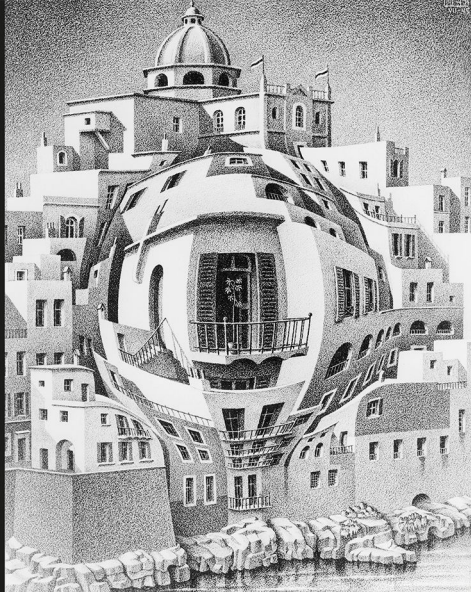




REAL-ESTATE DERIVATIVES

From Econometrics to Financial Engineering

RADU S. TUNARU

OXFORD

Real-Estate Derivatives

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Engineering

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This book is dedicated to my wife Diana, thanking her for her longstanding support and remarkable infinite kindness in the face of adversity.

■ PREFACE

Recently financial derivatives were portrayed as “weapons of mass destruction” by famous investors like Warren Buffett. This was not that long after he tried to buy Long Term Capital Management (LTCM) on the cheap, unsuccessfully. Should we really be worried about financial derivatives? First of all there is evidence that they were used as far back as 8000 B.C. by Sumer traders to lock in contracts in to the future and take advantage of seasonality. Thus, financial derivatives have been around for a long time and so far, there has not been a mass destruction. They could be used though to destabilize financial systems and in the last three decades almost all financial disasters involved financial derivatives. But this does not make Warren Buffett right. Antibiotics can also have a detrimental effect on millions of people if they are used wrongly. Still, I do not believe that we should eliminate antibiotics and likewise, I do not believe that we should stop using derivatives.

What famous people perhaps should argue for is not to use financial derivatives where they are not needed. Given that apart from forwards/futures and swaps the majority of financial derivatives have nonlinear payoffs, they can be used to leverage the positions and take high risk through financial markets. By the time the financial markets settle down large amounts of money can move into the hands of speculators.

Are derivatives needed by society? The most developed economies are dominated by real-estate which represents a very large part of total wealth. The crashing of property markets around the world has led to periods of recession and instability. It seems paradoxical that exactly where they are needed the most, in real-estate, derivatives are in infancy. Hopefully this book will motivate those in key positions to act immediately and help the expansion of real-estate derivatives. There is a general lack of knowledge of real-estate derivatives and this book is aiming at offering academics, investors, regulators, hedge-fund managers, risk managers, model validators, postgraduate and research students in Finance and Real-Estate, a valuable source of information that can serve them as a guide in their activities.

It is assumed that the reader has basic knowledge of financial markets, financial modelling, financial economics and statistics. The analysis presented in this book can be carried out with Excel and Matlab and many datasets used in this book are in the public domain.

While working on the RMBS desk in London at Merrill Lynch I came across a very interesting small portfolio in the aftermath of the subprime crisis. It was a set of property forwards on a real-estate index representative for the

UK market. Given the size of the residential mortgage backed securities I have thought that there *must* be a wide range of derivatives covering house prices offered by the banks. This proved to be wrong and there started my journey in this important area of finance.

At the time I have finished writing up this book the UK voted to leave in the Brexit referendum. There will be no doubt a lot of uncertainty over the years to come but I hope that the evolution of real-estate derivatives will not be hindered by the new political climate. There is a need for real-estate derivatives in order to stifle out speculation on property markets that are detrimental to us all. The big question is how to kick-start this market when the property markets stay for long time on a bull run reaching bubble states. The property owners would like to hedge the value of their properties and they would be naturally short on these property derivatives. The banks should be long property price risk since it is the only way they can be truly fully diversified. The recent stress exercises introduced by central banks and supervisory authorities will ask top banks to show the effects of a market downturn in real-estate on their portfolios. Property derivatives would help banks manage this enterprise risk management exercise. This seems to me to be the way forward.

Organization of the Book

This book can be used for a graduate class on real-estate finance and as an elective module on MBA and postgraduate research programmes in finance. Ultimately, the specialists working in investment area with exposure to real-estate price risk need to be aware of several facets of this type of risk, which are hopefully captured in the chapters of this book.

Chapter 2 presents the main real-estate indices used worldwide for investment purposes and on which derivatives contracts are very likely to be issued. For investors in financial markets, mortgages are the natural carrier of real-estate risk. Thus, an introduction to this asset class is given in Chapter 3. The distribution of risk resulting from holding mortgage loans has been done in recent years through the channels of securitization. The involvement of real-estate risk and description of some derivatives instruments directly related to the evolution of mortgages is covered in Chapter 4. A full description of real-estate derivatives is provided in Chapter 5 and some real-world applications are detailed in Chapter 6. The main models that have been proposed in the literature to help with this new important asset class are discussed at length in Chapter 7. A new frontier where real-estate derivatives are needed in relation to property price risk and negative equity insurance is highlighted in Chapter 8. The final chapter, Chapter 9, summarizes the main conclusions coming out of this monograph and also briefly discusses the outlook for real-estate derivatives.

■ ACKNOWLEDGEMENTS

This book took shape over a period of eight years, in the interesting times, for an academic, following the subprime crisis of 2007 and the series of events that followed. There are many people that helped me on this journey and to whom I will always be grateful. First of all, I would like to thank Robert Shiller for being a role model and for starting and persevering in advocating the promotion of real-estate derivatives as tools for stability in society. His contribution in this area over time has been truly outstanding and inspirational to myself. Secondly I would like to thank Frank Fabozzi for his constant help and advice on many issues related to this book.

I had the privilege to work with data on futures on IPD from their very beginning, after they were launched on EUREX. For this and for insightful discussions on the mechanics of the property futures, I am greatly in debt to Stuart Heath and Byron Baldwin and their team at EUREX in London for their support over the years. Special thanks are also owed to Tony Key at Cass Business School, for very interesting discussions on real-estate derivatives and for helping me contact other organizations who were doing actual business in real-estate derivatives. I would also like to acknowledge the help with data from Tradition Group in London, a market-maker in property derivatives, and the RBS real-estate desk, for help with unique datasets that are discussed in this book.

Some parts of this book emerged following joint research with some wonderful colleagues. To this end I am thankful to Silvia Stanescu and Made Reina Candradewi for their cooperation, particularly on the application on the arbitrage between total return swaps and futures markets on IPD. In addition, I would also like to thank participants at WHU Campus for Finance 2010, EFMA, Barcelona 2012, EFMA, Reading 2013, SUERF Property Prices and Real Estate Financing in a Turbulent World, Copenhagen 2013, for useful suggestions. I am indebted to Joao Cocco, Michael Dempster, Arturo Leccadito, Gianluca Marcato, Ekaterini Panopoulou, Hashem Pesaran for useful discussions and hints over the years, to Ana-Maria Dumitru, Jason Kynigakis, Tommaso Paletta, Sherry Zheng for help with data and to Filipa Tunaru for giving up her free time to proof-read the manuscript of this book.

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“Buy land, they are not making it anymore.”

Mark Twain

Quoted in *The Ladies' Home Journal*, Vol. 96 (1979), p. 10

1 An Overview of Real-Estate Prices

1.1 Introduction

In G7 countries, between 40% and 60% of total wealth is represented by real-estate. This is without a doubt one of the most important components in developed capitalist economies. Even after the introduction of new asset classes, the real-estate market still represents a substantial proportion of capital in the developed world. For example, the aggregate capital value of US stocks as of year-end 2008 was \$10.3 trillion, while for the same period this was \$20.5 trillion for residential housing and \$6.0 trillion for commercial property. As opposed to bond markets or equity markets where an investor has a flurry of financial products to choose from for various risk-return profiles, financial innovation seems to be lagging for real-estate. Academics have identified a series of possible factors that are an impediment to the evolution of financial products related to real-estate such as a lack of fungibility and granularity, tax, legal, and trading costs issues for the spot markets, a long intermediation period and so on. Large banks hold vast portfolios of assets, yet they have a limited exposure to real-estate. Hence, it is difficult to accept that they are really diversified. Their lack of engagement in real-estate investments is the main reason for the lack of development in real-estate spot and derivatives markets. Furthermore, every time there is a financial crisis investors move almost invariably their capital from various high-yield assets to where the fundamental value is perceived to be, with real-estate a particular destination. Gorton (2009) cited the lack of understanding of housing price risk as one of the major contributing factors to the subprime mortgage crisis.

1.1.1 REAL-ESTATE MARKETS

The real-estate market can be dichotomized into residential or housing properties on one side and commercial properties on the other. The former category has similar characteristics to fixed income markets driven by general evolution of interest rates and individual credit evaluations. The residential property embeds intrinsically a consumption aspect since by de facto people need to live somewhere. The latter category can be viewed as a combination of bond

and equity investments, the bond arising from the short-term lease. Supply and demand are very important for the price movements of both property markets. The relationship between storage and the commercial real-estate markets represented by the IPD index has been studied recently by Geman and Tunaru (2012).

US

At the turn of the new millennium Case et al. (2000) estimated the distribution of commercial real-estate in United States, with a total value of about \$6 trillion. By type of property, office was worth \$1.25 trillion, retail \$1.35 trillion, industrial and manufacturing \$0.8 trillion, apartments \$2.3 trillion, hotels \$0.22 trillion. From an owner perspective, commercial properties owned by corporate were valued at \$1.68 trillion, commercial mortgages \$1.43 trillion, \$0.175 trillion in equity real-estate investment trusts and \$0.110 in CMBS. Ruff (2007) pointed out that yields on commercial real-estate income in the US over the period 1965 to 2006 were always larger than 7% and averaged 9.6%.

UK

Baum (2001) has advocated the existence of cycles on property in the UK based on the evidence collated by IPD (RICS, 1999) for the period 1921 to 1998. Six cycles were identified given by the peaks in 1925–28, 1935, 1950, 1954, 1960–64, 1973, 1979–81, and 1989. Their research suggest that in the UK the cycles have a length between 4 to 12 years, with an average of 8 years.

Asian and Pacific countries

PWC (2016) describe the current trends in real-estate in Asian and Pacific countries.

The Japanese real-estate market is one of the largest in Asia. As with other developed economies, securitization connected the Japanese real-estate market with the financial investment market. However, in 2010 the securitized real-estate assets represented only 1.4% of the available real-estate assets. Japan suffers from a lack of inventory, having more buyers than available real-estate assets. Office values in Tokyo were up 20.6% year-on-year in the first half of 2015. Residential house prices look somehow stable, benefitting from a positive supply and demand balance. There is a real possibility of refinancing risk with many existing mortgage loans having a high LTV ratio becoming overdue.

There are some specific risks that may impact in the near future the real-estate market in Japan. The concentration of real-estate investment in Tokyo is a major concern as well as the well-known exposure to earthquake and

even tsunami. The ageing population may also cause problems in recirculation of real-estate inventory.

Singapore is another hot point for real-estate. The ten-year Urban Redevelopment Authority (URA) property price index generated an average capital return of almost 6% between 2005 and 2014. The hottest boom period was between 1989 and 1996, when real-estate prices in Singapore almost tripled in value.

Hong-Kong and Taiwan experienced periods of boom and bust in real-estate markets. They are very advanced in mortgage design and innovation. Given the problems posed by their ageing population needing long-term care is a significant problem. Thus, it is not surprising that new types of reverse mortgage type contracts are emerging from these areas.

Property market sentiment in China has turned negative in 2015, due to problems with the economy, a devaluation in the currency, and also the crash of the Shanghai stock exchange in the middle of 2015. Residential house prices decreased in the entire country with the exception of prime cities. Commercial property prices also dropped by 26% year on year in 2015. The cutting of interest rates, however, increased capital flows into real-estate in China. The difference between the real-estate market in China and that in other Asian countries like Japan, Australia, Hong Kong, Singapore, is that in China there is a need for more capital whereas in the other countries there is a need for more inventory.

1.2 Residential versus Commercial Property

As of 1999, Case et al. (2000) estimated that in United States there were approximately 103 million occupied houses, only two thirds being owned by their occupants. There were also an extra 13.4 million units that were occupied only seasonally or vacant. In United States, there have been periodic but localized housing price booms. In the 1980s the Massachusetts boom that occurred between the third quarter of 1983 until the third quarter of 1988 led to a total house value appreciation by \$116.8 billion. Subsequently, Massachusetts lost \$27.6 billion by the first quarter of 1991. Likewise, the California boom observed between the third quarter of 1985 to the third quarter of 1990 implied a total increase in house value of \$544.8 billion, but then it also lost \$121.5 billion by the first quarter of 1996. Furthermore, Texas also experienced a period of significant house value increase between the third quarter of 1986 and the third quarter of 1988 followed by a sharp fall. Other well-known property booms were the New England boom of 1983–88, the California boom of 1985–90, the Boston and Los Angeles booms in the late 1980s. In a series of papers Case and Shiller on one side (Case and Shiller,

1988, 1989, 1990) and also others such as Jim Clayton (Clayton, 1997) provide clear evidence that housing prices are sometimes driven by inertia and moreover, both housing buyers and sellers engage into house transactions based mainly on exuberant expectations. One of the main conclusions of the series of papers by Case and Shiller is that house price booms cannot be explained in terms of the value fundamentals, see Case and Shiller (1994) for a clear argument.

Case et al. (2000) reported that between 1988 to 1992 commercial real-estate values were falling dramatically on the north-eastern coast of United States and similar drops occurred all over Europe and in developed countries in Asia. As an example they pointed out that the 1.4-million-square-foot Wang Towers in Lowell, Massachusetts, acquired for \$107 million in 1988, was sold in 1992 for \$525,000. The sharp drop in value of commercial real-estate assets caused problems to many banks, leading some of them to failure. The House Banking Committee's review on Bank of New England's collapse in 1991 cited as the main cause the disintegration of the bank's commercial real-estate portfolio.

1.2.1 CHARACTERISTICS OF RESIDENTIAL PROPERTY

In order to establish a correct relationship between projected house prices and cash reserves against housing loans, we envisage that a good understanding of the dynamics of Case-Shiller index will benefit a wide range of financial advisors to households and financial institutions. Case and Shiller (1989) find positive serial correlation as well as inertia in house prices and excess returns, concluding that in the United States the market for single-family homes is inefficient. These characteristics make the real-estate market unique and the financial economics arguments invoked for product design, pricing or hedging are bound to be different from other asset classes.

1.2.2 CHARACTERISTICS OF COMMERCIAL PROPERTY

There is a well documented cyclicity, see Case et al. (2000), associated with commercial real-estate markets caused mainly by the long lag period of time between getting planning approved and finishing the construction of the new building. This time period is on average between five to ten years and for an investor this can be a very long period of time to wait. Furthermore, all other markets may experience important shifts during this time, new policies may be introduced, and the real economy as a whole may be influenced by external shocks. Hence, the expectations of future rents may change significantly. Furthermore, the inventory of similar available buildings plays also an important role in determining price for properties.

1.3 Empirical Characteristics of Real-Estate Prices Time Series

1.3.1 DETERMINANTS OF COMMERCIAL PROPERTY PRICES

One of the earlier research studies on establishing the determinants of commercial property prices was Hoag (1980) who proposed a technique, called the fundamental valuation, to determine the value of a commercial property at any point in time. The valuation was based on fundamental features such as business inventories, construction costs, transportation access and population, on economic and demographic variables at national, regional and local level and some temporal variables such as transaction prices and cash flows. The model was implemented for industrial properties and it can be described (see Hoag 1980, p.576) as:

$$P_{it} = \alpha_0 + \alpha_f f + \alpha_n n + \alpha_r r + \alpha_l l + \alpha_q q + \varepsilon_{it} \quad (1.1)$$

where f denoted general fundamental characteristic of value, n was the national economic concomitants of value, r is the regional economic concomitants of value, l is the local characteristics of value and q shows the temporal characteristics of value.

In his study a sample of 463 industrial properties with transaction prices reported in various quarter times during the period between the first quarter of 1973 and the last quarter of 1978 was used. Hoag (1980) employed a pooled cross-section time-series regressions with generalized least squares estimation to show that the average compound returns for the industrial real-estate value were 3.38% per quarter with a quarterly standard deviation of 8.61%. Over the same period the return seems high while the risk remains comparable with stocks and corporate bonds. Dobson and Goddard (1992) developed a regression model to calculate the prices and rents of commercial property as a linear function of employment and real interest rates. Their dataset covered price and rent for three sectors; industrial premises, shops and offices, in four regions in Great Britain between 1972 and 1987. The model is described by the following equation:

$$\text{real-estate price or rent} = p_{(k,t)}^j + r_{(k,t)}^j + e_{(k,t)}^j + i_t + h_{(k,t)} + w + x + y$$

where: $p_{(k,t)}^j$ is the logarithm of the inflation-adjusted capital value index for sector j and area k in year t , $r_{(k,t)}^j$ is the logarithm of inflation-adjusted rent index for sector j and area k in year t , $e_{(k,t)}^j$ is the logarithm of employees in employment index in sector j and area k in year t , i_t is the logarithm of $(1 + \text{real interest rate})$, where the real interest rate is the difference between the average yield on long-dated (20 year) British government securities and the rate of

increase in the retail price index in year t , $h_{(k,t)}$ is the logarithm of inflation-adjusted house price index for area k in year t , w is the dummy variable for area w ; x is the dummy variable for area x , y is the dummy variable for area y . Based on OLS estimation with and without restrictions Dobson and Goddard (1992) reveal that employment has an important influence on price, for industrial property in particular. Furthermore, both price and rents are also sensitive to interest rates. In a different study, Ling and Naranjo (1996) found evidence that the excess returns on commercial property is determined by the growth rate in real per capita consumption, the real T-bill rate, the term structure of interest rates, and unexpected inflation. Their study used data between the 1978 and 1994. The model they proposed, called the Multifactor Asset Pricing Model (MAP) is:

$$\tilde{r}_{it} = \lambda_0 t + \sum_{k=1}^K \beta_{ikt} \lambda_{kt} + \sum_{k=1}^K \beta_{ikt} [\tilde{F}_{kt} - E_{(t-1)}(F_{kt})] + \tilde{\varepsilon}_{it} \quad (1.2)$$

where the tilde () denotes a time t random variable and $\tilde{r}_{it}$ is the excess return for the i -th asset, $\lambda_0 t$ is the zero-beta excess rate of return, $E_{(t-1)}(z_t)$ is the expected value of z_t , F_{kt} is the k th of the K risk factors at time t , β_{ikt} is the possibly time-varying sensitivity of the i th asset to the k th risk factor, λ_{kt} is the risk premium (price of risk) corresponding to the k -th risk factor, $\tilde{\varepsilon}_{it}$ is a disturbance idiosyncratic to the i th asset. They reveal that the existence of a consistently significant risk premium on consumption suggests that previous literature highlighting significant abnormal returns (either positive or negative) but that have ignored consumption could be biased due to an omitted variables problem.

De Wit and Van Dijk (2003) searched for the determinants of office real-estate returns made of rents, capital appraisal, and total returns. The data under their analysis covered real-estate type variables such as the capital value, net rent, vacancy and office stock expressed in square meters but also macroeconomic indicators, such as GDP for Asia and Europe and GMP for the United States, unemployment on a national level for Asia and Europe and MSA employment for the United States, for 46 major office districts in Asia (13), Europe (24) and the United States (9) on quarterly basis between 1986 and 1999. The model they proposed as a vehicle for their analysis is a dynamic panel-data model that can prove to be very useful in accounting for a time lag to changing economic conditions. The model is specified as:

$$R_{it} = \beta_0 R_{i,t-1} + \beta_1 x_{1it} + \dots + \beta_K x_{Kit} + \mu_i + v_{it} \quad (1.3)$$

where R_{it} is the return of office district i in period t , x_{Kit} is a non-stochastic macroeconomic, supply or demand variable, β is the vector of parameters,