_t$.

The agent maximises expected utility of final wealth, which is generated by profits from trading and λ units of the option's payoff $h(S_T)$:

(20) $$v(t, x, S, \lambda) = \max_{\{\theta_u\}} E_t\left[U\left(X_T + \lambda h(S_T)\right)\right]$$

with
$$U(x) = -\frac{1}{\gamma} e^{-\gamma x}, \gamma > 0$$
$$X_T = X_t + \int_t^T \theta_u (dP_u / P_u)$$

where θ_t is the amount invested in the traded asset at time t. The risk-free rate is assumed zero for simplicity. Henderson(2002) argues that final wealth has to be non-negative due the form of the utility-function, therefore only short/long positions in put-options and long-calls are allowed, whereas short-calls are not because their payoff is unbounded below.

Reservation-price of the option

The option-premium in this framework corresponds to the reservation-price which is the adjustment p to initial wealth (t=0) necessary to equalise the expected utilities of two agents, one who receives a claim under the option and one who does not(Henderson,2002). It is therefore the price the agent is willing to pay for the claim:

$$v(0, x_0 - p, s_0, \lambda) = v(0, x_0, s_0, 0)$$

Re-arranging (20) results in:

$$v(t, X_t, S_t, \lambda) = -\frac{1}{\gamma} e^{-\gamma X_t} \inf_{\theta} E_t\left(e^{-\gamma \int \theta_u (dp_u / P_u) - \gamma \lambda h(S_T)} \right) = -\frac{1}{\gamma} e^{-\gamma X_t} g(T-t, \log S_t)$$

where g solves a non-linear partial differential-equation, which can be converted into a linear PDE (Hobson,1994 and Henderson/Hobson,2002). Using boundary-conditions, this ultimately results in the explicit solution for the value-function v(.) from which the reservation-price of $\lambda h(S_T)$ can be derived via the utility-indifference argument above(Henderson,2002):

$$p^e = -\frac{1}{\gamma(1-\rho^2)}\log E^0\left[e^{-\lambda\gamma(1-\rho^2)h(S_T)}\right]$$

This can be approximated for small λ through a Taylor-expansion:

(21) $p^e = \lambda E^0 h(S_T) - \frac{\gamma}{2}\lambda^2(1-\rho^2)\left[E^0\left[h(S_T)\right]^2 - \left[E^0 h(S_T)\right]^2\right] + O(\lambda^3)$

For call-options with strike-price K, $h(S_T)=\max(0,S_T-K)$ and thus $E^0h(S_T)$ equals the undiscounted Black/Scholes option-price with volatility η^2 and discount-rate $\delta = v - \mu\rho\eta/\sigma$, the drift-rate of S under the minimal martingale-measure. Also, for call options: $E^0\left[h(S_T)\right]^2 = s^2 e^{(2\delta+\eta^2)(T-t)}N(d_1+\eta\sqrt{T-t}) + K^2N(d_2) - 2Ke^{\delta(T-t)}sN(d_1)$, where d_1 and d_2 are the corresponding parameters from the Black/Scholes equation.

Discussion and application

It is important to note that solution (21) is wealth-independent. As Rouge/El Karoui(2000) note, this may be undesirable in some cases given that in general risk-attitude is assumed to depend on endowment[46], though given the solution is applied here to price derivatives held by many agents, it may not be important. It turns out that the solution in the case of CARA utility is wealth-dependent and Henderson(2002) shows that prices under both solutions are very close except for extreme values of risk-aversion.

Given that Henderson(2002) assumes that the pricing-processes for the two assets follow Brownian-motions, (19), the discussion in 7.1 on adjusting the Black/Scholes inputs for predictability of the underlying asset-returns applies.

Henderson(2002)'s derivation of the call-option price for non-traded assets that are correlated with traded assets, (21), can be evaluated directly for UK house-price indices if a suitable listed investment trust which is correlated highly enough with the option's underlying can be found[47]. This is somewhat difficult in the case of

[46] Henderson(2002) mentions the case of executive stock options, which by definition are held by a single, identifiable person.
[47] Henderson/Hobson(2002) deal in particular with cases where ρ is close to 1.

UK residential real-estate indices given that almost all currently listed UK property funds and trusts invest solely in commercial property and are thus unsuitable for hedging purposes in this model. Grainger Trust, the largest listed residential property-company has a market capitalisation of only £500mn. Also, REITs have not been introduced in the UK yet and no liquid and diverse market for listed REITs exists in the UK.

8. Economic Impact

The economic impact of the introduction of exchange-traded derivatives with respect to risk-sharing and price-finding are well-known. Due to the specific characteristics of the house-market further important aspects arise, in particular social risks and the impact on the business cycle.

8.1 Risk-sharing

Individual real-estate holdings are not only un-diversified, but also leveraged(Shiller,Weiss,1999) leading to substantial risks to households' wealth from fluctuations in property-prices due to local/specific or national/economy-wide factors. Liquid traded derivatives on house-price indices can help to stabilise households' wealth through hedging and de-leveraging.

But because retail insurance products will not be based on the individual house-price, but local or regional indices, hedging will be imperfect for households. Only mortgage-banks will be able to hedge perfectly given that their mortgage-portfolio can be expected to be diversified enough nationally to match a national house-price index closely. These banks will benefit greatly from a liquid property-derivatives market, given that so far it was not possible to hedge the exposure(Case/Shiller/Weiss,1993).

This is important because mortgage-defaults caused by declines in house-prices have lead to severe banking crises in the past, like in the US in the early 1930s following a slump in house-prices from their 1925-peak, or in Japan after 1990.

8.2 Price-finding

Impact on real-estate pricing

Home-buyers' price-expectations are substantially affected by recent price-trends, contributing to swings in house prices(Case/Quigley/Shiller,2003) given the circularity of pricing-setting. Rising prices push prices even higher while estate-agents have an interest in accelerating the effect.

A liquid, exchange-traded derivatives-market alleviates these problems through frequent re-pricing, continuous price publication and the involvement of larger and sophisticated market-participants. The tendency for cyclical and speculative price movements may therefore be reduced(Thomas,1996 and Case/Shiller/Weiss,1993).

Futures markets can make cash-markets more efficient. Eventually house-prices could be quoted in futures-terms(Case/Shiller/Weiss,1993) and feedback from the futures-market to the cash-market could occur. This happens in the case of oil where the global oil-price is not just determined by actual supply and demand but also by speculation in oil-futures. This could lead to more pricing certainty in private house-transactions if the transaction-price is indexed to the futures-price for the duration of the deal, which could easily be hedged directly via the futures market or using insurance-products.[48]

Case/Shiller(1988) note that prices are downward-sticky in house-markets due to the existence of sellers' reserve-prices, often the price at which the property was bought. Downward-stickiness can cause sharp drops in transaction-volume in a slump leading to unreliable prices. This could do more harm to the economy than a moderate price-decline(Case/Shiller,1988). Allowing unrestricted short-sales, liquid futures-markets can remove the downward-stickiness considering the above-mentioned feedback from futures to cash-market.

Price-rise

Being able to reduce the risk associated with holding property through derivatives-markets, agents will be more willing to hold property and consequently prices could rise, creating a windfall for existing home-owners. Thomas(1996) notes that this is not a loss to society but quantifies the gain from risk-sharing. Case/Shiller/Weiss(1993) argue that prices should rise at least initially given the short-term restriction on housing supply offset in the long-term by an increased supply of housing, making renters better off.

Volatility

Transactions in the housing-market take long to complete and given that contracts are usually verbal and non-binding until completion of the transaction, price-risk due to high house-prices volatility can deter buyers and sellers from entering the market(Gemmill,1990).

[48] See section 6.4

Case/Shiller/Weiss(1993) distinguish fundamental volatility, the reaction of price to fundamental news, and transaction volatility created by order-imbalances. While they argue that the effect of house-price derivatives on fundamental volatility will be “measurable, but small”(Case/Shiller/Weis,1993,p.16), transaction volatility should be reduced because bid-ask spreads will be narrowed due to higher liquidity in the derivatives market, thus limiting the effect of order imbalances on prices.

According to Case/Shiller/Weiss(1993) upward price-volatility is driven by buyers afraid to be priced-out of the market. This effect should be reduced with derivatives-markets as they will be able to participate in the price-development without the need for a cash-transaction.

Thomas(1996) however notes that speculative forces could also increase price-volatility and that the theoretical models trying to explain the effect on volatility from the introduction of derivative-markets are inconclusive with small specification-changes altering the results drastically.

Order-imbalances and conducive attitudes

Order-imbalances in cash-markets under conducive attitudes can lead to snow-ball effects in prices, with consequences similar to the price-circularity described above. In a liquid futures market, the impact of order-imbalances is reduced because the initial price change caused by the imbalance is prevented and the snow-ball effect will be limited(Case/Shiller/Weiss,1993).

8.3 Effect on the business-cycle

Using data for the UK housing-market and economy, the three Bank of England economists Aoki/Proudman/Vlieghe(2002) highlight that house-prices in the UK do not seem to be the source of economic shocks, but are part of the transmission mechanism by which interest-rates affect consumption, the output gap and inflation. They highlight that house-prices move strongly with output, but lag slightly. Furthermore, housing-investment leads house-prices and output, and there seems to be a strong co-movement between durables-consumption and house-prices(Aoki/Proudman/Vlieghe,2002).

Consumption

Financial innovation in the UK mortgage-market has allowed home-owners to withdraw housing-equity more easily to finance consumption.

Aoki/Proudman/Vlieghe(2002) note that durables-purchases in particular are more likely to be financed by borrowing, which is consistent with UK data. This establishes a direct link between house-prices and consumption, and output. Enabling households to hedge their exposure to house-markets and moderating swings in house-prices should therefore stabilise consumption.

Construction expenditure

A further moderating factor on the business-cycle could come from a more rational response by the construction industry to speculative demand(Case/Shiller/Weiss,1993). Builders will be able to assess potential future demand from the demand for house-price futures. They will be able to invest in long-term projects on a hedged basis, by selling the exposure to future house-prices in the derivatives market. Case/Shiller/Weiss(1993) argue that this may feed back to speculative behaviour, reducing house-price volatility in the long-term, which should cause a stabilisation in housing-investment.

8.4 Social risks/opportunities

Fluctuating house-prices pose social risks because rising prices distribute wealth in favour of house-owners(Giussani/Hadjimatheou,1991). Therefore, an increase in the general house-prices after the introduction of house-price derivatives could become a social problem as less wealthy renters are priced out of the property-market. This happens even though for society as a whole the price rise is neutral and merely reflects the gains from risk-sharing.

On the flip-side, low-income households could benefit from being able to insure against a decline in house-value which would hurt them more severely given they spend a disproportionate part of their income and wealth on housing. The availability of insurance could also attract low-income households to the house-market.[49]

8.5 Liquidity and easier market-access

The cash-market for residential real-estate prevents free entry and exit through substantial transaction-costs such as mortgage-costs, search-costs, legal fees and taxes. Greater liquidity provided by derivatives market lowers transaction

[49] See “Homeowners risk & safety nets”, report published by the Office of the Deputy Prime Minister, April 2004

costs both in terms of fees and bid-ask spreads. This allows more people to participate in the market and to express their opinion about the real-estate market through buying and selling of the derivatives, thus contributing to price-finding and efficient allocation of residential property.

8.6 Diversification into new asset class

So far a major assets class has been inaccessible for investors, resulting in inefficient and undiversified portfolios. This is particularly severe because house-prices have little correlation with equity-prices. Therefore, Seiler/Webb/Myer(1999) argue following Markowitz(1952,1959) that including real-estate in multi-asset portfolios should result in higher returns for given risk, which is confirmed by Webb/Curcio/Rubens(1988). This will be a gain in particular for relatively conservative investors, such as insurances and pension-funds, with obvious consequences for social welfare and the economy.

Conclusion

This paper has made the case for an exchange-traded derivatives market on UK house-price indices, with futures and options having the standard contract specifications of commodity futures, though with longer maturities (up to 2 years). Recognising that a large part of market-participants are private house-owners, the importance of intermediaries repackaging the derivatives into insurance contracts and retail-options was highlighted.

While a successful introduction is not guaranteed due to the need of the exchange to spend substantial amounts on marketing, investor education and on signing-up market-makers to provide initial liquidity, it has been shown that the conditions are better than before. Legal obstacles have been removed, derivatives markets are many times more liquid than 10 years ago, suitable house-price indices are established and City institutions have become familiar with them, and real-estate investors have become familiar with derivatives. Importantly, pricing models have been introduced to price the derivatives. Finally, UK house-prices have just started to decline after more than a decade-long boom, causing the market to start worrying about leverage and exposure.

The economic impact has been shown to be substantial in terms of de-leveraging and hedging for home-owners and mortgage-banks, diversification and access to a new asset class for institutional investors, price-finding and its effect on house-market efficiency, but importantly also on the real-economy through moderating the business cycle by stabilising construction-expenditure and consumption.

However, more work needs to be done. On the technical side, index-construction would need to be looked at in more detail, comparing the UK house-price indices according to their statistical properties and also their relations with their regional sub-indices. The pricing models presented have to be applied to actual data and simulated where closed-form solutions cannot be obtained. On the conceptual side, the contract-design should be discussed with market-participants, particularly speculators, e.g. day-traders and hedge-funds, which currently provide a major part of the liquidity on derivatives markets.

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