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The Anatomy of Public and Private Real Estate Return Premia

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Abstract Market-wide, stock market specific, and real estate market specific risk – what kind of risk and to which extent drives the returns of listed real estate? Based on a structural asset pricing model calibrated to the empirical data in the U.S., we show that at least two thirds of the risk premium of listed real estate are driven by the same factors as direct real estate. Our results shed new light on the risk-characteristics of listed real estate returns and are of high interest for academics, regulators, and portfolio managers alike.

Keywords Asset pricing · Direct real estate · Listed real estate · Real estate risk · Business cycle risk

JEL Classification G1 · G12 · G32 · R30

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Introduction

Over the past decades, the asset class of real estate has increasingly left 'Main Street' and entered 'Wall Street'. Real estate as the most important asset in the class of alternative investments has been securitized extensively during this time period. REITs are thereby the driving factor of an equity equivalent for stocks in the real estate sector. REITs – or listed real estate in general – overcome important challenges of investing in real estate markets, such as high transaction costs and time, high lot size, low liquidity, and information inefficiency, to name but a few. Substantial empirical work has been undertaken to shed light on the relationship between common stocks, listed real estate, and direct real estate (Ghysels et al. (2013) provide a comprehensive review of this literature). However, academics as well as practitioners are surprisingly divided in their opinion as to the fundamental driving factors behind the returns and risks of listed real estate investments. In line with a large part of the literature, the early study by Ross and Zisler (1991) finds that REITs co-move more closely with the stock market than with the real estate market.

Surprisingly, little research has been conducted to connect these findings in a theoretically rooted asset pricing framework, although a better understanding of this issue is of central importance for the literature. We give two recent examples from the literature to support this point. First, Ghysels et al. (2013) argue that REITs derive most of their income from real estate and thus provide a remarkably clean measure for testing real estate return predictability. Hence, econometric issues arising in forecasting regressions can largely be addressed. However, as the authors warn, if the risk and return characteristics of listed and direct real estate have different economic sources, results obtained from investigating the listed real estate market might not carry over to the direct real estate market. Second, following the arguments provided by Ang et al. (2013), determining the underlying risk factors of real estate assets is an important question for practitioners as well. Investors need a deeper understanding of the basic link between the different markets and influencing risk factors so that they know whether they are investing in real estate risk or stock market risk when they buy REIT shares – or to be more precise – to which extent they are exposing themselves to these risk factors.

This paper analyzes the joint stochastic properties of common stocks, listed real estate, and direct real estate, while providing a potential explanation of how a combination of risk factors might simultaneously drive the risk premia in all three markets. Our analysis proceeds as follows:

First, we investigate the empirical data as well as compare the return and risk characteristics of all three markets. We proxy common stocks with the Russell 3000 Index, listed real estate with the FTSE NAREIT Equity REIT Index, and direct real estate with the NCREIF NTBI Total Return Index. Our measure of direct real estate is a transaction-based index of the performance of real estate and is not subject to the appraisal smoothing bias (Ross and Zisler (1991) and Geltner (1993)). However, consistent with the literature, the NTBI moves with a time lag compared to REITs and is plagued with short-term noise at the quarterly time interval (Fisher et al. 2007). As a result, contemporaneous co-movement between direct real estate and listed real estate, as well as common stocks, is low. In contrast, measuring direct real estate returns with a lag of two quarters and sampling at an annual time interval, we find a significant correlation between direct real estate, listed real estate, and common stocks.

Second, after accounting for lagged movements in our measure of direct real estate returns, a principal component analysis reveals that two factors explain 94% of the variances of the three assets. The first is a common factor which loads almost equally on all three assets. We interpret this factor as evidence for the existence of a market-wide factor, i.e. business cycle risk, which affects all three assets. The second is a common stocks minus real estate assets factor. This factor loads positively on common stocks and negatively on listed real estate as well as direct real estate. We interpret this factor as the presence of two priced sources of risk in the data, namely stock market specific risk and real estate market specific risk, which show up as a long-short factor mimicking portfolio in the principal component analysis.

Third, we calibrate a simple asset pricing model which can replicate the observed empirical pattern and allows us to investigate the economic linkages between the stock market and the two real estate markets. This part is the main contribution of our paper. To the best of our knowledge, we are the first to quantitatively show to which extent REIT returns can be explained by a combination of risk factors in a structural model.

Motivated by the principal component analysis, our model has three sources of priced risk: business cycle risk, pure stock market risk, and pure real estate market risk. For a better understanding of potential linkages between the stock market and the real estate market, we apply two model specifications. In the first specification, there is a spillover channel from the stock market to listed real estate – which is not present in direct real estate. The second specification provides results for an idealized world in which listed real estate is exposed to *exactly* the same risk factors as direct real estate is.

We find that the model with stock market spillovers is closer to observed empirical characteristics of listed real estate than the model without spillovers is. It can replicate the descriptive statistics as well as the principal component analysis applied to the empirical data. However, due to the small sample nature of the empirical data, it is not possible to distinguish unambiguously between the two model specifications. In any case, the model allows us to dissect the risk premia of each of the three assets. For example, in the model specification with stock market spillovers, the expected listed real estate risk premium can be dissected into 36% stock market risk, 40% real estate risk, and 24% business cycle risk. Simply put, if we assume that listed real estate is exposed to additional risk factors, two thirds of the risk premium are still determined by the same sources of risk as for direct real estate. Therefore, our results show that listed real estate and direct real estate are likely to be driven (up to a large fraction) by common risk factors.

The remainder of this paper is organized as follows: In the next section, we give a short overview of the related literature. In "Empirical Data", we describe the empirical data we used and their descriptive statistics. The principal component analysis reveals the major risk factors driving the returns of each of the three assets. In "Model", we explain the risk sources of our structural model, the model calibration, and the simulation procedure. In "Results", we discuss our results in two different model specifications: with and without spillover effect from the stock market. The last section concludes.

Literature

The reason for investments in real estate is motivated by the attractive portfolio attributes, in particular with regard to low cross-correlation with stocks, low downside risk, and high inflation hedge ability. Private and institutional investors are interested in the risk-minimizing effects on their stocks- and bonds-dominated portfolios. There is broad literature on the portfolio diversification potential with real estate in a mixed-asset portfolio: The first strand of literature is domestic-oriented with Firstenberg et al. (1988), MacGregor and Nanthakumaran (1992), Byrne and Lee (1995), and Byrne and Lee (2005). The later studies focus more on the international perspective with Ziobrowski and Curcio (1991), Newell and Worzala (1995), Eichholtz (1996), Chua (1999), Stevenson (2000), Hoesli et al. (2004), and Kroencke and Schindler (2012) among others. All of them conclude – however, to a different extent – that real estate can serve as a risk diversifier as well as a return enhancer in a multi-asset portfolio.

Most of the studies use appraisal-based or transaction-based indices to approximate the return-risk relationship of the real estate sector. For example, Hoesli et al. (2004) find an optimal allocation of real estate of between 15% and 25% in a multi-asset portfolio with real estate stocks and direct real estate by using real estate indices. Although an index approximation is appropriate for the stock and bond markets through the easy replication possibility or the growing exchange-traded product market, there is no such possibility for the real estate market. To generate a more realistic volatility, many authors unsmooth the appraisal-based real estate indices that they used. In their parametric portfolio approach, Plazzi et al. (2011) show allocation benefits of different property types in a real estate portfolio. However, most investors are not able to invest in such a large number of properties as is necessary for mimicking a whole real estate index.[1] Subsequently, investors have to circumvent this drawback with an indirect investment vehicle, such as REITs. But therefore, it must be found out to what extent and temporal lag REITs are driven by the same risk factors as private real estate. For example, Ling and Naranjo (2015) show that REIT returns react to fundamental factors more quickly than private market returns do. Ghysels et al. (2013) trace the origin of predictability for both return series.

Since the market capitalization surge of listed real estate, many papers have brought different results for the question of whether REITs are real estate or stocks. But none of them have used a structural asset pricing model in their investigation. The large majority of these studies is empirical, resorting particularly to correlation and / or co-integration analyzes. Among the first studies examining common risk

[1] By using U.K. data from January 1979 to December 1982, Brown (1997) shows that an investor has to hold 100 properties to explain about 90% of the variation in portfolio returns. However, the market average of institutional investors with about 30 properties can only explain about 75%.

factors for private real estate markets and REITs, Liu et al. (1990) and Liu and Mei (1992) use a market integration approach and conclude that both markets are integrated. Along the same lines, Mei and Lee (1994) identify a common risk factor for indirect real estate and REIT returns. Whereas Li and Wang (1995) are not able to confirm a common real estate factor, they but identify dividend yield, term premium, and default premium as the three major risk factors for REIT returns.

The early correlation-based studies, among them are Goetzmann and Ibbotson (1990) and Ross and Zisler (1991), detect a return-risk profile of REITs similar to that of small-cap stocks and a stronger relationship between listed real estate and the general stock market rather than between listed real estate and the underlying real estate market. Goetzmann and Ibbotson (1990) compare the time series of REITs with commingled real estate funds as representatives for direct real estate investments and find only low correlation as well as deviating mean returns and volatilities. Their comparison with the S&P 500 Index also reveals closer similarities between REITs and the stock market. Ross and Zisler (1991) as well as later studies, among them are Clayton and MacKinnon (2001), confirm these results. In contrast, Barkham and Geltner (1995), Eichholtz and Hartzell (1996), and Seiler et al. (1999) among others, discover that direct and listed real estate are increasingly influenced by the same factors, so that real estate companies proxy the direct real estate market quite well. Moreover, Anderson et al. (2005) show that the volatility of REITs cannot be explained by other asset classes such as equity, bonds, and direct real estate. Ling et al. (2000) use multi-risk factors, including macroeconomic and financial risk factors, in order to explain excess REIT returns. They find that macroeconomic risk factors are of minor importance.

Recent co-integration studies, e.g. Morawski et al. (2008), Yunus et al. (2012), Boudry et al. (2012), and Hoesli and Oikarinen (2012), basically imply that private direct real estate lags behind listed real estate and that both types of investment may deviate substantially from each other, especially in the short-run. The long-term perspective, on the other hand, shows that direct and listed real estate have similar risk-return characteristics (e.g. Pagliari et al. (2005)). This is believed to be due to differences in terms of liquidity and valuation, which converge over time. As for listed real estate, liquidity induces more volatile returns Barkham and Geltner (1995). The appraisal-based valuation of the direct real estate market has lower frequencies and adjusts to market developments after a temporal lag (e.g. Giliberto (1990)). Both effects decrease over time. A reason for the remaining difference between these two investment vehicles can be found in the leverage effect. Oikarinen et al. (2011), for instance, explain the disparity by the average leverage level of indirect real estate companies in the U.S. Clayton and MacKinnon (2003) find that the REIT market moved from being largely driven by the same factors as large-cap stocks in the 1970s and 1980s to being dominated by small-cap and real estate driven factors in the 1990s. Assuming that REITs and direct real estate are driven by common shocks in the long-run, Ang et al. (2013) show that both real estate vehicles display similar characteristics over a full real estate cycle by controlling for the different level of leverage and property type focus. Ghysels et al. (2013) also emphasize the common dependency of the different real estate return series on the same factors.

To sum up, previous findings are not able to identify common risk factors for stocks, listed real estate, and private real estate markets, which are stable over a long time or different approaches. Thus, we want to go a step back and are interested in analyzing common factors between common stocks, listed real estate, and direct real estate with a structural asset pricing approach. By introducing this new model for an old research question, we would like to extend the tool kit, which may also point toward new avenues for future research.

Empirical Data

Data

This section presents the empirical data for common stocks, listed real estate, and direct real estate. Preferably, long time series are available to discover the relationship between these three assets. As is well known, data for the direct real estate market are the major limitation in this context and allow for an analysis of the time horizon from 1985 to 2011. The movements in the direct real estate market are gathered from the NCREIF NTBI Total Return Index. Following the argumentation of Boudry et al. (2012), this index is best qualified to be consistent with the investment universe of the listed real estate market. Besides its assets matching with the comparative listed market, this transaction-based index shows a better approximation of the direct real estate market than an appraisal-based index would do. These data are obtained from NCREIF's web page. For the listed real estate market, we use the FTSE NAREIT Equity REIT Index. This series includes all equity REITs not designated as timber or infrastructure REITs. These data are obtained from NAREIT's web page.[2] As a proxy for the risk-free interest rate, we use the data of the one-year treasury bill rates on Robert Shiller's web page.[3] To describe the properties of the stock market, we rely on the Russell 3000 Index. This series captures the returns of the largest 3,000 companies (based on total market capitalization) and represents around 98% of the investable U.S. equity market.[4] By using such a broad market index, we consider possible growth or market capitalization effects in returns. The returns are obtained from Thomson Financial Datastream.

Empirical Moments

Table 1 summarizes the empirical properties of common stocks, listed real estate, and direct real estate for the period from 1985 to 2011. The table provides results for data at quarterly as well as annual frequency. The annual frequency automatically filters short-term noise in the direct real estate data and also controls for the different transaction frequency among the quarters in the direct real estate market. Thus, we

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[2] See http://www.reit.com/DataAndResearch/IndexData.aspx for the data and http://www.ftse.com/products/downloads/FTSE_NAREIT_US_Real_Estate_Index_Series.pdf for a detailed description of the index classification system.

[3] See http://www.econ.yale.edu/~shiller/data.htm.

[4] See http://www.russell.com for a detailed description of the index.

Table 1 Empirical moments

	Yearly time interval, 1985-2011			Quarterly time interval, 1985-2011		
	STX	LRE	DRE	STX	LRE	DRE
$E\,(r^e)$	5.79	6.11	3.57	5.79	6.11	3.57
$\sigma\,(r^e)$	17.46	18.94	9.89	17.61	20.10	12.75
$AC1\,(r^e)$	−0.05	0.07	0.31	0.02	0.14	−0.16

The table shows empirical moments of common stocks (STX), listed real estate (LRE), and direct real estate (DRE) for a yearly and quarterly time interval. Returns are log returns in excess of the risk-free rate. Quarterly means and standard deviations are annualized. The sample period is 1985-2011

expect higher co-movement between direct real estate and the stock market, including listed real estate, at the annual frequency. We will focus our discussion on annual data; quarterly results are provided for completeness.

In line with the literature, we find lower average returns in excess of the one-year treasury bill for direct real estate (3.57%) compared to the listed real estate market (6.11%) and stocks (5.79%). Furthermore, not only the mean, but also the standard deviation is lower for the direct real estate market – 9.9% in comparison to 18.9% (listed real estate) and 17.5% (stocks). We do not observe lower return and risk for the direct real estate data due to the shortcomings of appraisal-based real estate indices – mostly influenced by the smoothing, temporal lag bias, and anchor effects of the appraisal process. These effects have no influence on our calculated average return, since we use a transaction-based index. First-order autocorrelation values are negative (−0.16) at the quarterly frequency and positive (0.31) at the annual frequency. Both first-order autocorrelations are not statistically significant and are around zero within the 95% confidence interval. This finding contrasts with appraisal-based indices, which would have a highly significant positive correlation, and therefore, a high predictive power for the return.

Co-movements

In a first step, we investigate pair-wise correlations between the different markets to identify linkages between them. To account for the lagged movement of direct real estate documented in the literature even for transaction-based real estate indices (e.g. Ang et al. (2013)), we investigate correlations between the stock market and real estate returns with a lag of up to eight quarters, as shown in Fig. 1. In line with the literature, we consider a maximum length of the temporal lag of two years or eight quarters.

At the quarterly frequency, the contemporaneous correlation between common stocks and listed real estate is about 0.60. In contrast, contemporaneous correlations between common stocks and direct real estate are close to zero using a quarterly time interval. Interestingly, up to two lags, correlations for lagged direct real estate tend to be larger. This could be driven by the methodology of the NTBI, as the hedonic value

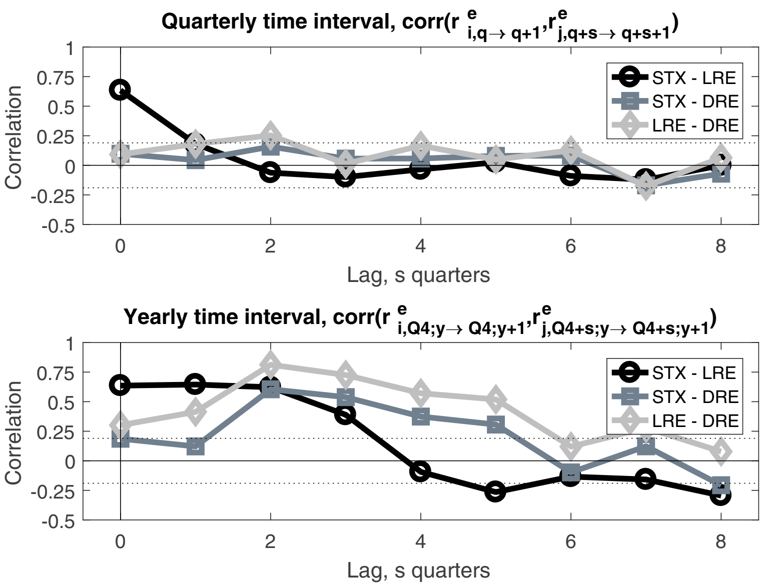

Fig. 1 Cross-correlation functions. The figure shows the cross-correlations of excess returns between common stocks (STX), listed real estate (LRE), and direct real estate (DRE). The upper figure provides correlations for quarterly returns. The lower figure provides correlations for (non-overlapping) fourth-quarter to fourth-quarter annual returns, whereas we lag annual returns in quarterly steps. For example, at lag=1, the figure shows the correlation between STX and DRE, where stock returns are measured from the fourth-quarter of year t to the fourth-quarter of year t+1, and direct real estate returns are measured from the next first-quarter to the following first-quarter. Dashed lines correspond to 95% confidence intervals. The sample period is 1985-2011

of its hedonic price model is lagged by two quarters prior to the current appreciation level.

At the annual time interval, we observe somewhat larger, but still low correlation between direct real estate and the other two assets when sampling them contemporaneously. We lag annual direct real estate returns using quarterly steps as well. More precisely, we begin with contemporaneous annual correlations which are computed from returns measured from the fourth quarter of year t to the fourth quarter of year t+1. At the lag length equal to one quarter, stock market returns are still computed from the fourth quarter of year t to the fourth quarter of year t+1, but direct real estate returns are now measured from the first quarter of year t+1 to the first quarter of year t+2. Notice that all annual returns are calculated non-overlappingly. Computing annual correlations with direct real estate lagged in quarterly steps accounts for the different transaction frequency among the quarters in direct real estate as well as for lags in transaction prices of direct real estate. When direct real estate returns are computed from the second quarter to the second quarter of the following year, the correlation between direct real estate and listed real estate is as large as 0.81, and the correlation between direct real estate and common stocks is 0.60. Regarding NPI appraisal data, we find the largest number of observations in the second calendar quarter, so that the income component of the NTBI is closer to the latest data of listed real estate and stock market in the second quarter than in the other three quarters. Also Fisher et al. (2004) report the values of the second quarter of each year in their analysis of the determinants of transaction frequency.

Principal Components

Table 2 provides the principal components of common stocks, listed real estate, and direct real estate by using the annual time interval. Direct real estate is lagged by two quarters, to account for transaction lags as described above, and such that we extract the maximum available correlation from the data.

The first principal component (PC1) is simply an average of all three assets and explains up to 79% of the assets' variances. We gage from the PC1 that there is one common factor between all three assets which drives their co-movement. The second principal component (PC2) is long in common stocks, short in listed real estate, and short in direct real estate. Interestingly, the short lag of this factor, the real estate component, has a larger weight in direct real estate than in listed real estate. The common stocks minus real estate factor explains up to 15% of the assets' variances.

Instead of a long-short portfolio factor, this factor can be interpreted without any loss of generality as two distinct (orthogonal) factors. The first one measures stock market specific risk, whereas the second measures real estate market specific risk.

Table 2 Principal components

	Yearly time interval, 1985-2011		
	Correlations		
	STX	LRE	DRE
STX, Q4-Q4	1.00		
LRE, Q4-Q4	0.64	1.00	
DRE, Q2-Q2, s=2	0.60	0.81	1.00
	Principal components		
	PC1	PC2	PC3
STX, Q4-Q4	0.54	0.84	0.06
LRE, Q4-Q4	0.60	−0.33	−0.73
DRE, Q2-Q2, s=2	0.59	−0.43	0.68
% Var.	79.10	14.69	6.21

The table reports the principal component coefficients for excess returns of common stocks (STX), listed real estate (LRE), and direct real estate (DRE) using a yearly time interval. The correlation matrix to compute the principal components (provided in the upper panel) is calculated from fourth-quarter to fourth-quarter returns for common stocks as well as listed real estate and from lagged (s=2) second-quarter to second-quarter returns for direct real estate. The last row gives the share of the total variance explained by each of the principal components. The sample period is 1985-2011

Accordingly, we will incorporate these two stock and real estate specific risk factors into our model.

Finally, the third principal component (PC3) is short in listed real estate and long in direct real estate and has no significant loading with respect to common stocks. This factor captures any remaining differences between listed and direct real estate, for example, different industry or geographical exposures of the two indices in the data. The PC3 only accounts for 6% of the assets' variances, and therefore, we ignore this component in the following.

To sum up, the principal component analysis suggests that we need at least three factors to jointly model common stocks, listed real estate, and direct real estate. First, a factor which is common to all three assets. We think of this factor as a business cycle risk, or market-wide risk, which affects common stocks as well as both real estate assets. The second factor is pure stock market risk and the third factor is pure real estate market risk. In the following, we will present a simple model of how these three factors may drive the returns of all three assets.

Model

We want to know how the determinants for risk premia of common stocks, listed real estate, and direct real estate are related to each other in order to generate the empirically observed patterns discussed in the previous section. To this end, this section proposes a structural model for analyzing the joint driving forces behind the returns of the three relevant assets. The aim is to quantitatively account for the stochastic properties of common stocks, listed real estate, and direct real estate, while at the same time the model enables an investigation of economic linkages between the stock market and the real estate market. Our modeling approach closely follows that of Koijen et al. (2017), which we extend and adapt for real estate assets.[5] The model has three main ingredients – business cycle risk, assets' characteristics, and the stochastic discount factor – which are discussed in the following subsections.

Market-wide Risk

The first ingredient of the model is the state variable, s_t, which measures activity in the real economy and can be interpreted as a leading indicator of the business cycle. In this connection, higher economic activity is transformed into higher values of s_t. With this factor, we summarize all dynamics between the state of the macroeconomy and the different assets' characteristics. In line with the data, the state variable has a modest autoregressive persistence at annual frequency, so that it oscillates with the business cycle (see Koijen et al. (2017)). The shocks to the state variable, ϵ^s_{t+1}, capture business cycle risk, or 'market-wide' risk, and are the first priced source of risk in the model.

[5] Koijen et al. (2017) characterize the relationship between business cycle risk, the bond risk premium, and the value premium of common stocks.

Assets' Characteristics

The second ingredient is a specification for the process of dividend growth ($\triangle d^i_{t+1}$) of the aggregate common stock market ($i = M$) as well as of the listed real estate market ($i = L$) and rent growth of the direct real estate market ($i = D$). The real dividend growth of all three assets is described by the equation:

$$\triangle d^i_{t+1} = \gamma_{0i} + \gamma_{1i} s_t + \sigma_{mi} \epsilon^m_{t+1} + \sigma_{di} \epsilon^d_{t+1}, \ \forall i = \{M, \ L, \ D\}. \tag{1}$$

Aggregate stock market dividend shocks are captured by ϵ^m_{t+1} and are the second priced source of risk. Similarly, real estate market rent shocks are captured by ϵ^d_{t+1} and are the third priced source of risk. Thus, cash-flow growth of all three assets depends on the state of the economy (s_t), i.e. market-wide risk, and a combination of stock market shocks (ϵ^m_{t+1}) and real estate market shocks (ϵ^d_{t+1}). Notice that stock market shocks and real estate market shocks are defined orthogonal to market-wide risk (ϵ^s_{t+1}), comparable to the principal component analysis above. They capture shocks that only affect the stock market *or* the real estate market.

Direct real estate has no exposure to stock market shocks ($\sigma_{mD} = 0$), and the stock market has no exposure to real estate market shocks ($\sigma_{dM} = 0$). However, the stock market and direct real estate market are positively exposed to the business cycle and therefore market-wide risk ($\gamma_{1M} > 0, \ \gamma_{1D} > 0$). Dividends as well as rents are high in economic upturns and they are low in economic downturns. This channel introduces co-movement between the two assets during the business cycle.

Listed real estate is a financially leveraged claim on direct real estate traded on a stock exchange. In our model, we take into account that listed real estate is highly leveraged and assume a leverage factor of two – defined as the debt-to-equity ratio. The underlying idea behind this assumption is the fundamental relation between return on equity (ROE), return on asset (ROA), interest rate for debt (r_{Debt}), and the leverage factor – measured by the ratio of debt (D) and equity (E) and formalized by: $ROE = ROA + \frac{D}{E}(ROA - r_{Debt})$. Transposed to our analysis, the return of listed real estate (ROE) can be explained by the financially unleveraged return of direct real estate[6] (ROA) and financial leverage. The historical balance sheet data for listed real estate show an average leverage factor of 2.[7] Accordingly, listed real estate is exposed to real estate market risk twice as much as direct real estate, $\sigma_{dL} = 2 \times \sigma_{dD}$. The same applies to the sensitivity to business cycle risk, $\gamma_{1L} = 2 \times \gamma_{1D}$. Furthermore, listed real estate companies are value stocks (e.g. Clayton and MacKinnon (2001)). Koijen et al. (2017) show that value stocks are more sensitive to business cycle risk; therefore, we impose the restriction $\gamma_{1L} > \gamma_{1M}$ on the model parameters.

[6]The real estate returns are reported to NCREIF on an unlevered basis. For a detailed description of the methodology for producing the transactions-based index (TBI) using the NCREIF database, see Fisher et al. (2007).

[7]For this approximation, we use the data of total debt and equity of Equity REITs between 1990 and 2010 obtained from SNL Financial. The precise ratio rounded to three decimal places is 1.995.

We consider the possibility of a stock market spillover on the market for listed real estate, which can be generally captured by $\sigma_{mL} \neq 0$. Particularly, we consider the following two alternative model specifications:

$$\sigma_{mL} = \begin{cases} \sigma_{mM}/2 & Model\ 1: \ with\ stock\ market\ spillovers, \\ 0 & Model\ 2: \ without\ stock\ market\ spillovers. \end{cases}$$

In model 1, shocks in the stock market are directly transmitted to the listed real estate market by a factor of one half. In model 2, shocks in the stock market are not transmitted to the listed real estate market. Notice that also in model 2, the business cycle channel (γ_{1i}) still connects both markets.

Stochastic Discount Factor

The last ingredient is a specification of the log stochastic discount factor (SDF), which summarizes the preferences of a marginal investor by:

$$-m_{t+1} = y + \Lambda' \epsilon_{t+1}, \tag{2}$$

where the vector $\epsilon_{t+1} = \left(\epsilon^s_{t+1}, \epsilon^m_{t+1}, \epsilon^d_{t+1}\right)'$ captures the shocks, and $\tilde{y} = y - \frac{1}{2}\Lambda'\Lambda$ is the real interest rate. Our SDF implies three positively priced sources of risk, which are summarized by the vector $\Lambda = (\Lambda_m, \Lambda_d, \Lambda_s)'$. The first element captures aggregate stock market risk ($\Lambda_m > 0$), the second aggregate real estate market risk ($\Lambda_d > 0$), and the third business cycle risk ($\Lambda_s > 0$). The risk factor prices will mainly determine the model-implied average returns of our three assets, given the pre-specified processes of dividend growth, and they are also the free parameters of our model. Further technical details of the model are shown in the Appendix.

Parameter Values and Simulation Procedure

We follow a two-step procedure to calibrate our model. First, we choose the dividend parameters for common stocks and direct real estate to match the empirical properties of dividends and rents. For listed real estate dividend growth, we follow our theoretical parameter restrictions outlined above. Parameter values for the state variable (s_t) are directly adopted from Koijen et al. (2017).[8] Second, given the parameter values of the first step, we choose SDF risk prices, the parameter vector Λ, to generate model-implied risk premia which are close to the observed average returns of common stocks, listed real estate, and direct real estate. The exact parameter values are provided in the Appendix.

To simulate data of common stocks, listed real estate, and direct real estate, we simulate monthly data for 27 years, which we convert to annual observations. Returns for stocks and listed real estate are calculated using end-of-year index level observations. For direct real estate, we sum index levels of October, November, and

[8]They calibrate the state variable according to the Cochrane and Piazzesi (2005) factor.

December to an aggregated fourth-quarter index, since this procedure is more similar to the construction of direct real estate indices, which are available in empirical data. Finally, we calculate annual direct real estate returns based on the aggregated fourth-quarter index. (This approach will also induce a modest degree of serial correlation in simulated direct real estate data.) We repeat this procedure 10,000 times and compare the simulations to 27 years of empirical data with annual observations from 1985 to 2011. We compare our model to the data at an annual time interval, since the annual frequency automatically filters out seasonality as well as short-term noise of quarterly direct real estate data.

Results

This section confronts our structural model with the data. We provide results from simulated model-implied returns for common stocks, listed real estate, and direct real estate. We examine two model specifications: first, a model specification with spillovers from common stocks to listed real estate; and second, a model specification without such spillover effects.

Model Specification with Spillovers (Model 1)

Table 3 shows medians and the 90% confidence intervals of 10,000 simulated moments for returns of common stocks, listed real estate, and direct real estate. Each simulation covers 27 observations of annual data, the same size as the empirical data available. The model with spillovers from the stock market to listed real estate matches the mean, standard deviation, and autocorrelation of each of the three assets well. In Panel A, comparable to the empirical data, average returns and standard deviations are slightly larger for listed real estate compared to common stocks, and the first and second moment are much lower for direct real estate compared to listed real estate. Only the empirical autocorrelation of direct real estate (0.31) is marginally outside of the 90% confidence interval of simulated returns ([−0.30, 0.30]).

In Panel B, the parameter values for the model with spillovers generates a correlation between common stocks and listed real estate of 0.62 and a correlation coefficient between listed real estate and direct real estate of 0.87; similar to the data (the respective numbers are 0.64 and 0.81). However, the correlation between common stocks and direct real estate is only 0.27 in the model compared to 0.60 in the data. Compared to direct real estate, the stock market correlation of listed real estate is twice as large (0.62 vs. 0.27).

Panel C reports the principal component coefficients for the simulated data. We identify the almost identical pattern in the simulated data to that in the actual data. The first principal component is equally weighted among the three assets and explains the majority of the variance of the three assets, i.e. 73% in the simulation compared to 79% in the actual data. The second principal component is a common stocks minus real estate assets factor and explains 25% of the variance of the three assets, compared to 15% in the data. Also, the qualitative magnitude of the PC2

Table 3 Simulated moments: model with spillovers

	Medians			90% Confidence intervals		
	STX	LRE	DRE	STX	LRE	DRE
Panel A: Mean, standard deviation, and serial correlation						
$E(r^e)$	5.32	5.78	2.01	[0.29, 10.24]	[−0.25, 11.87]	[−0.73, 4.77]
$\sigma(r^e)$	15.37	18.51	8.20	[11.96, 19.07]	[14.31, 22.85]	[6.38, 10.16]
$AC1(r^e)$	−0.04	−0.03	0.00	[−0.33, 0.27]	[−0.33, 0.26]	[−0.30, 0.30]
Panel B: Correlations						
STX	1.00					
LRE	0.62	1.00		[0.37, 0.78]		
DRE	0.27	0.87	1.00	[−0.07, 0.54]	[0.76, 0.93]	
Panel C: Principal components						
	PC1	PC2	PC3	PC1	PC2	PC3
STX	0.47	0.83	0.31	[0.26, 0.54]	[0.74, 0.92]	[0.20, 0.43]
LRE	0.66	−0.08	−0.74	[0.62, 0.71]	[−0.18, 0.03]	[−0.77, −0.70]
DRE	0.59	−0.55	0.59	[0.55, 0.65]	[−0.66, −0.38]	[0.51, 0.66]
% Var.	73.22	25.17	1.54	[63.21, 82.85]	[15.79, 34.89]	[0.81, 2.88]

The table shows simulated moments for returns of common stocks (STX), listed real estate (LRE), and direct real estate (DRE) for a yearly time interval. Returns are log returns in excess of the risk-free rate. Reported are the medians and the 90% confidence interval of 10,000 simulations with a length of 27 years. Data are simulated monthly and converted to an annual frequency

coefficients matches with the data: The coefficient on direct real estate is in absolute terms larger than the coefficient on listed real estate (−0.55 vs. −0.08). Intuitively in the model with spillover channel, direct real estate is a better measure of real estate risk than listed real estate is, which is reflected by these coefficients. The third principal component captures differences between listed and direct real estate and is only of marginal relevance in the simulation as well as in the data as discussed before.

Model Specification without Spillovers (Model 2)

Next, we switch off the stock market spillover channel from common stocks to listed real estate to see how our results change. As can be inferred from Panel A in Table 4, this model specification again matches the mean, standard deviation, and autocorrelation of each of the three assets well, i.e. the empirical moments are almost all within the 90% confidence interval of the simulated data. However, it turns out that it is more difficult to match average returns of listed real estate and direct real estate with the data, since listed and direct real estate returns are more closely linked to each other. To generate larger average returns of listed real estate compared to direct real estate, we need to increase the price of real estate risk (Λ_d), which in turn also

Table 4 Simulated moments: model without spillovers

	Medians			90% Confidence intervals		
	STX	LRE	DRE	STX	LRE	DRE
Panel A: Mean, standard deviation, and serial correlation						
$E\,(r^e)$	4.72	5.02	2.90	[−0.18, 9.69]	[−0.40, 10.49]	[0.18, 5.64]
$\sigma\,(r^e)$	15.39	16.94	8.18	[11.96, 19.06]	[13.16, 20.97]	[6.37, 10.13]
$AC1\,(r^e)$	−0.04	−0.04	0.00	[−0.33, 0.26]	[−0.34, 0.27]	[−0.30, 0.30]
Panel B: Correlations						
STX	1.00					
LRE	0.27	1.00		[−0.05, 0.55]		
DRE	0.26	0.95	1.00	[−0.07, 0.54]	[0.91, 0.98]	
Panel C: Principal components						
	PC1	PC2	PC3	PC1	PC2	PC3
STX	0.33	0.93	0.01	[0.04, 0.49]	[−0.97, 1.00]	[−0.07, 0.09]
LRE	0.67	−0.22	−0.71	[0.62, 0.71]	[−0.35, −0.02]	[−0.72, −0.69]
DRE	0.67	−0.24	0.71	[0.62, 0.71]	[−0.37, −0.03]	[0.69, 0.72]
% Var.	69.53	28.93	1.48	[64.73, 79.34]	[19.16, 33.32]	[0.73, 2.95]

The table shows simulated moments for returns of common stocks (STX), listed real estate (LRE), and direct real estate (DRE) for a yearly time interval. Returns are log returns in excess of the risk-free rate. Reported are the medians and the 90% confidence interval of 10,000 simulations with a length of 27 years. Data are simulated monthly and converted to an annual frequency

increases average returns of direct real estate. Furthermore, the missing spillover channel reduces the standard deviation of simulated listed real estate returns and also reduces the correlation coefficient between common stocks and listed real estate to 0.27 (model 1: 0.62, empirical data: 0.64) in Panel B.

Panel C shows that the first two principal components again identify an equally weighted factor among all three assets as well as a common stocks minus real estate assets factor, similar to model 1 and the data. One difference is that in the model without spillovers, the PC2 coefficients on direct real estate and listed real estate have now the same magnitude. This is sensible for model 2, as both real estate assets reflect real estate risk equally well.

Dissecting Risk Premia

A potential pitfall of the principal component analysis is that the factors we extract are mixtures of the ‘true’ underlying driving factors. For example, the first principal component (in the model as well as in the data) is basically an equally weighted portfolio of common stocks, listed real estate, and direct real estate; thus, it captures stock market risk, real estate market risk, and business cycle risk at the same time and is therefore difficult to interpret. Fortunately, we can exactly dissect

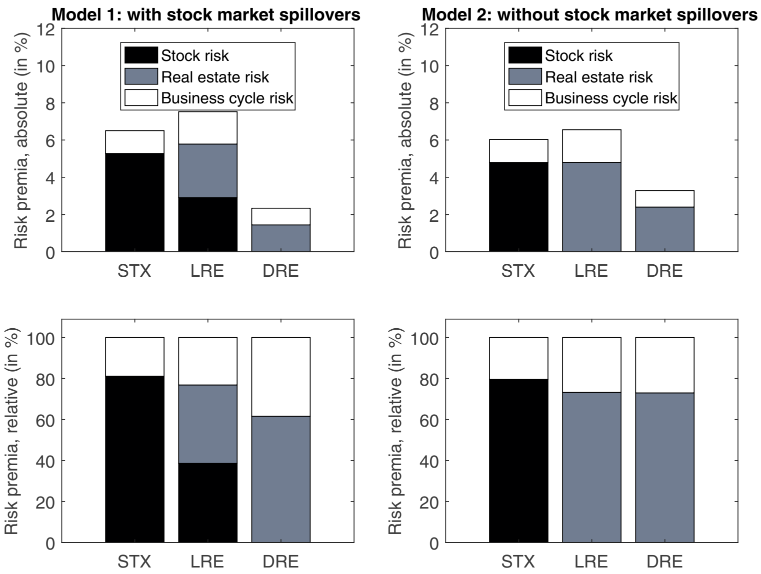

Fig. 2 Dissecting risk premia. The figure dissects the model-implied expected risk premia of common stocks, listed real estate, and direct real estate in compensation for stock market risk, real estate market risk, and business cycle risk. Model 1 includes stock market spillovers, and model 2 does not include them

average returns of the three assets with respect to the three factors by using our model.[9]

As we show in Fig. 2, in the model with spillovers, the expected stock market premium is composed of 81% stock market risk and 19% business cycle risk. The expected direct real estate premium combines 62% real estate risk and 38% business cycle risk. Finally, the expected listed real estate premium can be split into 36% stock market risk, 40% real estate risk, and 24% business cycle risk.[10] In contrast, in the model without spillover effects, the expected listed real estate premium is now basically a leveraged claim on the same combination of risk factors as for direct real estate. The total risk premium of listed *and* direct real estate is composed of 73% real estate risk and 27% business cycle risk. Similar to the first model, the expected premium on common stocks comprises 80% stock market risk and 20% business cycle risk.

Clearly, in both models, the common risk factor (business cycle risk) is of minor importance for explaining average returns of the three factors compared to the stock market risk specific factor or the real estate market risk specific factor. The bottom line of this figure is that even if common stocks and real estate assets are explained by their first principal component to a large extent, as in the data and our model, their returns may be extensively driven by distinct factors.

[9]Computational details are provided in the Appendix.

[10]The slightly larger business cycle risk of listed real estate compared to that of stocks is consistent with the fact that these companies are value and small / mid cap stocks (see Koijen et al. (2017)).

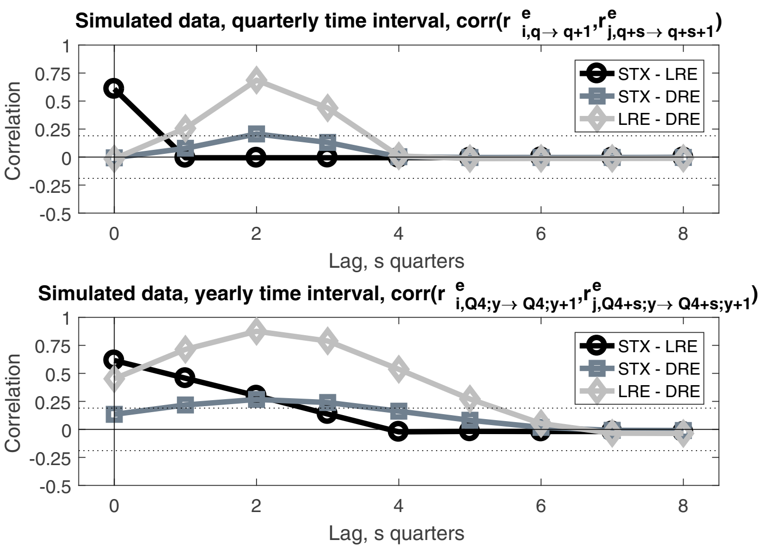

Fig. 3 Cross-correlation functions of simulated data. The figure shows the cross-correlations of simulated (model 1, with spillovers) excess returns between common stocks (STX), listed real estate (LRE), and direct real estate (DRE)

Accounting for Lags in Transaction Prices

Figure 1 shows that transaction prices of direct real estate display a substantial lag of several quarters compared to listed real estate. So far, we have ignored this fact in our structural model. In this section, we propose a simple approach to incorporate the lag pattern in transaction prices. We assume that the *measured* return of direct real estate, $\tilde{r}_t^d$, is a weighted average of *true* returns of direct real estate with some lag, r_{t-k}^k:

$$\tilde{r}_t^d = \sum_{k=k1}^{K} r_{t-k}^k, \tag{3}$$

where the time interval is monthly. The idea here is that the price of a property is fixed at $t - k$; however, it takes up to t until the transaction has been executed and incorporated into the transaction-based price index. Moreover, the exact time span between the time when the price of a property is fixed until the transaction has been executed might differ from property to property.[11] To account for this variation, we take a weighted average of lagged true direct real estate returns in our model from the past 8 to 3 months ($k1 = 3$, $K = 8$) and compute a lagged direct real estate return series, which we convert to a quarterly and annual time interval such that the series are comparable to the data. For the U.K. market, Crosby and McAllister (2004) and Bond et al. (2007) find an average time period from the marketing to the price agreement of 6.0 months, to the exchange of contracts of 8.7 months and to the period

[11]Notice that this transaction lag is distinct from the smoothing lag induced by the appraisal-based estimation process.

of completion of 9.4 months.[12] For the U.S. market, we assume similar marketing periods so that we vary the lag between the above mentioned lengths.

Figure 3 provides the cross-correlation function for the simulated lagged direct real estate returns, using the same procedure as applied in Fig. 1 for the empirical data. Our simple adjustment to account for lags in transaction prices of direct real estate can match the hump-shaped cross-correlation functions in the data well, in particular at an annual time interval. At the quarterly time interval, the simulated data show larger correlation compared to the empirical data. This finding, again, is likely to be explained by seasonality and short-term noise in quarterly direct real estate data.

Conclusion

We propose a structural asset pricing model to disentangle the relationships between common stocks, listed real estate, and direct real estate market. In line with a principal component analysis of the empirical data, the model has three sources of risk, which we identify as: market-wide risk (or business cycle risk), stock market specific risk, and real estate market specific risk. The model can replicate several empirical properties of all three assets. A specification which includes a medium-sized spillover channel from common stocks to listed real estate – which is not present in direct real estate – is closest to the data and exhibits that the expected listed real estate risk premium can be dissected into 36% stock market risk, 40% real estate risk, and 24% business cycle risk. However, also a model in which listed and direct real estate are exposed to exactly the same risk factors is not rejected by the data. Our results show that listed real estate and direct real estate are likely to be driven up to a large fraction by common risk factors. We hope that our approach and results will point toward new avenues for future research into the relationship between different risk factors for listed and direct real estate. The influence of more risk factors, higher frequency, different time periods as well as different spillover specifications for different market periods is an area requiring further studies.

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Appendix: Details of the Model

In this section, we outline the details of our structural model of listed and direct real estate. The model is a variant of Koijen et al. (2017). The derivations below closely follow their discussion.

[12] The sample is based on 177 transactions between 1995 and 2002 of three institutional investors.

Economy Macroeconomic activity, s_{t+1}, is the central state variable of the structural model. It captures business cycle activity, i.e. the state of the economy, through an autoregressive process and can be described by the following process:

$$s_{t+1} = \rho_s s_t + \sigma_s \epsilon^s_{t+1}.$$

High values of s_{t+1} correspond to strong economic activity. The parameter ρ_s implies that business cycle activity is to some degree persistent. The innovation term, ϵ^s_{t+1}, is the first priced source of risk in the model.

We model the returns of three assets. The first is the aggregate stock market (M), the second is listed real estate (L), and the third is direct real estate (D), so that the real dividend growth of asset $i = \{M,\ L,\ D\}$ is described by:

$$\triangle d^i_{t+1} = \gamma_{0i} + \gamma_{1i} s_t + \sigma_{mi} \epsilon^m_{t+1} + \sigma_{di} \epsilon^d_{t+1},\ \forall i = \{M,\ L,\ D\}.$$

Shock ϵ^m_{t+1} is an aggregate stock market dividend shock, the second source of risk for the structural model. Shock ϵ^d_{t+1} is an aggregate direct real estate rent shock and the third source of risk. The parameter γ_{1i} is the sensitivity of dividend growth to business cycle activity. Listed real estate is leveraged; thus, we set $\gamma_{1L} = 2 \times \gamma_{1D}$ and $\sigma_{dL} = 2 \times \sigma_{dD}$ to capture a leverage of two against direct real estate. Furthermore, listed real estate vehicles are value stocks. In line with this observation, we impose $\gamma_{1L} > \gamma_{1M}$, since Koijen et al. (2017) show that value stocks are more sensitive to recession risk than growth stocks. The coefficient σ_{mi} represents stock market risk and is zero for direct real estate ($\sigma_{mD} = 0$). We can utilize this coefficient to model stock-market spillovers in listed real estate by $\sigma_{mL} > 0$.

Investors' preferences are captured by a stochastic discount factor (SDF) following the log process:

$$-m_{t+1} = y + \Lambda' \epsilon_{t+1},$$

where the vector $\epsilon_{t+1} = \left(\epsilon^m_{t+1}, \epsilon^d_{t+1}, \epsilon^s_{t+1}\right)'$captures the shocks, and $\tilde{y} = y - \frac{1}{2}\Lambda'\Lambda$ is the real interest rate. This model has three positively priced sources of risk: aggregate stock market dividend risk ($\Lambda_m > 0$), aggregate direct real estate rent risk ($\Lambda_d > 0$), and business cycle risk ($\Lambda_s > 0$), which are summarized via the vector:

$$\Lambda = \begin{pmatrix} \Lambda_m \\ \Lambda_d \\ \Lambda_s \end{pmatrix}.$$

Asset Prices The log return of asset i follows:

$$r^i_{t+1} = \kappa_{0i} + \kappa_{1i} pd^i_{t+1} + \triangle d^i_{t+1} - pd_t,$$

where pd^i_{t+1} is the log price-dividend ratio, and κ_{0i}, κ_{1i} are constants (see below). The log-price-dividend ratio is linear in the state of the economy:

$$pd^i_{t+1} = A_i + B_i s_{t+1},$$

where

$$B_i = \frac{\gamma_{1i}}{1-\kappa_{1i}\rho_s},$$
$$A_i = \frac{-y+\gamma_{0i}+\kappa_{0i}+\frac{1}{2}\sigma_{mi}^2+\frac{1}{2}\sigma_{di}^2+\frac{1}{2}\kappa_{1i}^2 B_i\sigma_s^2-\Lambda_m\sigma_{mi}-\Lambda_d\sigma_{di}-\Lambda_s\kappa_{1i}B_i\sigma_s}{1-\kappa_{1i}}.$$

Decomposition of Risk Premia The risk premium for our three assets can be computed by the covariance to the SDF:

$$\begin{aligned} E_t\left(r_{t+1}^i-y\right)+\frac{1}{2}V_t\left(r_{t+1}^i\right) &= Cov_t\left(-m_{t+1},r_{t+1}^i\right) \\ &= Cov_t\left(\Lambda'\epsilon_{t+1},\kappa_{1i}B_i\epsilon_{t+1}^s+\sigma_{mi}\epsilon_{t+1}^m+\sigma_{di}\epsilon_{t+1}^d\right) \\ &= \Lambda_m\sigma_{mi}+\Lambda_d\sigma_{di}+\Lambda_s\kappa_{1i}B_i. \end{aligned}$$

The first component of the constant risk premium compensates investors for aggregate stock market dividend risk ($\Lambda_m\sigma_{mi}$). For direct real estate $\sigma_{mD} = 0$; thus, this term is zero. The second component of the constant risk premium compensates investors for aggregate real estate rent risk ($\Lambda_d\sigma_{di}$). For the aggregate stock market $\sigma_{dM} = 0$; thus, this term is zero. The third constant risk premium term compensates for business cycle risk ($\Lambda_s\kappa_{1i}B_i\sigma_s$).

Proof The logreturn for any asset i can be approximated by e.g. Campbell et al. (1997):

$$\begin{aligned} r_{t+1} &= \kappa_0+\kappa_1 pd_{t+1}+\Delta d_{t+1}-pd_t, \\ \kappa_0 &= ln\left(exp\left(\bar{pd}\right)+1\right)-\kappa_1\bar{pd}, \\ \kappa_1 &= \frac{exp\left(\bar{pd}\right)}{exp\left(\bar{pd}\right)+1}, \end{aligned}$$

where we drop the subscripts i for convenience. The log price-dividend ratio is assumed to be linear in the state of the economy:

$$pd_{t+1} = A + Bs_{t+1}.$$

The coefficients A and B are found by solving the asset pricing equation:

$$E_t\left(M_{t+1}R_{t+1}\right) = 1,$$

$$1 = E_t\left(exp\left(m_{t+1}+r_{t+1}\right)\right),$$

$$0 = E_t(m_{t+1}) + \frac{1}{2}V_t(m_{t+1}) + E_t(r_{t+1}) + \frac{1}{2}V_t(r_{t+1}) + Cov_t(m_{t+1}, r_{t+1}),$$
$$= -y + \kappa_0 + \gamma_0 + \gamma_1 s_t + (\kappa_1 - 1)A + (\kappa_1\rho_s - 1)Bs_t + \frac{1}{2}\sigma_m^2 + \frac{1}{2}\sigma_d^2$$
$$+ \frac{1}{2}\kappa_1^2 B^2\sigma_s^2 - \Lambda_m\sigma_m - \Lambda_d\sigma_d - \Lambda_s\kappa_1 B\sigma_s.$$

Collecting all s_t terms and all others results in the following system of two equations:

$$0 = \gamma_1 s_t + (\kappa_1\rho_s - 1)Bs_t,$$
$$0 = -y + \kappa_0 + \gamma_0 + (\kappa_1 - 1)A + \frac{1}{2}\sigma_m^2 + \frac{1}{2}\sigma_d^2 + \frac{1}{2}\kappa_1^2 B^2\sigma_s^2 - \Lambda_m\sigma_m - \Lambda_d\sigma_d - \Lambda_s\kappa_1 B\sigma_s,$$

which can be solved as:

$$B = \frac{\gamma_1}{1 - \kappa_1\rho_s},$$

$$A = \frac{-y + \gamma_0 + \kappa_0 + \frac{1}{2}\sigma_m^2 + \frac{1}{2}\sigma_d^2 + \frac{1}{2}\kappa_1^2 B^2\sigma_s^2 - \Lambda_m\sigma_m - \Lambda_d\sigma_d - \Lambda_s\kappa_1 B\sigma_s}{1 - \kappa_1}.$$

Parameter Values This section provides details on how we calibrate our structural model. We simulate the model using a monthly time interval 10,000 times and afterwards, we convert the data to an annual time interval with a sample length of 27 years. The persistence parameter for the state of the economy ($\rho_s = 0.936$) is taken from Koijen et al. (2017). On an annual basis, this is equal to a modest persistence of 0.45. The volatility parameter ($\sigma_s = 0.01$) is an arbitrary normalization.

The stock market dividend volatility parameter ($\sigma_{mM} = 0.04$) and the direct real estate rent volatility parameter ($\sigma_{dD} = 0.02$) closely match the empirical annual dividend volatilities of 13.2% and 5.3%. The respective volatilities implied by our calibration are 13.9% ($= 4\% \times \sqrt{12}$) and 6.9% ($= 2\% \times \sqrt{12}$). The listed real estate dividend and rent volatility parameters depend on our model assumptions, i.e. (i) σ_{mL} will be one half of the value of σ_{mM} if there are stock market spillovers and (ii) zero if there are no stock market spillovers. The parameter σ_{dL} is two times σ_{dD} to reflect leverage of listed real estate.

We impose two restrictions on the recession risk sensitivity parameters, (i) $\gamma_{1L} = 2 \times \gamma_{1D}$ to reflect leverage of listed real estate and (ii) $\gamma_{1L} > \gamma_{1M}$, since listed real estate are value stocks and should be more exposed to recession risk than common stocks. The parameter values $\gamma_{1D} = 0.10$, $\gamma_{1L} = 0.20$, and $\gamma_{1M} = 0.14$ satisfy these criteria.

After defining the parameters for the business cycle state variable, dividend growth and rent growth, we choose in a final step SDF risk prices, i.e. the parameter vector Λ, to generate risk premia which are as close as possible to the observed average returns of common stocks, listed real estate, and direct real estate. Since we measure returns in excess of the risk-free rate, the real interest rate ($\tilde{y}$) does not affect our results on risk premia and is set to 2% p.a. in all simulations.

Table 5 Parameter values

Monthly time interval			
	Symbol	Model 1	Model 2
	Long-run business cycle risk		
Persistence	ρ_s	0.936	0.936
Normalized volatility	σ_s	0.01	0.01
	Stock market (M)		
Mean dividend growth	γ_{0M}	0.002	0.002
Recession sensitivity (leverage)	γ_{1M}	0.14	0.14
Dividend volatility multiple	σ_{mM}	0.04	0.04
Rent volatility multiple	σ_{dM}	**0.00**	**0.00**
	Listed real estate (L)		
Mean dividend growth	γ_{0L}	0.002	0.002
Recession sensitivity (leverage)	γ_{1L}	0.20	0.20
Dividend volatility multiple	σ_{mL}	**0.02**	**0.00**
Rent volatility multiple	σ_{dL}	0.04	0.04
	Direct real estate (D)		
Mean dividend growth	γ_{0D}	0.001	0.001
Recession sensitivity (leverage)	γ_{1D}	0.10	0.10
Dividend volatility multiple	σ_{mD}	**0.00**	**0.00**
Rent volatility multiple	σ_{dD}	0.02	0.02
	Risk prices		
Stock market risk	Λ_m	**0.11**	**0.10**
Real estate risk	Λ_d	**0.06**	**0.10**
Recession risk	Λ_s	0.05	0.05

This table reports the parameter values that we adopt for our simulation. Recession risk (s_{t+1}) and dividend growth ($\triangle d^i_{t+1}$) of the stock market ($i = M$), listed real estate ($i = L$), and direct real estate ($i = D$) follow the processes:

$$s_{t+1} = \rho_s s_t + \sigma_s \epsilon^s_{t+1},$$

$$\triangle d^i_{t+1} = \gamma_{0i} + \gamma_{1i} s_t + \sigma_{mi} \epsilon^m_{t+1} + \sigma_{di} \epsilon^d_{t+1},$$

where $\epsilon_{t+1} = \left(\epsilon^s_{t+1}, \epsilon^m_{t+1}, \epsilon^d_{t+1}\right)$ are Gaussian shocks. Below are the factor risk prices of the stochastic discount factor, $-m_{t+1} = y + \Lambda' \epsilon_{t+1}$, where Λ are the factor risk prices. The values in bold indicate the differences between model 1 and model 2

References

Anderson, R., Clayton, J., MacKinnon, G., Sharma, R. (2005). REIT Returns and pricing: the small cap value stock factor. *Journal of Property Research*, *22*(4), 267–286.

Ang, A., Nabar, N., Wald, S.J. (2013). Searching for a common factor in public and private real estate returns. *Journal of Portfolio Management*, *39*(5), 120–133.

Barkham, R., & Geltner, D. (1995). Price discovery in American and British property markets. *Real Estate Economics*, *23*(1), 21–44.

Bond, S.A., Hwang, S., Lin, Z., Vandell, K.D. (2007). Marketing period risk in a portfolio context: comment and extension. *Journal of Real Estate Finance and Economics*, *38*(2), 447–461.

Boudry, W.I., Coulson, N.E., Kallberg, J.G., Liu, C.H. (2012). On the hybrid nature of REITs. *Journal of Real Estate Finance and Economics*, *44*(1-2), 230–249.

Brown, G.R. (1997). Reducing the dispersion of returns in U.K. real estate portfolios. *Journal of Real Estate Portfolio Management*, *3*(2), 1–12.

Byrne, P., & Lee, S. (1995). Is there a place for property in the multi-asset portfolio?. *Journal of Property Finance*, *6*(3), 60–83.

Byrne, P., & Lee, S. (2005). The impact of real estate on the terminal wealth of U.K. mixed-asset portfolios: 1972-2001. *Journal of Real Estate Portfolio Management*, *11*(2), 133–145.

Campbell, J.Y., Lo, A.W., MacKinlay, A.C. (1997). *The econometrics of financial markets*, 2nd edn. Princeton: Princeton University Press.

Chua, A. (1999). The role of international real estate in global mixed-asset investment portfolios. *Journal of Real Estate Portfolio Management*, *5*(2), 129–137.

Clayton, J., & MacKinnon, G. (2001). The time-varying nature of the link between REIT, real estate and financial asset returns. *Journal of Real Estate Portfolio Management*, *7*(1), 43–54.

Clayton, J., & MacKinnon, G. (2003). The relative importance of stock, bond and real estate factors in explaining REIT returns. *Journal of Real Estate Finance and Economics*, *27*(1), 39–60.

Cochrane, J.H., & Piazzesi, M. (2005). Bond risk premia. *American Economic Review*, *95*(1), 138–160.

Crosby, N., & McAllister, P. (2004). Deconstructing the transaction process: an analysis of fund transaction data. In Lizieri, C. (Ed.) *Liquidity in commercial property: Research findings*. London: Investment Property Forum.

Eichholtz, P.M. (1996). Does international diversification work better for real estate than for stocks and bonds?. *Financial Analysts Journal*, *52*(1), 56–62.

Eichholtz, P.M., & Hartzell, D.J. (1996). Property shares and the stock market: an international perspective. *Journal of Real Estate Finance and Economics*, *12*(2), 163–178.

Firstenberg, P.M., Ross, S.A., Zisler, R.C. (1988). Real estate: the whole story. *Journal of Portfolio Management*, *14*(3), 22–32.

Fisher, J., Gatzlaff, D., Geltner, D., Haurin, D. (2004). An analysis of the determinants of transaction frequency of institutional commercial real estate investment property. *Real Estate Economics*, *32*(2), 239–264.

Fisher, J., Geltner, D., Pollakowski, H. (2007). A quarterly transactions-based index of institutional real estate investment performance and movements in supply and demand. *Journal of Real Estate Finance and Economics*, *34*(1), 5–33.

Geltner, D. (1993). Estimating market values from appraised values without assuming an efficient market. *Journal of Real Estate Research*, *8*(3), 325–345.

Ghysels, E., Plazzi, A., Valkanov, R., Torous, W. (2013). Forecasting real estate prices. In Elliott, G., & Timmermann, A. (Eds.) *Handbook of Economic Forecasting*, Vol. 2A. Amsterdam: Elsevier.

Giliberto, S.M. (1990). Equity real estate investment trusts and real estate returns. *Journal of Real Estate Research*, *5*(2), 259–263.

Goetzmann, W.N., & Ibbotson, R.G. (1990). The performance of real estate as an asset class. *Journal of Applied Corporate Finance*, *3*(1), 65–76.

Hoesli, M., & Oikarinen, E. (2012). Are REITs real estate? Evidence from international sector level data. *Journal of International Money and Finance*, *31*(7), 1823–1850.

Hoesli, M., Lekander, J., Witkiewicz, W. (2004). International evidence on real estate as a portfolio diversifier. *Journal of Real Estate Research*, *26*(2), 161–206.

Koijen, R.S., Lustig, H., Nieuwerburgh, S.V. (2017). The cross-section and time series of stock and bond returns. *Journal of Monetary Economics*, *88*, 50–69.

Kroencke, T.A., & Schindler, F. (2012). International diversification with securitized real estate and the veiling glare from currency risk. *Journal of International Money and Finance*, *31*(7), 1851–1866.

Li, Y., & Wang, K. (1995). The predictability of reit returns and market segmentation. *Journal of Real Estate Research*, *10*(4), 471–482.

Ling, D.C., & Naranjo, A. (2015). Returns and information transmission dynamics in public and private real estate markets. *Real Estate Economics*, *43*(1), 163–208.

Ling, D.C., Naranjo, A., Ryngaert, M.D. (2000). The predictability of equity REIT returns: time variation and economic significance. *Journal of Real Estate Finance and Economics*, *20*(2), 117–136.

Liu, C.H., & Mei, J. (1992). The predictability of returns on equity reits and their co-movement with other assets. *Journal of Real Estate Finance and Economics*, *5*(4), 401–418.

Liu, C.H., Hartzell, D.J., Greig, W., Grissom, T.V. (1990). The integration of the real estate market and the stock market: some preliminary evidence. *Journal of Real Estate Finance and Economics*, *3*(3), 261–282.

MacGregor, B.D., & Nanthakumaran, N. (1992). The allocation to property in the multi-asset portfolio: the evidence and theory reconsidered. *Journal of Property Research*, *9*(1), 5–32.

Mei, J., & Lee, A. (1994). Is there a real estate factor premium?. *Journal of Real Estate Finance and Economics*, *9*(2), 113–126.

Morawski, J., Rehkugler, H., Füss, R. (2008). The nature of listed real estate companies: property or equity market?. *Financial Markets and Portfolio Management*, *22*(2), 101–126.

Newell, G., & Worzala, E. (1995). The role of international property in investment portfolios. *Journal of Property Finance*, *6*(1), 55–63.

Oikarinen, E., Hoesli, M., Serrano, C. (2011). The long-run dynamics between direct and securitized real estate. *Journal of Real Estate Research*, *33*(1), 73–103.

Pagliari, J.J.L., Scherer, K.A., Monopoli, R.T. (2005). Public versus private real estate equities: a more refined, long-term comparison. *Real Estate Economics*, *33*(1), 147–187.

Plazzi, A., Torous, W., Valkanov, R. (2011). Exploiting property characteristics in commercial real estate portfolio allocation. *Journal of Portfolio Management*, *35*(5), 39–50.

Ross, S.A., & Zisler, R.C. (1991). Risk and return in real estate. *Journal of Real Estate Finance and Economics*, *4*(2), 175–190.

Seiler, M.J., Webb, J.R., Myer, F.C.N. (1999). Are EREITs real estate? *Journal of Real Estate Portfolio Management*, *5*(2), 171–181.

Stevenson, S. (2000). International real estate diversification: empirical tests using hedged indices. *Journal of Real Estate Research*, *19*(1), 105–131.

Yunus, N., Hansz, J.A., Kennedy, P.J. (2012). Dynamic interactions between private and public real estate markets: some international evidence. *Journal of Real Estate Finance and Economics*, *45*(4), 1021–1040.

Ziobrowski, J.A., & Curcio, R.J. (1991). Diversification benefits of U.S. real estate to foreign investors. *Journal of Real Estate Research*, *6*(2), 119–142.