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Claudia Pigrum, BA(Hons)

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ABBREVIATIONS

REIT	Real Estate Investment Trust
NAV	Net Asset Value
EPRA	European Public Real Estate Association
UCITS	Undertakings for collective Investments in transferable securities
TER	Total Expense Ratio
IATX	Immobilien Austrian Traded Index
SICAV	Société d'Investissement à Capital Variable
KAG	Kapitalanlagegesellschaft
f.v.	Fund Volume
p.a.	per annum
ATX	Austrian Traded Index
MSCI	Morgan Stanley Capital International

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Introduction

Since the summer of 2007 the real estate sector has attracted a remarkable amount of attention. As real estate stocks tumbled in the wake of the sub-prime crisis, investors began to ponder the opportunities that securitized real estate investments provide. In January 2008, the Government of Singapore (GIC) acquired a 3% position in British Land, the largest U.K. property company. Post Properties in the US received a takeover offer 25% above its share price, and Nakheel, a state-owned property developer in Dubai, acquired a 5% stake in the Mirvac Group[1]. In September 2008 the U.S. government decided to step-in and save the two mortgage giants Fannie Mae and Freddie Mac[2]. Increased securitization and globalization of the real estate sector have given rise to a proliferation of investment vehicles. In the face of all the recent tumult on the real estate markets, investors are faced with the basic decision whether to include these vehicles into their portfolios, and with the more complex task of selecting specific vehicles and their proportions.

This thesis aims to disentangle the diverse range of securitized real estate assets, and provide a guideline for institutional investors seeking to optimize their portfolios. The volume of available data is analyzed and an approach to optimizing a portfolio with securitized real estate constituents is offered. In order to facilitate the task, the perspective of a hypothetical Austrian pension fund operating within the framework of Austrian law has been chosen. We aim to guide the fund through the investment process in four main sections.

The first section will define the most important concepts, and offer an introduction to the various real estate investment vehicles. It will provide an overview of the qualitative characteristics of each vehicle, explain the business models that underlie the securities, and point out the quandaries that the vehicles may entail. It will also outline the rather intricate Austrian legal constructions pertaining to the investments of pension funds.

The second section delves into the quantitative characteristics of the various investment vehicles. The third section addresses optimization problems with real estate assets, whereas the fourth section examines the factors that influence real estate returns.

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1 ING CLARION REAL ESTATE SECURITIES, 2008, *Global Real Estate Securities Market Commentary*, London, UK

2 The Economist*, Hank to the rescue*, September 11 2008

1 THE FRAMEWORK

1.1 Definition of Important Concepts

1.1.1 Institutional Investors

Institutional investors can be defined as legal entities that invest a substantial volume of assets in a professional manner[3]. This definition can be expanded to include the investment and management of assets that originate from a dispersed body of owners[4]. In the instance of our exemplary pension fund, this dispersed body of owners would be synonymous with the beneficiaries of the fund.

Examples of institutional investors are banks, insurance companies, investment companies, and the afore mentioned pension funds. Institutional investors can issue securities, as do investment fund management companies, or they can act as investors, as do pension funds. Institutional investors are characterized by their voluminous trades, their low transaction costs and their high level of professionalism. Due to relatively frequent portfolio re-balancing, institutional investors contribute to the liquidity of capital markets, as well as acting as active shareholders. Active shareholders use their large holdings in order to mitigate agency problems[5] that can arise in corporations between managers and investors, thereby optimizing the returns of the shareholders of the corporation at large. Small investors can profit from the presence of institutional investors as these are able to pool risks and provide attractive risk-return profiles. The California Public Employees Pension Fund is an institutional investor that is notorious for its activities as one of the biggest and most influential active shareholders[6].

In recent years the volume of assets managed by institutional investors has risen sharply. Figure 1 shows the increase in the volume managed by investment funds in Austria between 1980 and 2007.

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3 Kalss S., Oppitz M., Zollner J., 2005, *Kapitalmarktrecht*, Linde Verlag Wien, pp. 647

4 Kalss S., Oppitz M., Zollner J., 2005, *Kapitalmarktrecht*, Linde Verlag Wien

5 Jensen M. C., Meckling W. H., 1976, *Theory of the Firm: Managerial Behaviour, Agency Costs and Ownership Structure*, The Journal of Financial Economics, Vol. 3, Nr. 4 pp. 305-360

6 Shleifer A., Vishny R. W., 1997, *A Survey of Corporate Governance*, The Journal of Finance, Vol. 52, pp. 737-783

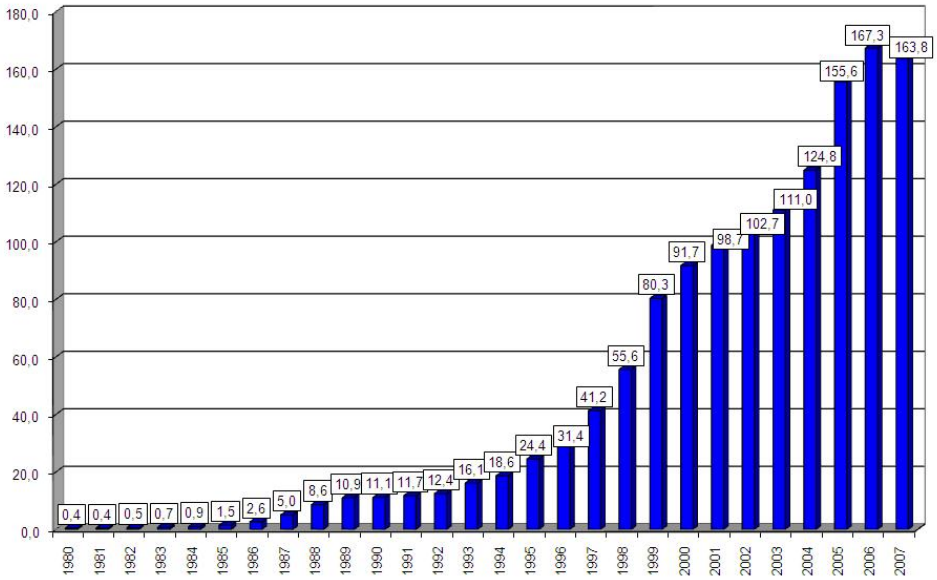

Figure 1: Volumes managed by Austrian investment funds between 1980 and 2007 (billion euros)
Source: Vereinigung Österreichischer Investmentgesellschaften

This increase in volumes can be attributed to both demand and supply side factors, as well as additional factors such as compounding effects over time and pricing effects. Particularly the year 2008 will highlight the impact that pricing effects can have on the volume of assets managed by pension funds. These can be expected to be considerably lower at the end of 2008 than in previous years. Demand side factors are mainly demographic in nature. State interventions to create incentives for the investment in private pension funds have been abundant, resulting in a system of tax reductions, subsidies, and capital guarantees[7].

The pressures on the state pension system are amplified by increasing life expectancies. Figure 2 shows the anticipated demographic changes in Austria until 2030, which will most definitely continue to generate state incentive schemes to magnify the role of private pension plans.

[7] Halling M., Randl O., Mosburger G., 2004, *Die prämienbegünstigte Zukunftsvorsorge in Österreich: Ein attraktives Investment*, Financial Markets and Portfolio Management

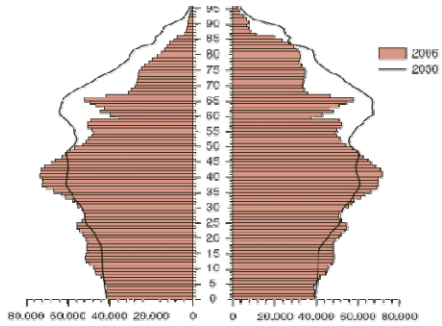

Figure 2: The population pyramid for Austria between 2006 and 2030

Men are shown on the left of the table, women on the right. The central axis shows age in years.

Source: Statistik Austria

Supply side factors pertain to the increased efficiency of the financial services provided by institutional investors as opposed to smaller corporations and trusts. This efficiency is derived from improved diversification, lower transaction costs, higher liquidity, and, in some cases, tax benefits.

1.1.2 Groups of Institutional Investors and their magnitude in Austria

As mentioned in the previous sub-section, institutional investors include banks, insurance companies, pension funds, investment fund management companies, and trusts and corporations[8], provided that they are of sufficient magnitude. Banks form the largest group of Austrian institutional investors, with a total of 899.5 billion Euros on their balance sheets[9] in 2007. Insurance companies had a volume of 82 billion Euros on their balance sheets in 2007[10]. Pension funds form a further significant group of institutional investors in Austria. By 2007 this group of investors had a volume of 12.2 billion Euros of assets on their balance sheets[11]. This volume is expected to rise further over the following decades due to the previously mentioned demographic factors, due to the effects of compounding over time, and due to pricing effects. Pension fund asset allocations are subject to the comparatively restrictive regulations of the Company Pension Fund Act (Pensionskassengesetz PKG). Figure 3 illustrates the development of the volume of assets under management by pension funds from 2003 to 2007.

8 Ibid S. 647

9 Fachverband der Banken und Bankiers

10 Versicherungsverband Österreich

11 Österreichische Nationalbank Pensionskassen – Vermögensbestand

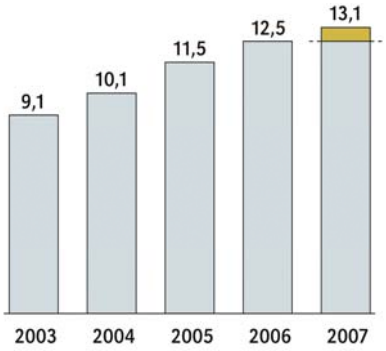

Figure 3: The Assets under Management of Austrian Pension Funds in Billions

The yellow shaded area above 2007 shows the 4.8% increase in assets under management since 2006

Source: Fachverband der Pensionskassen

1.1.3 Summary

In the above, institutional investors and their magnitude in Austria have been discussed. The next section will categorise and describe real estate investments, in order to provide the reader with an overview of the available investment universe. The categorization is one relevant particularly to Austrian institutional investors.

1.2 Real Estate Investment Vehicles

This section provides a qualitative overview of the most prominent forms of real estate investments. It must be noted that the following descriptions and figures are not exhaustive - there are other forms of real estate investment that are available to more adventurous institutional investors. The business models that underlie each investment form in the figure below will be discussed, and the quandaries associated with each vehicle will be pointed out. Figure 4 illustrates the various vehicles which are subsequently portrayed.

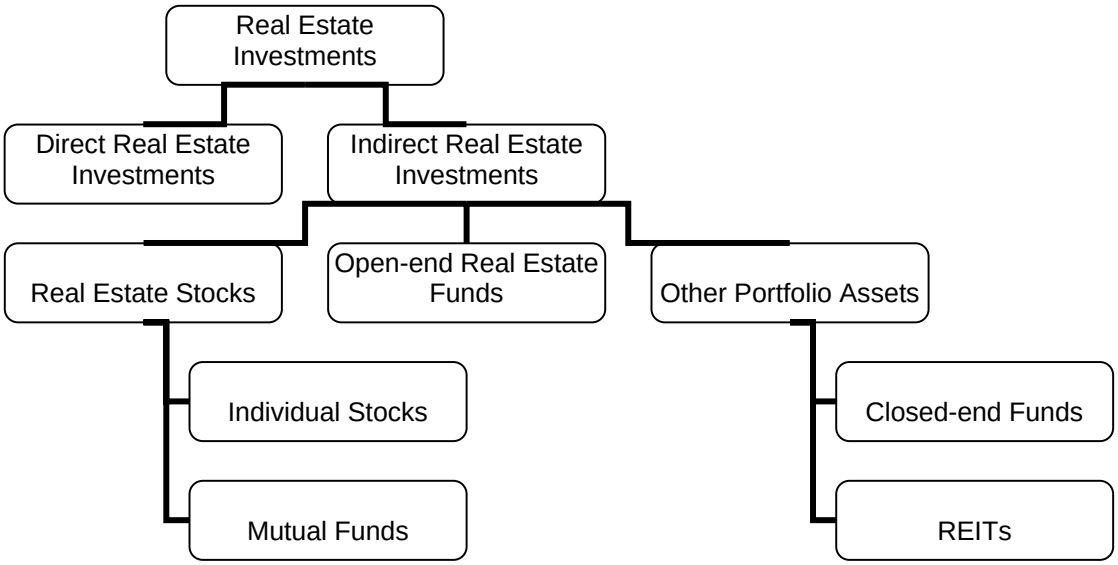

Figure 4: Real Estate Investments

1.2.1 Direct versus Indirect Real Estate Investments

Fundamentally, real estate investments can be categorized as direct or indirect in nature. Direct real estate investments can be sub-divided into investments into residential and commercial properties. Direct real estate investments comprise the development, management and the trading of real estate, and are characterized by high transaction costs, high initial investments, and the substantial know-how that is required. As direct real estate investments are valued only once a year, they appear to exhibit artificial low price volatilities. Due to the illiquidity of the market, the valuation of a real estate asset does not necessarily correspond to its market value. This is of particular significance when considering securitized real estate investments whose value depends largely on real estate assets, as it implies that a certain degree of inefficient pricing is present in the market. This inefficient pricing may be viewed by the prudent investor as an opportunity to capitalize on returns that are not entirely

anticipated by the market. Furthermore, inefficient markets are a feature often desired by investors, as they can be exploited to generate higher returns.

Securitized forms of real estate investments are considered indirect investments. These comprise the shares of companies that deal in real estate in one form or another, open-end real estate funds, and what are legally termed “other portfolio assets[12].” The advantages of indirect investments over their direct counterparts are the lower transaction costs, the enhanced possibilities of diversification, higher liquidity, and the professional management of real estate assets.

Direct real estate investments may already exist as a component of the assets held by a pension fund. Securitized real estate assets, in their various forms, can be added to the portfolio of a pension fund via mutual funds distributed by investment fund management companies. The discussion of the most common real estate investments will be continued from right to left of Figure 5.

1.2.2 Other Portfolio Assets

Overview

According to §20a) of the Federal Act on Investment Funds other portfolio assets may include „assets that are marketable only to a limited extent, are subject to large price fluctuations, have a limited (dispersion) or (the) valuation of which is difficult[13].“ These assets can range from investments in hedge funds through unit certificates of closed-end real estate funds. The prerequisites for an investment in other portfolio assets are that these are securitized, and that obligations for subsequent payments are excluded.

With reference specifically to real estate assets, these are limited to encompass unit certificates of closed-end real estate funds, and shares of Real Estate Investment Trusts (REITs). A typical example of a closed-end fund is the Bank Austria *Real Invest 5 Deutschland*[14] Fund. REITs are a legal construction that is not recognized by Austrian law. This means that usually REITs are classified according to their respective business models by Austrian law. In Germany, the REIT structure

12 Vereinigung Österreichischer Investmentgesellschaften, 2006, *Federal Act on Investment Funds*, §20a)

13 Vereinigung Österreichischer Investmentgesellschaften, 2006, *Federal Act on Investment Funds* , §20a)

14 www.realinvest5.at

has been recognized since October 2007. The first company to receive REIT status in Germany was the Alstria Office REIT-AG[15].

The Business Models

Closed-end real estate investment funds invest in residential as well as in commercial properties. Income is generated by means of rental revenues during the finite lifetime of the fund, and by means of sales revenues with the maturity of the fund. Closed-end real estate funds issue a fixed amount of shares that cannot be redeemed directly with the issuing company until maturity. However, the shares can be traded in secondary markets. Subsequent payments are not permissible, so potential loss is limited to the initial investment.

REIT structures exist in 19 countries including Canada, the USA, Belgium, France, the Netherlands, Singapore, Australia, Hong Kong, Japan and South Korea[16]. Although REIT structures vary from country to country, certain generic features can be identified[17]. Basically, REITs exist predominantly in the form of closed-end funds or trusts, in countries with developed property markets. There are two main forms of REITs. Equity trusts invest directly in real estate, whereas mortgage trusts invest in mortgage and construction loans. Equity REITs hold, manage and maintain real estate assets. REITs do not focus their operational activities on the trading of real estate assets, but tend to lease their assets to tenants. This characteristic makes them comparable to open-end real estate funds, which will be discussed in Section 1.2.3. Usually, REITs have a large shareholder base and many are listed on stock exchanges. A further key feature of REITs is their special tax position, which is designed to replicate that of a direct real estate investment. Furthermore, REITs are obliged to distribute a large proportion of their profits to shareholders.

In order to illustrate the general features of REITs, we have chosen to outline the key features of the US REIT, as this was the country which developed the REIT system and forms the blueprint for other REIT structures.

15 www.alstria.com

16 Ernst and Young

17 HM Treasury, 2005, *UK Real Estate Investment Trusts: a Discussion Paper*; UK

Key features of the US REIT:

- At least 90% of taxable income must be distributed to shareholders in the form of dividends
- 75% of total assets must be invested in real estate assets
- At least 75% of gross income must be generated from rental revenues from real property, or from interest on mortgages on real property
- A maximum of 20% holdings in other taxable REITs
- No more than 50% of shares may be held by fewer than 5 individuals in the last half of each tax year
- No taxation at the corporate level
- REITs tend to be highly leveraged, with debt ratios of up to 70%[18]

Potential Pitfalls

Closed-end real estate funds have low liquidity because shares cannot be redeemed directly with the fund until maturity. However, shares can be traded on the secondary markets.

Closed-end funds are not valued daily by their net asset value. Instead their component properties are valued once a year. This does not substantially differentiate closed-end funds from open-end funds, as the properties of open-end funds are valued twice a year, and this valuation is used as a basis for the calculation of the net asset value for the rest of the period. Open-end funds will be discussed in more detail in the next section. It may be problematic that closed-end funds are susceptible to sustaining a realized loss at maturity if this point in time coincides with a downturn in the business cycle.

The volatility of closed-end funds is smoothed by the valuations of the component properties that are at comparatively long intervals, and is hence deceptively low. In relation to the declared volatility, the return of these funds may seem comparatively lucrative. The diversification benefits of closed-end funds in a portfolio of real estate assets can be expected to be moderate, as cyclical price movements in the real-estate market are reflected in a lagged way.

Closed-end funds are often associated with high leverage. This may increase the return of the fund, due to the leverage effect, but it will also inherently increase

[18] Bodie Z., Kane A., Marcus J. M. , 2005, *Investments*, McGraw Hill Irwin

the risk of equity investors. The available data for closed-end funds in Austria is extremely limited. Due to the practical difficulties that this entails, closed-end funds will be excluded from data analysis.

REITs are problematic for Austrian investors as their legal structure is not legally recognised in this country. Hence, Austrian investors can only purchase REITs within mutual funds, or within the framework of “other portfolio assets”. However, it is important to note that many investors already hold REITs within other products, such as instruments based on the MSCI index series.

Stock-market listed REITs are associated with the same liquidity benefits as other stock-market listed companies, meaning that investors can relatively easily trade their shares, provided that their holdings are not so large as to effect the market price. For non-listed REITs that are run as closed-end funds, the same liquidity restrictions apply as to the closed-end funds mentioned earlier in this section. As for the liquidity of the REIT itself, there are no specifications as to how high the liquidity reserve of a REIT must be.

The fundamental value of REITs is dependent on the value of the real estate assets in their portfolios, and upon the rental incomes that are generated from these assets. These are used to determine the net asset value (NAV) of the REIT, which is the per share market value of the REIT. The assets are valued once every quarter, which leads to smoother artificial volatilities. As the rental incomes of properties are prone to limited fluctuation, these lead to genuinely lower volatilities. However, stock-market listed REITs tend to move with the general market sentiment, making their share prices and volatilities dependent on those of the market, and not on those of their fundamentals. Furthermore, stock-market listed REITs are valued according to the balance of supply of new buildings and demand for new space. When supply of new buildings is higher than demand, vacancy rates may increase, which puts a downward pressure on NAVs. The expectation of a lower NAV is priced into the share before the assets of the REIT are actually re-valued. A movement with the market means that REITs may not yield great diversification benefits when mixed into a portfolio of real estate assets that also contains real estate stocks, although REITs are usually said to have a low correlation with the general stock market.

A high debt ratio may be associated with more volatile returns to equity-holders than in an entirely equity financed scenario. Although the 70% maximum leverage

ratio of REITs may seem high, it must be noted that listed property developers in particular sometimes have leverage ratios of 80% to 100%[19]. However, listed real estate companies in all of their various forms can not generally be associated with high leverage ratios. Open-end real estate funds, which will be discussed in the next section, have a comparatively low maximum leverage ratio of 50%. Open-end real estate funds are an appropriate benchmark to compare REITs to, as the two categories share a common focus on buy-hold-rent business models.

1.2.3 Open-end Real Estate Funds

Overview

An open-end fund is one which is allowed to issue unit certificates at several points in time, as opposed to funds that are allowed to issue certificates exclusively at initiation. Every time the fund intends to acquire new real estate assets, it secures financing in this way. The certificates are valued by means of the net asset value[20] of the fund, which is calculated on a daily basis by the depository bank, which also stores the certificates. The fund must remain in the position to repurchase unit certificates at the request of unit holders, even if this necessitates the sale of real estate assets. The fund must maintain 10 – 49% of liquid assets in order to ensure compliance with the regulations regarding repurchasing of certificates. Liquid assets may include money market instruments, stocks, and bonds with a maturity of at the most three years[21]. Companies do not tend to hold their liquid assets as cash. The rules concerning the investments of the funds offer the unit holders protection in the form of minimum dispersion requirements. For Austrian open-end real estate funds, this means that the fund must be in possession of at least ten real estate assets, which can include developed real estate, undeveloped real estate or building rights and superstructures[22].

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19 See figure 6 for the different forms of real estate companies

20 The net asset value of a mutual investment fund is the value of real estate assets, liquid assets and accounts receivable less the liabilities of the fund. The net asset value per share is simply the net asset value of the fund divided by the total amount of certificates issued. Regarding open-end real estate funds, other measures of net asset value can be cited, such as the EPRA NAV and the Triple NAV. The EPRA NAV includes the fair value of development projects, as opposed to the regular NAV which incorporates only the costs of development projects as liabilities. Hence, the EPRA NAV tends to be higher than the "regular" NAV. The Triple NAV includes financial instruments in the assets of an open-end real estate fund. Bron J. F., 2007, *Der G-REIT*, Baden-Baden

21 Austrian Real Estate Investment Fund Act § 32

22 Austrian Real Estate Investment Fund Act § 21

In Austria, an open-end real estate fund is defined by §1 of the Austrian Real Estate Investment Fund Act (ImmoInvFG) as „a portfolio of assets (…) which is divided into equal units evidenced by securities and (....) established in accordance with the provisions of this federal act[23]“. In Austria, a real estate investment fund can be created exclusively by a real estate investment management company, as opposed to a regular investment fund management company. A slightly different case is the special real estate fund, which is „a portfolio of assets whose unit certificates are held, in accordance with the fund regulations, by no more than ten unit holders who shall be known to the real estate investment management company and who shall not be natural persons[24]“. An example of an Austrian open-end real estate fund is the Bank Austria *Real Estate Austria* Fund[25].

The Business Models

The business model underlying an open-end real estate fund is one in which commercial and residential real estate assets are developed, maintained and leased. The purchase of assets is financed by means of issuing certificates to shareholders and by taking up leverage up to a maximum of 50% of the value of the real estate assets of the fund. As previously noted in Section 1.2.3, some of this leverage will be held in the form of money-market instruments, bonds or stocks in order to maintain the liquidity reserve that is required by law.

The real estate assets of the fund are valued twice a year by two independent auditors. The value determined by the auditors is then incorporated into the net asset value of the fund. In turn, the net asset value is dependent upon the underlying property values, as well as the rental revenues of the fund. It is important to note that although the net asset value is calculated daily by the depositary bank, the underlying assets are only valued twice a year.

Potential Pitfalls

Liquidity risk is one of the two main potential pitfalls of open-end real estate funds. It must be noted in this context that liquidity premiums are a phenomenon generally present in financial markets[26], and that liquidity issues are not restricted to real estate investments. Nonetheless, the liquidity issues pertaining to open-end real

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23 Vereinigung Österreichischer Investmentgesellschaften, 2006, *Real Estate Investment Fund Act* , §1

24 Vereinigung Österreichischer Investmentgesellschaften, 2006, *Real Estate Investment Fund Act* , §1-3

25 www.realinvest.at

26 Townshend H., 1937, *Liquidity Premium and the Theory of Value*, The Economic Journal, Vol. 47, No.185

estate funds will be briefly discussed, in order to clarify the implications of this dilemma to the reader. Theoretically, an open-end real estate fund must remain in the position to repurchase unit certificates at all times. However, this can practically become problematic if a large number of investors attempt to liquidate their positions simultaneously. In this case, the open-end fund is obliged to divest some of its real estate assets. However, these may only be sold at a price which does not significantly undercut their value. In order to comply with this regulation, Austrian open-end real estate funds are permitted to suspend trading in unit certificates for a period of up to two years. Ultimately, this can lead to a situation where an investment in an open-end real estate fund is completely illiquid for up to twenty-four months. The investor's dilemma is further compounded by the fact that the real estate assets of the fund are valued twice during the period of illiquidity, and it is to be expected that these valuations will be lower than the preceding ones, which further reduces the net asset value of the fund, and thereby the value of the investment. Hence, the investor remains in possession of an illiquid and depreciating asset.

The second is related to the volatility smoothing property of annual valuations. The net asset value of the fund is calculated daily, whereas the main component of this value is calculated semi-annually. This leads to a deceptively low volatility compared with other real estate assets, such as stocks, whose value can genuinely fluctuate on a daily basis. Even in the case of REITs, where the value of the assets is determined quarterly, the market value of stock-listed REITs can be determined daily.

The maximum 50% leverage ratio of open-end investment funds is particularly interesting, as it is combined with specified liquidity reserves. This produces a business model based on a relatively high amount of leverage, which nonetheless requires liquidity reserves that are themselves presumably based to some degree on leverage. On the other hand, a cash reserve of 50% of the funds assets entails a relatively low market exposure.

1.2.4 Real Estate Stocks

This section will focus first on real estate stocks in general, and then devote a sub-section to mutual funds, which will address UCITS[27] funds and regulations. REITs are excluded in this section as they were outlined in Section 1.2.2, and because their legal construction is not recognized in Austria.

[27] Undertakings for collective Investments in transferable securities

Overview

Real estate stocks can be defined as the shares of listed corporations whose value is significantly influenced by the real estate assets in their possession. These corporations were either founded with the intention of focusing their operations on real estate in some form, or gradually shifted their focus in this direction[28]. These corporations are usually termed “property companies”. It is furthermore possible to invest in bonds that the relevant company issues, or in derivatives, such as options if these are available. Real estate stocks can be purchased as shares of a single company or via a mutual fund that invests in real estate stocks. Real estate stocks are relatively liquid compared to open-end real estate funds, and the value of the company or fund is assessed on a daily basis by market participants.

The Business Models

All stocks that qualify as real estate stocks focus their operations on real estate in one form or another. However, there are several distinct business models that underlie real estate stocks, which may imply varying valuations and reactions to market developments. Figure 5 shows an approach to classifying different types of property companies. This classification is not exhaustive, but merely provides an overview of the multitude of property companies that exist

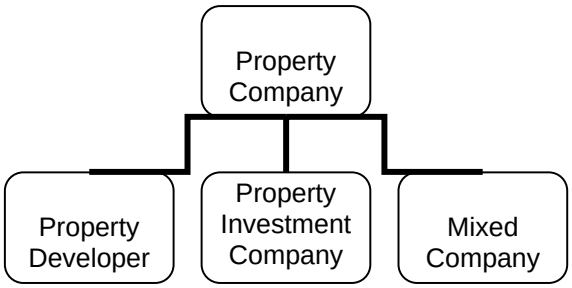

Figure 5: The different Business Models of Property Companies

Property companies can be divided into three categories which encompass property developers, investment companies, and mixed companies. Investment companies buy, hold and rent properties. Property investment companies do not necessarily have to own real estate assets, but may be involved in the financing of real estate assets, hence making their returns dependent on real estate and thereby qualifying as a property stock. An example of a property investment company is the Immofinanz AG or the ECO Business Immobilien AG. Property development

[28] Bone-Winkel S., 1998, *Handbuch Immobilien Investitionen*, Cologne, Germany pp. 516

companies buy, develop and sell properties. The holding periods are much shorter than those of investment companies. The conwert AG engages in a combination of property development and investment. Each of the above company types may have a domestic focus, a specific regional focus, or a global focus.

Property companies tend to focus their operations on specific types of properties, which vary in their reactions to changes in the economic environment and more specifically to swings in the business cycle. Figure 6 is an attempt to illustrate the different types of real estate assets that property companies can invest in.

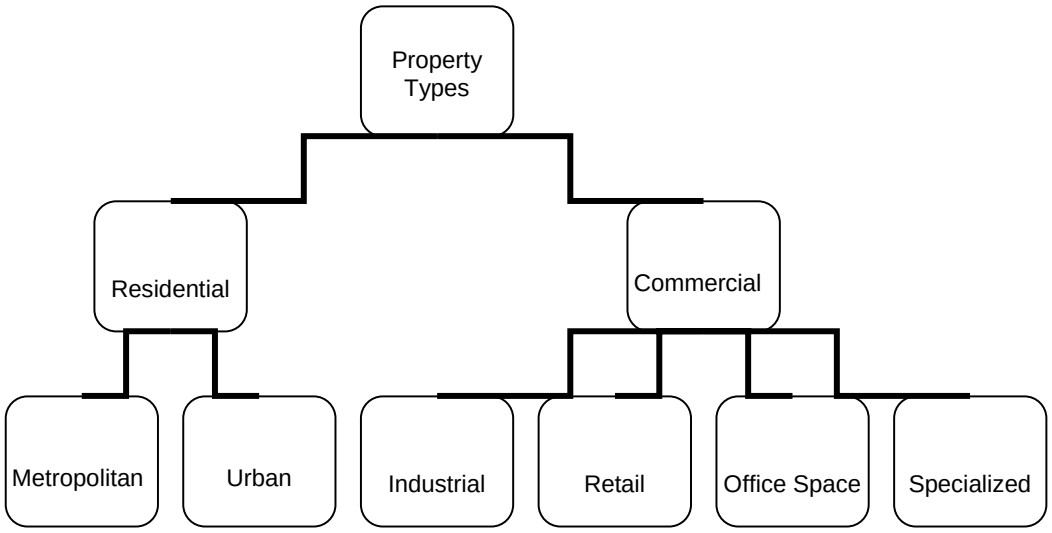

Figure 6: Property Types

Potential Pitfalls

The main issue that investors encounter when investing in stocks of any kind is that the value of the company underlying the stock does not necessarily correspond to its market price. The market price of a stock reflects the value of the company, expectations about the future, and the general market sentiment. For example, the net asset value of the Immoeast AG was € 10.53[29] on 31.10.2007, whereas the same firm's average stock price in October 2007 was € 8.23. This deviation may be attributed to general market developments, to property valuations underlying the net asset value that were made some time ago and are no longer accurate, or to a combination of several factors. It must also be noted that investments in individual stocks incorporate the unsystematic risk that is associated with the company itself. This risk can be minimised by means of sufficient diversification.

[29] Semi-annual report of Immoeast AG on the 31.10.2007

The liquidity of real estate stocks is conditioned by the liquidity of the stock market that the stock is listed on, and by the market capitalisation of stocks. Generally, real estate stocks are far more liquid than closed-end funds or open-end funds.

The volatilities of real estate stocks depend largely on those of the stock markets that they are listed on. As real estate stocks move with the market to a certain degree, the diversification benefits that can be obtained by integrating real estate stocks into a broad-based portfolio of stocks are limited. The leverage ratio of real estate stocks varies widely with the specific business model of the company.

Further potential pitfalls associated with real estate stocks are common to investments in foreign currencies and regions. Investments in foreign currencies bring foreign exchange risks with them. Investments in foreign geographical regions can yield positive diversification effects, but are also associated with risks related to the general economic and political climate of the area, which may adversely affect the development of stock markets in the region.

1.2.5 Mutual Funds based on Real Estate Stocks

The Business Model

An alternative to the purchase of individual real estate stocks is an investment in mutual funds which hold a diversified portfolio of real estate securities as well as other liquid securities and money market instruments. An example of a mutual real estate fund is the Constantia European Property Fund. The return of a mutual fund is measured by the change in net asset value plus dividends and capital gains[30]. Mutual funds are associated with several forms of transaction costs such as front-end loads that are to be paid on purchase, back-end loads that are to be paid on redemption, and operating expenses which include administrative costs incurred by the fund and advisory fees paid to the investment manager. Operating expenses are not paid explicitly by investors, but periodically deducted from the assets of the fund. Sometimes funds publish their Total Expense Ratio (TER), which states the total expenses of the fund as a percentage of the fund volume. This is useful to investors as fund expenses can more easily be compared to each other. UCITS regulations, which will be discussed in the next section, require the disclosure of the TER of a

[30] Bodie Z., Kane A., Marcus J. M. , 2005, *Investments*, McGraw Hill Irwin

fund. Mutual real estate funds vary widely in their regional focus and in the types of property companies and securities that they invest in.

An Austrian institutional investor can only invest in UCITS funds that are registered in Austria, and that have a fiscal representation in Austria. An investor that purchases shares of a mutual fund that is not fiscally represented in Austria incurs financial penalties. This considerably limits the universe of real estate mutual funds that is available to Austrian investors.

UCITS Funds

The UCITS guidelines provide a general standard for undertakings for collective investments in transferable securities throughout the EU. These include funds whose business model encompasses exclusively the investment in securities. Hence, mutual real estate funds can be UCITS funds, whereas open-end real estate funds cannot be UCITS funds. As is the case with open-end real estate funds, a net asset value is calculated for UCITS funds, which is defined as the total assets of the fund less its liabilities. A UCITS fund is permitted to be leveraged up to 100% of its net asset value[31]. The fund must remain in the position to repurchase the unit certificates at all times. REITs themselves cannot be UCITS funds, as these invest mainly in properties and not in securities. However, listed REITs can form components of UCITS funds, making these available to Austrian investors.

Potential Pitfalls

The liquidity of mutual funds is assured by the requirement that the mutual funds must be able to repurchase all of their outstanding certificates at any point in time. As mutual funds are based on securities and not on properties, the components of a mutual fund are far more liquid than those of an open-end real estate fund.

The pitfalls of mutual real estate funds are similar to those of individual real estate stocks, in that the value of the mutual fund can very much depend on the general market sentiment. Furthermore, as is the case with individual real estate stocks, mutual real estate funds can be subject to currency risks and to regionally specific risks. However, as mutual funds invest largely in stocks as opposed to properties, their valuations tend to be more current than those of open-end real estate funds.

31 The Alternative Investment Management Association

The implications for the volatility of mutual funds are that these will tend to be more volatile than open-end real estate funds. This is due to the higher volatility of their component assets. However, depending on the proportion of equities actually held in the fund as opposed to cash and bonds, funds may differ in their volatilities, and in the equity market dependence of their volatilities and their returns. However, it must be noted that the other types of securities that can be integrated into mutual funds, such as derivatives, fixed income and money market securities carry a host of specific risks with them. Furthermore, funds are obliged only to limited transparency, which means that the investor yields a degree of control to the fund management.

Mutual funds invest in relatively broadly diversified real estate stocks, which brings considerable diversification benefits with it compared to investments in individual stocks. Furthermore, mutual funds may yield a diversification benefits when mixed into a portfolio of open-end funds, as they have different underlying assets.

The previous section outlined the most prominent forms of real estate investment vehicles available to the Austrian institutional investor. The following section will discuss the legal constraints that must be heeded when integrating these assets into the various types of funds available to the Austrian institutional investor.

1.3 The Legal Framework in Austria

An institutional investor has the possibility of investing in securitized real estate assets that have been bundled into a mutual fund by an investment fund management company. This section will describe the legal framework in Austria in terms of the types of mutual funds that investment fund management companies offer, and proceed to elaborate the additional restrictions that Austrian pension funds are subject to when selecting mutual funds.

An Austrian investment fund management company can create mutual funds according to the guidelines of §20 of the Austrian Investment Fund Act, or in accordance with §20a) of the same Act. Pension Funds are not permitted to create funds. Additionally, special funds along the lines of the two above mentioned paragraphs can be created. Depending on the structure of the fund, different components can be integrated in varying proportions. It is important to note that none of the mutual funds allow the integration of direct real estate investments.

§20 funds can act as sub-funds and can be distributed outside of Austria. This consideration may be of particular importance for institutional investors, as they may wish to purchase an umbrella fund, with one of the component sub-funds being a real estate fund. Therefore, it is usually in the interest of investment fund management companies catering to institutional investors to create funds that can easily be integrated into an investors existing portfolio in the form of a sub-fund. § 20a) funds additionally allow for the integration of open-end real estate funds and other portfolio assets. These funds cannot be components of an umbrella fund, and can only be distributed domestically. Special funds have less restrictive asset allocation quotas, and allow for the purchase of special real estate funds. A further special form of fund is one created especially for large-scale investors, in which the specific asset allocation is a matter of mutual agreement among the parties involved. Table 1 displays a matrix of Austrian real estate funds and their components.

Austrian real estate investment funds and their components			
	§20	**§20a)**	**Special funds**
Direct real estate investments	- Prohibited	- Prohibited	- Prohibited
Real estate stocks	- Allowed - A maximum of 10% of fund volume (f.v.) can be invested per stock - If more than 5% of holdings are from the same issuer, the sum of these must not exceed 40% of the f.v. - A maximum of 20% of f.v. can be invested in the same group - A maximum of 35% of f.v may be invested in issuances guaranteed by a member state	- Allowed - A maximum of 10% of fund volume (f.v.) can be invested per stock - If more than 5% of holdings are from the same issuer, the sum of these must not exceed 40% of the f.v. - A maximum of 20% of f.v. can be invested in the same group - A maximum of 35% of f.v may be invested in issuances guaranteed by a member state	- Allowed - A maximum of 10% of fund volume (f.v.) can be invested per stock - If more than 10% of holdings are from the same issuer, the sum of these must not exceed 80% of the f.v. - A maximum of 40% of f.v. can be invested in the same group - A maximum of 70% of f.v may be invested in issuances guaranteed by a member state
Austrian and foreign OGAW/UCITS real estate mutual funds	- Allowed - A maximum of 20% of f.v can be invested into each fund - A component sub-fund must not invest more than a total of 10% of f.v. into sub-funds - Foreign mutual funds must have a representation for tax purposes in Austria	- Allowed - A maximum of 50% of f.v. can be invested into each fund - Foreign mutual funds must have a representation for tax purposes in Austria	- Allowed - Doubling of allocation limits depending on whether the fund is a §20 or a §20a) fund. - Foreign mutual funds must have a representation for tax purposes in Austria
Special real estate funds	- Prohibited	- Prohibited	Möglich Maximal 10% FV in einen Fond In Summe maximal 20%
Austrian open-end real estate funds (as outlined by ImmoInvFG)	- Prohibited	- Allowed - A maximum of 10% of f.v. can be invested in each fund - In total open-end funds must represent less than 20% of f.v.	- Allowed - A maximum of 10% of f.v. can be invested in each fund - In total open-end funds must represent less than 20% of f.v.
Foreign open-end real estate funds	- Prohibited	- Allowed - A maximum of 10% of f.v. can be invested in each fund - In total open-end funds must represent less than 20% of f.v. - Foreign mutual funds must have a representation for tax purposes in Austria	- Allowed - A maximum of 10% of f.v. can be invested in each fund - In total open-end funds must represent less than 20% of f.v. - Foreign mutual funds must have a representation for tax purposes in Austria
Other portfolio assets	- Prohibited	- Allowed - A maximum of 10% of f.v. can be invested in other securitized portfolio assets	- Allowed - A maximum of 10% of f.v. can be invested in other securitized portfolio assets

Table 1: Austrian Real Estate Investment Funds and their Components

Pension funds are subject to additional restrictions. A pension fund may invest a total of 5% of its assets under management in a single stock, a maximum of 10% in the same group, and a maximum of 30% in foreign currencies. At least 30% of the funds assets under management must be invested in bank deposits or in government bonds.

1.4 Summary

Section 1 aimed to introduce the reader to the basic concepts pertaining to the real estate investments of Austrian institutional investors. A scenario has been defined in which an Austrian pension fund aims to better diversify its portfolio by means of the integration of securitized real estate assets. The main forms of real estate investment vehicles were described in a qualitative manner, and the predicaments that an investor may be faced with when investing in such assets were outlined. In addition, the legal constraints on the pension fund were outlined. The following section will offer a quantitative analysis of the various real estate investment vehicles with respect to their descriptive statistics. These will compared to a representative portfolio for an Austrian pension fund. The issue of portfolio optimisation will be addressed in Section 3.

2 THE UNIVERSE OF INVESTMENTS AND ITS' DESCRIPTIVE STATISTICS

2.1 Guidelines and previous empirical research

Hübner, Schwaiger and Winkler (2003)[32] have conducted one of the few analyses of securitized Austrian real estate investments. The authors use monthly returns of the IATX from 1996-2002 in their study, and compare the behaviour of the IATX to bonds and to a general Austrian stock index in order to establish whether Austrian real estate assets provide a potential for diversification in a portfolio that includes a wide range of Austrian stocks and bonds. Hübner, Schwaiger and Winkler (2004)[33] also published a study in which they focus on the diversification potential of real estate investments in Germany. This study encompasses German open-end real estate funds as well as real estate stocks. As in the study of the Austrian market, the diversification potential of real estate assets in a portfolio of German stocks and bonds is analyzed. The reason that the Austrian study by the three authors does not

[32] Hübner R., Schwaiger M. S., Winkler G., 2003, *Das Diversifikationspotential österreichischer Immobilienwertpapiere*, Österreichisches Bankenarchiv, Vol.8, pp. 565-576

[33] Hübner R., Schwaiger M. S., Winkler G., 2004, *Indirekte Immobilienanlagen im Portfoliomanagement am Beispiel des deutschen Marktes,* Swiss Society for Financial Market Research, Vol. 18, Nr. 2., pp. 181-198

include open-end real estate funds is that these were not recognized in Austria until 2002.

The data analysis in this study will follow the guidelines provided by Hübner, Schwaiger and Winkler in the two papers mentioned above. However, this thesis will include Austrian open-end real estate funds and Austrian mutual real estate funds. Furthermore, the question analyzed in this thesis is an extension of the question regarding the general diversification potential of Austrian real estate assets. The question analyzed is whether real estate assets provide a potential for diversification in the portfolio of a representative Austrian pension fund.

2.2 The selected Universe of Austrian Real Estate Investments

2.2.1 Real Estate Stocks

The sample of domestic real estate stocks available to the Austrian institutional investor is represented by the Austrian Real Estate Index, the IATX. The IATX encompasses the eight most important real estate companies in Austria. In order to be eligible for the index, companies must be in the prime segment of the Austrian stock market. This guarantees a certain level of transparency and disclosure, as well as a certain proportion of shares in free float[34]. The table below shows the members of the IATX and their relative market capitalizations on 7 July 2008[35].

Company	Relative market share
CA Immo International AG	3.84
CA Immobilien Anlagen AG	10.48
Conwert Immobilien Invest AG	7.70
ECO Business-Immobilien AG	2.22
IMMOEAST	43.79
Immofinanz AG	25.56
Sparkassen Immobilien AG	4.10
Warimpex AG	2.32

Table 2: The relative market share of the IATX members

[34] Closely held shares are those held by shareholders that own more than 5% of the share capital. The remaining shares are in free float.

[35] Data from Bloomberg on July 7, 2008

2.2.2 Mutual Real Estate Funds

As previously outlined in Section 1.2.5, there are several criteria that need to be fulfilled by a mutual fund, which invests only in securities and not in properties, in order to make it suitable for an Austrian institutional investor. The fund must comply with UCITS regulations, and it must be both registered and fiscally represented in Austria. Failure to fulfill these criteria has considerable administrative and financial ramifications for the potential investor. As this study focuses on Austrian institutional investors, funds will only be included into the analysis if they meet all three criteria. The information concerning the compliance of the various funds with the criteria necessitated by an Austrian institutional investor is derived from the websites of the relevant regulatory bodies in Austria[36].

A second set of constraints on the universe of mutual funds analyzed is the volume of data available. The increase in the value of real estate stocks that could be observed between 2003 and mid 2007[37] brought a proliferation of mutual real estate funds with it, for which the available data is extremely limited. Hence, only those funds were included into the sample for which data is available from the beginning of 2005 onwards. The following selection of mutual real estate funds was made in the light of the above considerations.

Investment Company	Fund	ISIN
CPB KAG	Constantia European Property	AT0000746268
ERSTE-SPARINVEST KAG	ESPA STOCK EUROPE PROPERTY	AT0000708342
Credit Suisse Equity Fund	European Property	LU0129337381
Davis Funds SICAV	Davis Real Estate Fund	LU0082098806
Henderson Horizon Fund SICAV	Pan European Property Equities Fund	LU0088927925
ING (L) Invest SICAV	European Real Estate	LU0119205192
Robeco Capital Growth Funds, SICAV	Robeco Property Equities	LU0187079180
Sarasin Investmentfonds SICAV	S.I.-S. Real Estate Equity - Global	LU0198389438

Table 3: Selected Austrian mutual real estate funds

36 http://www.fma.gv.at/cms/site/DE/einzel.html?channel=CH0124
https://www.bmf.gv.at/Service/Allg/ivf/AusschErtr/_start.asp?Typ=2007

37 http://www.wienerborse.at/indices/

2.2.3 Open-end Real Estate Funds

Open-end real estate funds do not qualify as UCITS funds, as they do not primarily invest in securitized assets, but in properties. Other than this, the same selection criteria applied to them as to mutual real estate funds. This means that the funds must be both registered and fiscally represented in Austria in order to avoid substantial additional administrative expenses on the part of the investor[38]. The information about the compliance of the various funds with the criteria necessitated by an Austrian institutional investor is derived from the same sources as in the previous section.

The selected open-end real estate funds are listed in the table below:

Investment Company	Fund	ISIN
BA-CA Real Invest Immobilien KAG	Real Invest Austria	AT0000634365
CPB Immobilien KAG GmbH	Constantia Real Estate	AT0000615158
ERSTE Immobilien KAG GmbH	Immofonds 1	AT0000632195
Raiffeisen Immobilien KAG GmbH	Raiffeisen-Immobilienfonds	AT0000633417
AXA Investment Managers Deutschland GmbH	AXA Immoselect	DE0009846451
Credit Suisse Asset Management Immobilien KAGmbH	Credit Suisse Euroreal	DE0009805002
UBS Real Estate KAGmbH	UBS (D) 3 Kontinente Immobilien	DE0009772681

Table 4: Selected Austrian open-end real estate funds

2.2.4 Other Portfolio Assets

The subject of other real estate portfolio assets is rather laborious for the Austrian institutional investor. Data on closed-end funds in Austria is not publicly available. As for REITs, their legal construction is not recognized in Austria. In practice this means that a REIT is classified by the Austrian regulatory authority in terms of its business model. Nonetheless, as already mentioned in Section 1.2.2, many Austrian investors hold REITs in their portfolios as components of mutual funds or of passive investment instruments.

38 The so-called 'Blütenweiße Fonds'

2.2.5 The Representative Pension Fund Asset Allocation

Innovest AG constructed a representative portfolio of an Austrian pension fund using monthly data[39] and the following assets and corresponding weights[40].

Asset	Weight
MSCI North America in EURO	16%
MSCI Europe in EURO	12%
MSCI Emerging Markets in EURO	8%
MSCI Pacific in EURO	6%
Equities	**42%**
J.P.Morgan EMU Traded Index, EMU Aggregate	27%
J.P.Morgan GBI Broad, EUR Terms Hedged	8%
J.P.Morgan EMBI Global Diversified, 90% EUR Terms Hedged	3%
Citigroup World Broad Investment-Grade Bond Index Corporate, EUR Terms Hedged	2%
Bonds	**40%**
J.P.Morgan EMU Traded Index EMU Aggregate + 80bp pro Jahr	18%

Table 5: The representative pension fund portfolio asset allocation

2.3 Data Analysis

2.3.1 Methodology

In order to analyze the available data for Austrian real estate investments and to compare it with the representative pension fund portfolio, the shortest common time horizon over all the assets was selected. This time horizon ranges from 01/2005 – 07/2008, which allows for at least three full years of time series, and which coincides with a general upswing in the real estate markets followed by a downswing. Weekly returns obtained from Bloomberg are used for all the calculations in this section. Hübner, Schwaiger and Winkler do not give a particular reason for using monthly data in any of their work, so it is assumed that this factor is not of great consequence to the results of the analysis. Possibly their choice can be explained by the larger volumes of data available in their studies compared to the volume of data available for this thesis, especially in the case of their German analyses. The IATX is used to

39 For the purposes of this study, the same representative pension fund portfolio was constructed using weekly data from 01/2005-07/2008

40 Source: Innovest AG

represent the universe of real estate stocks. A mutual fund index was constructed by using the relative volumes of the funds in 2005, as the full set of historical fund volumes was not readily available. This strategy has the merit that it can be replicated at any point in time. An open-end real estate fund index was calculated in the same way. The resulting three indices were compared with the representative pension fund portfolio, constructed using the assets and weights listed in Section 2.1.5.

First, the descriptive statistics for each of the four indices will be presented and interpreted. Secondly, the correlations for each pair of indices will be calculated as this yields information about the diversification potential of the assets. Some additional issues regarding the nature of the data are analyzed. Subsequently, the stability of the correlation between the indices will be examined, as this is relevant to the stability of the optimization results when they are calculated ex-post over the entire time period.

2.3.2 Descriptive Statistics

The table below shows the descriptive statistics of each of the indices described in Section 2.2. All of the return and risk statistics are shown as per annum percentage values.

	Representative Pension Fund	IATX	MUTUAL FUNDS	OPEN-END FUNDS
Mean return p.a	4.68%	-3.54%	6.40%	1.35%
Median return p.a	15.01%	10.85%	27.65%	3.82%
Standard Deviation p.a	12.47%	17.54%	15.78%	5.71%
Sample Variance p.a	1.56%	3.08%	2.49%	0.33%
Modified Sharpe Ratio	0.38	-0.20	0.41	0.24
Kurtosis	0.14	3.73	1.70	171.74
Skewness	-0.31	-0.86	-1.04	-13.08
Range[41]	8.92%	18.07%	12.21%	10.63%
Minimum	-4.64%	-9.42%	-7.52%	-10.32%
Maximum	4.27%	8.65%	4.69%	0.31%
Beta with ATX	0.00	0.46	0.18	0.00
Beta with MSCI Europe	0.87	0.01	0.08	0.07
Observations	173	173	173	173

Table 6: Descriptive statistics in the period from 01/2005 to 07/2008

Mean and Median

The mean return of the mutual funds is the highest over the analyzed period, followed by the representative pension fund portfolio. The mean return of the IATX is the only one that is negative over the time period, probably conditioned by the precipitous fall of stock prices after the summer of 2007. The mean return of the open-end fund index is small but positive. In the case of the IATX, the median return paints a different picture than the mean, indicating that the IATX went through periods of positive performance. The median return also indicates that the magnitude of the negative returns rather than the amount of individual negative returns is likely to have generated the negative mean returns of the IATX.

41 The range is the difference between the highest return and the lowest return in a given period. The range gives an indication of the variability of the returns of an asset.

Standard Deviation, Variance and Modified Sharpe Ratio

The standard deviation and the variance of the four indices indicate that the IATX is the most volatile category, followed by the mutual funds. Open-end funds are markedly less volatile than the other three real estate asset categories. This is due to the infrequent valuation of the underlying assets of open-end funds, which create artificially smooth returns. An investor must be aware that the prices of open-end funds are not market prices, but rather heavily smoothed valuations of the underlying assets of the fund, which are not necessarily related potential transaction prices. The modified Sharpe ratios[42] indicate that all of the categories other than the IATX have a positive return to risk ratio. In other words, the investor is compensated for the risk the he incurs with real estate investments.

Skewness and Kurtosis

A risk-averse investor tends to prefer positive uneven moments of a distribution and negative even moments of a distribution[43]. The skewness[44] is the third moment of a distribution. This means that risk-averse investors prefer a portfolio that exhibits a positive skewness over one that exhibits a negative skewness assuming that all other moments of the distribution are equal. A normal distribution has a skewness of 0. Kurtosis[45] is the fourth moment of a distribution. A risk-averse investor prefers a

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42 The modified Sharpe Ratio puts the average annualized return over a given time period into the context of the risk incurred to obtain this return. The modified Sharpe ratio makes the returns of different assets comparable by adjusting them for the risk incurred by the investor. The modified Sharpe ratio is a measure which exposes the risk-return trade-off that an investor is faced with. (Bodie Z., Kane A., Marcus J. M. , 2005, *Investments*, McGraw Hill Irwin, pp. 868)

$$ModSharpe = \frac{\bar{r}_p}{\sigma_p}$$

Where:

r_p = average portfolio return over a given period

σ_p = portfolio standard deviation over a given time period

43 Scott R. C., Horvath P. A., 1980, *On the Direction of Preference for Moments of Higher Order than the Variance*, The Journal of Finance, Vol. 35, Nr.4 pp. 915-919

44 Skewness measures the asymmetry of a distribution. A normal distribution has a skewness of 0. A negative skewness indicates that the distribution is skewed to the left. A positive skewness indicates that a distribution is skewed to the right.

$$Skewness = \frac{\sum (y_i - \bar{y}_i)^3}{(n-1)s^3}$$

Where: y_i = return in period I and s = standard deviation

45 Kurtosis describes the distribution of data around a mean. A normal distribution has a kurtosis of 3. A high kurtosis is an indication of “fat tails”. This means that higher probabilities are assigned to extreme values than in a normal distribution. Often, 3 is subtracted from this value to give excess kurtosis. Hence, a normal distribution has an excess kurtosis of 0.

negative kurtosis over a positive kurtosis assuming that all other moments of distribution are equal. The excess kurtosis of a normal distribution is zero. All of the above indices exhibit negative skewness. All of the indices exhibit a positive kurtosis. The distribution of the returns of open-end funds is further away from that of a normal distribution than the distributions of the other indices. This is probably because a large fraction of the returns is artificially generated by the infrequent valuations of the real estate assets of the fund.

Range, Minimum and Maximum

The range is the difference between the highest return and the lowest return in a given period. The range gives an indication of the variability of the returns of an asset. The return range is smallest for the representative pension fund portfolio, followed by the open-end fund index, and the mutual fund index. The relatively high range of the open-end funds returns is conditioned by the comparatively low minimum return. This minimum was generated mid-2008 when the underlying assets of the open-end real estate funds were marked down in their values. The minimum and the maximum of the open-end fund time series indicates that open-end funds have a relatively low upside potential, but a downside potential exists when the value of the underlying assets in the fund is corrected downwards. However, this must be put into the context of stocks, which can loose their entire value in the worst-case scenario. A complete loss in value appears less likely in the instance of a pool of real assets. The IATX has the lowest minimum and the highest maximum return, which is a reflection of the high volatility of the index.

Beta with ATX and MSCI Europe

The beta[46] with the Austrian Traded Index (ATX) and the MSCI Europe indicates the dependence of the real estate indices on the general Austrian stock market and on the European stock market over the period analyzed. The results show that the IATX and the mutual funds have a degree of dependence on the ATX. This is due to

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$$Kurtosis = \frac{\sum (y_i - \bar{y}_i)^4}{(n-1)s^4}$$

[46] Beta can be defined as "the extent to which an instrument and the market move together". This means that if a security has a beta of 1 and the return of the market is 10%, the return of the security will also be 10%. Beta is calculated as the covariance between the market and the index divided by the variance of the market.

$$\beta_i = \frac{Cov\ (r_i, r_m)}{\sigma_{m^2}}$$

(Bodie Z., Kane A., Marcus J. M. , 2005, *Investments*, McGraw Hill Irwin, pp. 283)

the fact that the IATX is a component of the ATX, and mutual funds probably include ATX stocks in their portfolios. The representative pension fund portfolio and the open-end fund index move independently of the ATX. In the case of the MSCI Europe the situation is very different. The representative pension fund portfolio has a very high beta with the MSCI Europe, whereas the other indices have very low betas. This is because the MSCI Europe has a 12% share in the representative pension fund portfolio.

Summary

The descriptive statistics analysed in this section were the mean and the median, the standard deviation, variance and modified Sharpe ratio, the skewness and kurtosis, the range, minimum and maximum, and the betas with market indices.

The mean and the median give an indication of the general development of the indices in the time period analysed. The sharp drop in the IATX since the summer of 2007 is reflected in the negative mean of the index. The standard deviation and the variance clearly indicate that the IATX is the most volatile of the indices, whereas the open-end fund index is much more stable. The skewness and kurtosis of the indices indicate that the returns of the indices are not normally distributed. We will come back to this point later in this thesis. The beta with the ATX shows that the IATX is dependent to a degree on the ATX, whereas the other indices barely move with the ATX. Only the representative pension fund portfolio appears to move closely with the MSCI Europe.

The following section will examine further particular aspects of the data used in this thesis, including the short time series available, the variation within the real estate investment categories, the autocorrelation in open-end funds, and correlations between the indices as well as the stability of this correlation.

2.3.3 Short Time Series

The Austrian data on real estate investments is fraught with problems. One of the main problems is the short time frame that the data is available for. Short time frames may give an investor that uses a certain time frame to make investment decisions a skewed impression of the nature of an investment. In order to illustrate this problem, the risk and return was calculated for the representative pension fund portfolio, the IATX, the mutual fund index and the open-end fund index, assuming various decision points. It was assumed that an investor had to judge the various

indices based on data from only 2005, from 2005 and 2006, from 2005, 2006, and 2007, and finally over the entire time period.

Average Return				
	Representative Pension Fund Portfolio	**IATX**	**Mutual Funds**	**Open-end Funds**
2005 p.a	22.83%	14.89%	24.10%	3.94%
2005 and 2006 p.a.	17.82%	16.51%	29.93%	4.23%
2005, 2006 and 2007 p.a.	12.42%	-0.42%	11.88%	4.40%
Whole Period p.a.	4.68%	-3.54%	6.40%	1.35%
Standard Deviation				
	Representative Pension Fund Portfolio	**IATX**	**Mutual Funds**	**Open-end Funds**
2005 p.a.	9.50%	4.10%	9.73%	0.31%
2005 and 2006 p.a.	9.83%	5.11%	10.73%	0.35%
2005, 2006 and 2007 p.a.	11.11%	15.58%	14.73%	0.34%
Whole Period p.a.	12.44%	17.49%	15.74%	5.70%
Modified Sharpe Ratio				
	Representative Pension Fund Portfolio	**IATX**	**Mutual Funds**	**Open-end Funds**
2005 p.a.	2.40	3.63	2.48	12.81
2005 and 2006 p.a.	1.81	3.23	2.79	12.19
2005, 2006 and 2007 p.a.	1.12	-0.03	0.81	12.97
Whole Period p.a.	0.38	-0.20	0.41	0.24

Table 7: Average returns measured over various time periods

The table above shows that an investor making a decision based on information exclusively from 2005, or from 2005 and 2006 is likely to see real estate investments as an attractive investment opportunity. Mutual funds and real estate stocks offer lucrative returns, and open-end funds have extremely high modified Sharpe ratios. The inclusion of 2007 changes the picture substantially. Real estate investments on the whole remain profitable, as does the representative pension fund portfolio, but the IATX delivers a negative average return and a negative Sharpe ratio. All the asset categories become less attractive in terms of return. Aside from the open-end real estate funds, which are only implicated as of 2008, all of the assets become a lot more volatile. The inclusion of the whole time period, and thereby the revaluation of

the open-end funds in 2008 also reduces the attraction of open-end funds, with the modified Sharpe ratio of the funds falling to 0.24. This indicates that open-end funds may tend to exhibit lagged responses to market developments.

The lesson to be learned is that an investor should pay close attention to the time period that returns and volatilities are based on. Return and volatility calculations based on different time periods may deliver very different results. Furthermore, future developments will not necessarily follow patterns exhibited in the past. This does not necessarily invalidate information derived from past returns. It merely emphasizes that a prudent investor must pay attention to the data involved in generating the results that he bases his decisions on.

2.3.4 Selection within categories

The analyses in the previous section are based on indices constructed from the members of each real estate investment category. These indices may lead an investor to believe that an investment in the relevant category of assets will exhibit similar characteristics to the index, regardless of the members selected. In this section, the real estate investment indices are decomposed into their respective instruments. The same time period is analyzed as with the indices, and weekly returns are used. The best and the worst performer in each category in terms of return are identified. The volatility per annum and the modified Sharpe ratio of the asset are calculated. The value of a € 100 initial investment at the end of the time period on the 4.08.08 is calculated. The components of the IATX that came into existence after 2005 are excluded in this analysis.

IATX

	Best performer Immofinanz AG[47]	**Worst performer** CA Immobilien AG
Average Return p.a.	0.63%	-11.89%
Volatility p.a.	21.34%	22.38%
Mod. Sharpe Ratio	0.03	-0.53
4.07.08 value of €100 investment	94.53	61.56

Table 8: IATX best and worst performers

Mutual Funds

	Best performer ERSTE ESPA Stock Europe Property	**Worst performer** Credit Suisse European Property
Average return p.a.	7.76%	0.49%
Volatility p.a.	15.93%	18.00%
Mod. Sharpe Ratio	0.49	0.03
4.07.08 value of €100 investment	124.01	96.17

Table 9: Mutual Fund best and worst performers

Open-end real estate funds

	Best performer Constantia Real Estate	**Worst performer** AXA Immoslect
Average return p.a.	4.44%	4.23%
Volatility p.a.	0.65%	0.34%
Mod. Sharpe Ratio	6.88	12.50
4.07.08 value of €100 investment	122.93	117.55

Table 10: Open-end Fund best and worst performers

[47] It must be noted that the results of this analysis are based on a snapshot in time. The results are based on data from the period between 01/2005 and 07/2008. An analysis of a different time period may yield results that deviate widely from these.

Verdict

The above tables show that there is considerable variation in terms of return and volatility within the assets in a real estate investment category. This indicates that an investor should not assume that the returns and volatilities of a few selected assets from a category will have the same characteristics as an index calculated across the category. Furthermore, it indicates that selection capabilities will be of use to an investor when confronted with a universe of real estate investments from within a category. Alternatively, an investor may attempt to diversify very broadly across the investment category.

Approaches to selection

When selecting individual investments from a broad category, investors may be tempted to use exclusively quantitative criteria. However, it may be useful to include other aspects into the analysis of an asset, such as qualitative criteria. The following qualitative criteria, suggested by Golec (2001)[48] and by Chevalier and Ellison (1999)[49] maybe of use:

- Industry factors
- Management fees
- Fund volume
- Tenure of the fund manager
- Education of the fund manager

The above criteria may be especially useful when dealing with asset categories that do not supply the potential investor with real market prices, as is the case with open-end real estate funds.

[48] Golec J. H., 2001,*The Effects of Mutual Funds Managers' Characteristics in Their Portfolio Performance, Risk and Fees*, Financial Services Review

[49] Chevalier J., Ellison G., 1999, *Are Some Mutual Fund Managers better than Others? Cross-sectional Patterns in Behaviour and Performance*, Journal of Finance, Vol. 54

2.3.5 Autocorrelation in open-end real estate funds

Many studies that focus on the properties of open-end real estate funds in Austria and in Germany, such as Maurer, Rainer and Sebastian (2004)[50] base their analysis on the autocorrelation of open-end real estate funds, or on the autocorrelation of the real estate components of open-end real estate funds. Having shown that the returns of these funds are autocorrelated, they proceed to unsmooth the returns, which raises the volatility that the returns exhibit. The mean volatilities and returns obtained in this process can subsequently be used to compute the variance-covariance matrix for an ex-post optimisation problem.

The autocorrelations of the open-end real estate fund index are computed with a 1-week lag to a 12-week lag. Statistically significant autocorrelation cannot be found in any of the lags.

The open-end fund data may be modified by attempting to eliminate the non-real estate components from the returns of the open-end real estate funds. However, this procedure does not seem to be the optimal solution in this case, as it is not only extremely laborious, but also leaves several problems unaddressed. The main problem that such an approach entails is that it is a precursor to an ex-post optimization. This problem is discussed in more detail from Section 2.2.4 onwards. Furthermore, an unsmoothing of the returns and an extraction of the real estate components may lead to a further distortion of returns that are far from market prices in the first place. The validity of an optimization using such returns and volatilities is probably questionable.

2.3.6 Correlation

The correlations between the various real estate categories with each other and with the representative pension fund portfolio are shown in the table below. The correlations are calculated over the entire time period, as specified in Section 2.3.1. The t-statistics of the values are in the brackets below. The statistically significant correlations are in bold. The correlations between two assets can provide a

[50] Maurer R., Sebastian S., Stephan T. G., 2000, *Immobilienindizes im Portfoliomanagement* , Deutsche Gesellschaft für Versicherungsmathematik (Ed.), Investmentmodelle für das Asset-Liability-Modelling für Versicherungsgesellschaften

preliminary estimation of the diversification potential that the inclusion of an asset into a portfolio containing the other asset may yield[51].

	Representative Pension Fund Portfolio	**IATX**	**Mutual Funds**	**Open-end Funds**
Representative Pension Fund Portfolio	1			
IATX	0.01 (0.08)	1		
Mutual Funds	0.03 (0.39)	**0.26** **(3.56)**	1	
Open-end Funds	0.16 (2.10)	0.04 (0.48)	-0.09 (-1.25)	1

Table 11: Correlations between the representative pension fund portfolio and the various real estate investment categories

The above correlation matrix indicates that the only significant correlation can be found between the IATX and mutual funds. This is to be expected, as mutual real estate funds largely include real estate stocks, which are likely to exhibit some correlation with the IATX. The other asset categories are uncorrelated with each other, indicating that they are likely to yield diversification potential when included into a portfolio. Most importantly, none of the asset categories are significantly correlated with the representative pension fund portfolio, indicating that real estate assets should yield diversification benefits when integrated into the portfolio of the pension fund.

2.3.7 Stability of Correlation

The stability of the correlation between the various asset categories over time is important in deciding whether an ex-post optimization approach will yield useful results. An ex-post optimization[52], using the entire available history of returns to create a covariance matrix, gives the investor the optimal allocation for one specific point in history. It yields no information for the future, unless the correlation matrix can be shown to remain stable over time.

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[51] Hübner R., Schwaiger M. S., Winkler G., 2003, *Das Diversifikationspotential österreichischer Immobilienwertpapiere*, Österreichisches Bankenarchiv, Vol.8, pp. 568

[52] Schwaiger S., Winkler G., Hübner R., 2003, *Die Attraktivität verbriefter Immobilienanlagen in der Portfolio-Selection – eine ex-ante Analyse für Deutschland*, Zeitschrift für Betriebswirtschaft, Vol .12, pp.1256

In order to test whether the correlations between the asset categories remain stable over time, the same approach was used as Schwaiger, Winkler and Hübner (2003)[53]. The time period was split into two equal periods of 86 weekly returns each[54]. The correlations were calculated over each of the two periods. To test the stability of the diversification potential of the various asset categories, the Jennrich (1970)[55] approach was used. Here it must be noted that the description of the Jennrich test by Schwaiger, Winkler and Hübner[56] contains a typing error[57]. The null-hypothesis in this test is that the two correlation matrices are stationary, i.e. H_0: $R_1 = R_2$. When the period from 01/2005-07/2008 is split into two equal sections, the following results are obtained. The chi-squared statistic in the table below shows that there is no statistically significant difference between the correlation matrices.

Test Statistik	10%
6.03	15.98

Table 12: Test statistic for the Jennrich Test when the period 2005-2008 is split into two equal halves

In order to further test the stability of the correlation matrices over time, the correlation matrix was calculated for the weekly returns in 2005 and for the weekly returns in 2007. Again, these were tested for equality in the correlation matrices with the Jennrich Test. The table below shows that for each of the confidence levels, the hypothesis that the correlation matrices are equal can be discarded.

Test Statistik	10%	5%	1%
30.16	15.98	18.31	23.21

Table 13: Test statistic for the Jennrich Test (year-to-year)

The results of this test show that an ex-post optimization approach will not yield reliable information, as the correlation matrices do not remain constant over time.

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53 Schwaiger S., Winkler G., Hübner R., 2003, *Die Attraktivität verbriefter Immobilienanlagen in der Portfolio-Selection – eine ex-ante Analyse für Deutschland*, Zeitschrift für Betriebswirtschaft, Vol .12, pp. 1249-1283

54 The first return was omitted as the original number of returns in the sample was uneven

55 Jennrich R. J., 1970, *An Asymptotic c-Test for the Equality of two Correlation Matrices* Journal of the American Statistical Association, Vol. 65, pp. 904-912

56 Schwaiger S., Winkler G., Hübner R., 2003, *Die Attraktivität verbriefter Immobilienanlagen in der Portfolio-Selection – eine ex-ante Analyse für Deutschland*, Zeitschrift für Betriebswirtschaft, Vol .12, pp. 1257

57 The correct calculation according to Jennrich is $Z = c^{1/2}R^{-1}(R_1-R_2)$, and not (R_1-R_2) as published by Schwaiger, Winkler and Hübner.

2.4 Summary

The second section of this thesis provided a description of the data available for Austrian real estate investments. The descriptive statistics of the data were discussed. The problem of the short time series available for Austrian real estate funds was highlighted. It was pointed out that an investment in an index across a real estate asset category is not equivalent to an investment in randomly chosen category members. Selection abilities are of use to an investor when making a securitized real estate investment in Austria. An alternative to quantitative selection approaches may be a qualitative approach, especially when faced with returns that do not reflect the market price of instruments, as is the case with open-end real estate funds.

The correlations of the assets with each other and with the representative pension fund portfolio were computed. The correlations were tested for their stability over time. The results showed that the correlations between the various real estate asset categories are in fact not stable over time. This makes the use of an ex-post optimization approach questionable, as it has no value for the future. Instead, an ex-ante approach to optimization will be introduced and implemented in the next section.

3 OPTIMIZATION

The issue that will be addressed in the course of this section is the diversification potential of Austrian real estate assets when mixed into the portfolio of a representative Austrian pension fund. This encompasses both the question whether real estate assets generally yield diversification benefits, as well as the question which real estate investment categories and which combinations of real estate investment categories yield the most diversification benefits.

The structure of this section will be as follows. First, the difference between an ex-ante and an ex-post approach will be outlined, and the advantages of the latter will be briefly discussed. Secondly, the input parameters for the optimizations will be detailed. Portfolios consisting of the representative pension fund portfolio and the seven possible combinations of Austrian real estate investment categories will be defined. The three different forms of portfolio optimization used in the analysis will be described. Issues concerning the estimation period and the holding period will be considered. Next, the results of the optimization will be presented and interpreted. The statistical significance of the performance improvement will be established. In a last step, the problem of the lacking normal distribution of the returns will be

addressed by optimizing using the lower partial moment as opposed to the standard deviation as a measure of risk.

3.1 Ex-post versus Ex-ante Optimisation

The main hurdle in an optimization problem of this sort is the definition of an accurate structure of risk and return. Risks, returns, and the corresponding variance-covariance matrix must be estimated. The more accurate the estimation is, the more reliable the results of the optimization. However, even small changes in the estimates of risk and return can lead to large swings in the portfolio weights that are assigned to each asset in the optimized portfolio.

Jorion (1985)[58] describes ex-post analysis and concisely summarizes the problems inherent in this approach. Ex-post mean-variance analysis involves using past averages as a substitute for expected returns. The assumption is that the past mean is an accurate approximation of the expected return. The possibility of estimation errors generated by this substitution is conventionally not considered. This approach gives rise to a number of problems. The results obtained from an optimization using an ex-post approach tends to have little relevance for out-of-sample periods, resulting in bad performance (Jorion, 1985). In other words, an ex-post analysis reflects what would have been the best strategy at a single point in time, given the volume of available historical data. Consequently, the results prove to be very unstable. Adding or subtracting a few values at the beginning or at the end of the period can deliver very different results. Clearly, instability of results and inapplicability to out-of-sample periods draw the value of a practical implementation of ex-post analysis into question.

Table 5 highlights a further problem pertaining to the specific data used in this thesis that is relevant to ex-post analysis. If the mean return per annum is calculated for each real estate investment category over the entire sample period, this figure is negative for the IATX. The negative average is due to the bad performance of the assets in the last year. The negative average is not an indication that the mean return per annum was necessarily negative in the past, regardless of the sample period, nor is it an indication that the mean will remain negative in the future. However, an ex-

[58] Jorion P., 1985, *International Portfolio Diversification with Estimation Risk*, The Journal of Business, Vol. 58, No. 3, pp. 259-278

post optimization approach is likely to under-weight real estate stocks due to the negative mean return that is fed into the optimization in place of the expected return.

In order to mitigate the problems of an ex-post approach the ex-ante approach attempts to circumvent the problem of estimating a correct risk and return structure, which may be subject to considerable changes over time. Instead, the ex-ante approach uses two moving time windows. The first is the estimation period, which is used to derive approximations for the mean returns, correlations and variances over the period. The optimal portfolio weights are computed using these parameters. The second is the holding period, in which a portfolio with the weights computed from the estimation period is held. The performance of the portfolio is measured at the end of the holding period, based on the results of the holding period. Performance is measured in terms of average return as well as in terms of the modified Sharpe ratio. In other words, this approach uses historical data to determine the portfolio weights for the subsequent period, which is the evaluation period for the portfolio. In the next steps, the estimation period is moved forward by a certain increment of time and the process is repeated. Data of a certain age begins to fall out of the sample, and more recent data is considered in its place. Clearly, ex-ante analysis yields a larger volume of results to evaluate whether a category of assets should be included into a portfolio than an ex-post analysis.

3.2 Input Parameters and Methods

3.2.1 Portfolios

In order to satisfactorily answer the question whether and which Austrian real estate investments yield diversification benefits in the portfolio of our exemplary Austrian pension fund, several different portfolios must be formed and tested. The representative Austrian pension fund portfolio is a component of every portfolio. It consists of the following assets:

Asset	Weight
MSCI North America in EURO	16%
MSCI Europe in EURO	12%
MSCI Emerging Markets in EURO	8%
MSCI Pacific in EURO	6%
Equities	**42%**
J.P.Morgan EMU Traded Index, EMU Aggregate	27%
J.P.Morgan GBI Broad, EUR Terms Hedged	8%
J.P.Morgan EMBI Global Diversified, 90% EUR Terms Hedged	3%
Citigroup World Broad Investment-Grade Bond Index Corporate, EUR Terms Hedged	2%
Bonds	**40%**
J.P.Morgan EMU Traded Index EMU Aggregate + 80bp pro Jahr	18%

Table 14: The component assets of the representative portfolio of an Austrian pension fund

The allocation above, which is that of a representative Austrian pension fund portfolio, is compared to every optimal portfolio consisting of a mixture of the assets in the table above and the assets in the various real estate investment categories. The assets that are available to be mixed into the representative pension fund portfolio are shown in the table below:

IATX
CA Immo International AG
CA Immobilien Anlagen AG
Conwert Immobilien Invest AG
ECO Business-Immobilien AG
IMMOEAST
Immofinanz AG
Sparkassen Immobilien AG
Warimpex AG
MUTUAL FUNDS
Constantia European Property
ESPA STOCK EUROPE PROPERTY
European Property
Davis Real Estate Fund
Pan European Property Equities Fund
European Real Estate
Robeco Property Equities
S.I.-S. Real Estate Equity - Global
OPEN-END FUNDS
Real Invest Austria
Constantia Real Estate
Immofonds 1
Raiffeisen-Immobilienfonds
AXA Immoselect
Credit Suisse Euroreal
UBS (D) 3 Kontinente Immobilien

Table 15: Assets to be mixed into the representative pension fund portfolio

This results in seven portfolios that can be compared to the representative pension fund portfolio. The table below shows the seven portfolios. The table is to be read in rows. For example, the second portfolio consists of the pension fund asset

allocation and the IATX. The third consists of the pension fund asset allocation and mutual funds.

Pension Fund	IATX	Mutual	Open
x			
x	x		
x		x	
x			x
x	x	x	
x	x		x
x		x	x
x	x	x	x

Table 16: The seven portfolios used in optimization

It is important to realize that the portfolios consist of the individual time series of the pension fund components and of each of the real estate categories. This means that the asset allocation of the pension fund can be changed by the optimization, as long as it remains within the legal constraints described in Section 1.3. The portfolios are compared to the asset allocation of the representative pension fund portfolio in the fixed proportions described in Section 2.2.5.

3.2.2 Approaches to Optimization

Two approaches to the optimization of the above portfolios were taken. A minimum variance portfolio[59] and a portfolio with a maximized modified Sharpe ratio[60] were formed for each of the combinations in Section 3.2.1. A naïve portfolio[61] was also formed. As mentioned above, the representative pension fund portfolio in the constant proportions listed in Section 2.2.5 was used as a comparison. The minimum variance portfolio best reflects the allocation strategy of a very risk-averse investor, as is probably the case with a pension fund. The maximum Sharpe portfolio represents a more aggressive asset allocation.

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59 Schwaiger M. S., Winkler G., Hübner R., 2004, *Die Attraktivität verbriefter Immobilienanlagen in der Portfolio Selektion – eine ex-ante Analyse für Deutschland,* Zeitschrift für Betriebswirtschaft Vol. 12, pp. 1258

60 Schwaiger M. S., Winkler G., Hübner R., 2004, *Die Attraktivität verbriefter Immobilienanlagen in der Portfolio Selektion – eine ex-ante Analyse für Deutschland,* Zeitschrift für Betriebswirtschaft Vol. 12, pp. 1258

N.B.: In this thesis the formula used by in the paper in this reference was altered to the modified Sharpe Ratio, which simply excludes the risk-free rate from the expression.

61 A naïve portfolio includes all the assets in equal proportions.

In the portfolio optimizations, the constraints that a pension fund is faced with were taken into consideration. As outlined in Section 1.3, at least 30% of the assets of a pension fund need to be invested in cash or in government bonds. A maximum of 5% of the fund volume may be invested in the same stock. In the case of a §20 fund, open-end funds are prohibited, and a maximum of 20% of the fund volume may be invested in each fund. This scenario is represented by the three portfolios that exclude open-end funds, which are outlined in Section 3.2.1. In the case of a §20a) fund, a maximum of 20% of the fund volume may be invested in open-end funds. No more than 10% of the fund volume may be invested in each open-end fund. In this case, a maximum of 50% of the fund volume can be invested in one mutual fund. These funds cannot be used as components of an umbrella fund. This scenario is represented by the remaining four portfolio combinations outlined in Section 3.2.1. It is important to note that the naïve portfolio does not have much relevance to an Austrian pension fund, as it is not compatible with the regulations pertaining to these funds. The naïve portfolio is simply a comparison to determine the merits of the other two portfolio strategies.

3.2.3 The Estimation Period

The asset allocation of the portfolios in the holding period is determined by the returns, risks, and correlations observed in the estimation period. If the correlations in the estimation period and in the holding period deviate from each other substantially, this leads to some of the same problems as the use of an ex-post estimation, as the results of the estimation period have little relevance for the holding period. Hence, the length of observation period should be chosen such that the difference between the correlation in the observation period and in the holding period is minimized.

Schwaiger, Winkler and Hübner (2004) make the following comments on the selection of the estimation period. The authors choose a four-year estimation period in their study, as this period maximizes the stability of the correlation matrix. Longer periods of time tend to exhibit lower stability. The authors are of the opinion that four years are the upper boundary for the time-span of the estimation period. No lower boundary is mentioned for the estimation period. Hübner, Schwaiger and Winkler (2003) use a one-year estimation period for their Austrian analysis. As this thesis is based to some degree on their work, a one-year estimation period will be adopted for our data set.

3.2.4 The Holding Period

The lower boundary for the holding period is constrained by the required parameters for later tests of the statistical significance of the performance improvement, which will be discussed in more detail in Section 3.4. This test[62] requires that $\frac{T}{N} \geq 3$, where T is the number of observations, N is the number of assets, where the result represents the degrees of freedom. This results in a minimum holding period for our data of 87 weeks[63]. As this holding period is within the realm of the reasonable for an institutional investor, and the available data for this thesis is limited, the minimum requirement was selected. Assuming that this strategy is rolled forward in one month increments, as is the case in the work of Schwaiger, Hübner and Winkler (2003, 2004), this generates 9 sets of results for each portfolio[64].

3.3 Preliminary Results

The table below shows the results obtained from the procedure detailed above for the representative pension fund portfolio and for the combination of the representative pension fund portfolio and the assets of the IATX. The full table of results can be found in the Appendix. The mean return and the modified Sharpe ratio are calculated for every holding period. The mean return is shown as a percentage above the modified Sharpe Ratio. The modified Sharpe ratios that are higher than those of the representative pension fund portfolio are in bold.

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62 Gibbons M. R., Ross S., Shanken J., 1989, *A Test for the Efficiency of a given Portfolio*, Econometrica, Vol. 57, pp. 1136

63 The representative pension fund portfolio comprises 9 assets. The requirement for the holding period is that the significance test can be applied to the largest portfolio. The largest portfolio includes all the assets of all the real estate categories, i.e. 5 IATX stocks, 8 mutual funds and 7 open-end funds. This totals 29 assets. Hence, the minimum holding period must be 87 weeks.

64 This means that 9 results are calculated for each portfolio optimization strategy, resulting in a total of 27 results for each of the 7 portfolios excluding the representative pension fund portfolio.

	HOLDING PERIOD								
PORTFOLIO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Representative Pension Fund Portfolio (PFP)									
Mean return p.a.	9.22%	5.77%	4.97%	-0.38%	1.94%	-0.16%	3.59%	0.83%	-3.32%
Modified Sharpe ratio	0.8085	0.4758	0.4082	-0.0292	0.1510	-0.0122	0.2624	0.0596	-0.2309
PFP + IATX	Number of modified Sharpe ratios higher than PFP: 2								
Naïve Allocation									
Return	3.41%	-1.59%	-1.34%	-5.49%	-2.84%	-2.68%	-0.02%	-1.66%	-4.54%
Mod. Sharpe Ratio	0.5372	-0.2206	-0.1734	-0.6308	-0.3221	-0.3027	-0.0176	-0.1852	-0.4947
Minimum Variance Portfolio									
Return	0.92%	-0.96%	-0.53%	-1.36%	-0.22%	0.84%	0.01%	0.35%	-1.03%
Mod. Sharpe Ratio	0.3158	-0.3377	-0.1712	-0.4057	-0.0706	**0.2871**	0.0149	**0.1165**	-0.3495
Maximum Modified Sharpe Ratio									
Return	1.44%	-1.25%	-1.27%	-3.06%	-1.71%	-1.57%	-0.02%	-0.91%	-1.92%
Mod. Sharpe Ratio	0.3952	-0.3371	-0.2691	-0.5886	-0.3289	-0.2803	-0.0270	-0.1754	-0.4651

Table 17: Sample results for Minimum Variance and Maximum Sharpe Ratio optimization – The representative pension fund portfolio and an optimal portfolio consisting of the representative pension fund portfolio and the assets of the IATX

The results show that the inclusion of real estate assets into the portfolio of an Austrian pension fund does not consistently improve performance as measured by the modified Sharpe ratio. Both the inclusion of mutual funds and open funds improves the performance of the minimum variance portfolio relative to the representative pension fund portfolio in seven instances. The inclusion of several real estate asset categories improves the performance of the minimum variance portfolio in more instances if one of the categories is an open-end real estate fund. This is plausible due to the high Sharpe ratio that open-end real estate funds tend to exhibit. The limited benefit of this feature can be attributed to the fact that the proportion of open-end real estate funds in the portfolio is capped at 20%.

In order to assess the relevance of the above results, it is necessary to determine whether the observable performance improvements are of statistical significance. This subject is addressed in the following section.

3.4 Statistical Significance

The modified Sharpe ratios that are higher than those of the representative pension fund portfolio are tested for their statistical significance. This is done using the test by Gibbons (1989), see also Schwaiger, Winkler, Hübner (2004), pp. 1260[65]. According to this test statistic, there are no statistically significant improvements to be obtained from the inclusion of real estate assets into the portfolio of the pension fund asset allocation.

The next section will repeat the above ex-ante optimization procedure with a different approach to optimization. This approach is attempted because the skewness and kurtosis of the indices of the real estate investment categories calculated in Section 2.3.2 indicate that the returns of the real estate investment categories are not normally distributed. As the normal distribution of returns is one of the main prerequisites for a minimum-variance optimization, an apparent lack of this characteristic warrants further examination.

3.5 Using the Lower Partial Moment as a Measure of Risk

The lower partial moment[66] approach is used by Hübner, Schwaiger and Winkler (2003)[67]. If the solution obtained from a minimum-variance optimization is to be

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65 H_0: $SR^{mod}_i = SR^{mod}_j$, where SR^{mod} is the modified Sharpe ratio. The test statistic W is calculated as follows:

$$W = \left(\frac{\sqrt{\left(1 + SR_i^2\right)}}{\sqrt{\left(1 + SR_j^2\right)}} \right)^2 - 1$$

If the null hypothesis holds, W=0. If W is of significant magnitude, the null hypothesis does not hold. This statistic is then converted into one with that follows a central F-distribution with (T-N-1) degrees of freedom, where N is the number of assets and T is the number of observations.

$$\frac{T(T-N-1)}{N(T-2)} W \sim F_{N,(T-N-1)}$$

66 The lower partial moment is the expected value of the downwards deviations from a basic return. In this analysis, the downwards deviation from a return of 0 was used. Mathematically, the lower partial moment can be defined as the following problem:

$$LPM^1 = \frac{1}{T} \sum_{T=1}^{T} \max\left\{0, BZ_t - \sum_{i=1}^{N} x_i R_{i,t}\right\} \rightarrow \min$$

Where BZ is the basic expected return, $R_{i,t}$ is the return of asset I in period t,, and x is the weight of the asset in the portfolio.

Under the conditions that:

$$\sum_{i=1}^{N} x_i \overline{R}_i = \overline{R}_p \quad \text{and} \quad \sum_{i=1}^{N} x_i = 1$$

67 Hübner R., Schwaiger M. S., Winkler G., 2003, *Das Diversifikationspotential österreichischer Immobilienwertpapiere*, Österreichisches Bankenarchiv, Vol. 8, pp. 573

consistent with the utility maximization of the investor, one of the two criteria below must be fulfilled. The returns of the analyzed assets must either be normally distributed, or the investors in question must have a quadratic utility function.

A quadratic utility function is unlikely in practice. According to Mossin (1973)[68] the presence of quadratic utility functions implies that every investor holds the same percentage of every security in equilibrium.

The index of every real estate asset category was tested for normal distribution using the Jarque-Bera test[69]. The results, which show that none of the real estate asset categories are normally distributed at a 10% significance level, are displayed in the table below.

	IATX	MUTUAL FUNDS	OPEN_END FUNDS
JARQUE BERA	24.9	43.11	2167.46
SIG 10%	0.0201	0.0201	0.0201

Table 18: Results of Jarque Bera test for normality

The absences of the two criteria which make mean-variance analysis compatible with utility maximization give rise to an interest in alternative measures of performance. Aside from the irrelevance of distributions and utility functions to the lower partial moment method, the approach offers further merits. One of the main advantages of the lower partial moment method is that it uses a very intuitive concept of risk. Risk, as used in the lower partial moment, is the possibility that the portfolio as a whole produces a negative return. This concept is very tangible to investors, as these are usually favorably inclined to upwards movements, and see their own risk as the possibility of a downwards development of their portfolio, rather than as a deviation on both sides of the mean. Furthermore, the only criteria that needs to be fulfilled for the lower partial moment approach is the existence of unsatisfied risk-averse investors[70]. In combination with lower partial moments, the Sortino ratio[71] is used as a performance measure in place of the Sharpe ratio.

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68 Mossin J., 1973, *Theory of Financial Markets*, Prentice-Hall

69 Hübner R., Schwaiger M. S., Winkler G., 2003, *Das Diversifikationspotential österreichischer Immobilienwertpapiere*, Österreichisches Bankenarchiv, Vol. 8, pp. 575

70 Hübner R., Schwaiger M. S., Winkler G., 2003, *Das Diversifikationspotential österreichischer Immobilienwertpapiere*, Österreichisches Bankenarchiv, Vol. 8, pp. 573

As in the previous section, an ex-ante approach was used with the same estimation and holding period. The portfolio with a minimal lower partial moment was estimated and invested during the holding period. The performance of the portfolio was calculated on the basis of the holding period. The results were tested for significance in the same way as described in Section 3.4. As in the previous section, the results for the representative pension fund portfolio and for a combination of the representative pension fund portfolio and the assets of the IATX are shown below. The complete table of results can be found in the Appendix.

	HOLDING PERIOD								
PORTFOLIO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Representative Pension Fund Portfolio (PFP)									
Mean return p.a.	0.18%	0.11%	0.10%	-0.01%	0.04%	0.00%	0.07%	0.02%	-0.06%
LPM	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008
Sortino Ratio	0.3380	0.1856	0.1564	-0.0103	0.0557	-0.0044	0.0976	0.0211	-0.0774
PFP + IATX	Number of modified Sharpe ratios higher than PFP: 1								
Mean return p.a.	0.02%	-0.03%	0.00%	-0.04%	-0.04%	0.00%	-0.11%	-0.10%	-0.06%
LPM	0.0001	0.0001	0.0002	0.0002	0.0003	0.0004	0.0018	0.0004	0.0005
Sortino Ratio	**1.9285**	-3.0034	0.0664	-2.0550	-1.3817	-0.0950	-0.6284	-2.414	-0.5425

Table 19: Sample results of the Lower Partial Moment optimization: mean returns p.a., lower partial moments and Sortino ratios

The results of the lower partial moment optimization show that the inclusion of real estate investments into the portfolio of an Austrian pension fund improves the Sortino ratio in every instance when mutual funds alone are mixed into the portfolio, and when mutual funds and open-end funds are mixed into the portfolio together. The inclusion of the open-end funds alone improves the Sortino ratio in all but one instance. The inclusion of the other combinations of real estate investment assets improves the Sortino ratio in far fewer instances. However, testing for the statistical significance of the improvements in the Sortino ratio shows that none of the improvements are statistically significant.

[71] The Sortino ratio is calculated as follows: $SOR = \frac{\overline{R_p} - BZ}{LPM^1}$ where R_p is the return of the portfolio, BZ is the basic expected return and the LPM is the first lower partial moment.

3.6 Summary

This section has shown that mutual funds and open-end real estate funds offer the most diversification benefits, whereas the IATX does not appear to offer much diversification. However, although investments in real estate can improve the performance of an Austrian pension fund as measured by the Sharpe ratio and the Sortino ratio, the performance improvements are not statistically significant. Once again, it must be pointed out that open-end funds should be treated with great caution, as their volatilities are strongly smoothed, and their prices are a far cry from the fair market values of the funds.

It is conceivable that one of the reasons for the lacking statistical significance of the results in this section is the limited volume of data available for the analysis. In order to shed a different light on the dilemma, the next section will give an overview of some of the macroeconomic factors that influence real estate returns. Furthermore, the inclusion of macroeconomic factors into the analysis may be useful in the prediction of the risk and return structure of real estate investments, which in turn has the potential to improve the results of an optimization problem. Finally, one scenario that encourages a rise in real estate prices, and one which indicates falling real estate prices will be outlined.

4 THE DRIVERS OF REAL ESTATE RETURNS

Despite the ex-ante optimisation attempts made in the previous section, Austrian real estate investment time series remain exceptionally short. Three years of data render it impossible to evaluate real estate investment vehicles over different phases of the business cycle. This section will identify the factors most commonly associated with changes in real estate prices in the corresponding literature, and outline a positive and a negative environment for real estate investments for the benefit of those investors unperturbed by the lack of statistical significance found in the previous section.

4.1 Drivers of Real Estate Returns discussed in the relevant literature

4.1.1 Inflation

Tsatsoronis and Zhu (2003)[72] find that inflation is most clearly a driver of real house prices. This finding is made using a vector autoregression model in their study, which focuses on residential real estate. However, the authors are unable to determine whether a change in inflation rate affects real house prices in a negative or a positive direction. They suggest that this is because their sample includes the 1970's a well as the 1990's, which incorporates periods of high and of low inflation into the sample.

Folger, Granito and Smith (1985)[73] analyze the connection between unanticipated inflation and real estate returns and conclude that an increase in inflation beta signifies a positive effect on real estate returns. Himmelberg, Mayer and Sinai (2005)[74] study the presence of housing bubbles in US cities and find that conclusive statements about whether house prices are justified by underlying fundamentals cannot be made without considering the impact of expected inflation. Sirmans and Nietz (2001)[75] discuss several studies which establish a relationship between inflation and real estate prices.

4.1.2 GDP growth

Ceron and Suarez (2006)[76] examine quarterly inflation adjusted housing price data in 14 developed countries. The authors use a multi-country approach because they are concerned that the available time series are too short to accommodate the length of a cycle in the housing markets. A two-state Markov switching model with parameters that are common to all countries, as well as a country specific parameter is used. They find that the expected real growth rate of house prices increases with the lagged quarterly real rate of GDP growth.

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72 Tsatsaronis K., Zhu H., 2003, *What drives housing price dynamics: cross-country evidence*, BIS Quarterly Review

73 Folger H. R., Granito M. R., Smith L. R., 1985, A Theoretical Analysis of Real Estate Returns, The Journal of Finance, Vol. XL, No. 3

74 Himmelberg C., Mayer C., Sinai T., 2005, *Assessing High House Prices: Bubbles, Fundamentals and Misperceptions*, The Journal of Economic Perspectives, Vol. 19, pp. 67-92

75 Benjamin J.D. , Sirmans S.G., Nietz E.N., 2001, *Returns and Risk on Real Estate and Other Investments: more Evidence*, Journal of Real Estate Portfolio Management, Vol. 7

76 Ceron J., Suarez J., 2006, *Hot and Cold Housing Markets: International Evidence*, CEMFI Working Paper No. 0603

Borio and Mcguire (2004)[77] study the relationship between equity peaks and housing peaks and discover that housing peaks tend to follow periods of strong economic activity, as measured by GDP growth.

4.1.3 The unemployment rate

Ceron and Suarez (2006) also discover that the expected real growth rate of house prices decreases with the lagged one-year change in the unemployment rate. Borio and Mcguire (2004) are able to associate a decrease in the unemployment rate in previous periods with a higher probability of a peak in housing prices in quarters ahead. However, Liang and McIntosh (1998)[78] show that changes in unemployment contribute to real estate returns only in the short run. A growth in employment is positively related to real estate returns.

4.1.4 Interest Rates

Ceron and Suarez (2006) associate the expected real growth rate of house prices with the lagged long-term nominal interest rate. Borio and Mcguire (2004) find that an increase in interest rates brings rising house prices to a halt. The European Central Bank (2003) establishes a connection between nominal interest rates and house prices. Borio and Mcguire (2004) identify the short-term interest rate as the most important factor influencing real house prices. They find that real interest rates influence the development of real house prices, but with less significant coefficients than the corresponding nominal rates. Himmelberg, Mayer and Sinai (2005) find that house prices increase in the presence of low real long-term interest rates. Eichholz and Huisman (2001)[79] show that interest rates are negatively related to real estate returns. McCue and Kling (1994)[80] find that macroeconomic variables such as the real interest rate explain almost 60% of price variation in real housing prices.

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77 Borio C., McGuire P., 2004, *Twin peaks in equity and housing prices?*, BIS Quarterly Review, March

78 Liang Y., McIntosh W., 1998, *Employment Growth and Real Estate Return: Are They Linked?*, Journal of Real Estate Portfolio Management, Vol. 4:2, pp. 125–33

79 Eichholtz P., Huisman R., 2001, *The Cross Section of Global Property Share Returns*, A Global Perspective on Real Estate Cycles, Kluwer Academic Publishers, Boston

80 McCue T. E., Kling J. L., 1994, *Real Estate Returns and the Macroeconomy: Some Empirical Evidence from Real Estate Investment Trust Data, 1972–1991*, Journal of Real Estate Research, Vol. 9:2, pp. 277–87

4.1.5 Households disposable income

The European Central Bank (2003) mentions household's disposable income as having an influence on real estate prices. Himmelberg, Mayer and Sinai (2005) connect the expected increases in income of households with changes in real estate prices.

4.1.6 Demographics

Mankiw and Weil (1989)[81] pointed out that demographic factors have an effect on housing prices. They predict that one of the consequences of aging population may be a fall in housing prices. This view is supported by McFadden (1993)[82]. Hoynes and McFadden (1994)[83] examine whether housing prices can be forecasted from current information on demographics and house prices. However, the authors are unable to produce conclusive answers to these questions.

4.1.7 Lagging of variables

Eppli, Shilling and Vandell (1998)[84] show that macroeconomic variables explain less than 3% of the variability in unsmoothed metropolitan real estate returns. Lagging the same variables yields explains 28% of variability. Hence, when looking at the variables that affect real estate returns, it is important to note that these often affect the real estate market in a lagged form. This is especially relevant for GDP growth rates and the unemployment rate.

4.2 Summary

Empirical evidence has shown that the following factors have an influence on real estate prices: inflation, GDP growth, the unemployment rate, the long-term nominal interest rate, the long-term real interest rate, disposable income and demographics. The tables below show an environment that puts an upward pressure on real estate prices, and an environment that puts a downward pressure on real estate prices.

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81 Mankiw N.G., Weil D. N., 1989, *The Baby Boon, The Baby Bust, and the Housing Market,* Regional Science and Urban Economics, Vol. 93, pp. 235-258

82 McFadden D., 1993, *Demographics, The Housing Market, and the Welfare of the Elderly,* The University of Chicago Press and NBER

83 Hoynes H.W., McFadden D., 1994, *The Impact of Demographics on Housing and non-Housing Wealth in the United States,* NBER

84 Eppli M. J., Shilling J. D., Vandell K. D., 1998, *What Moves Retail Property Returns at the Metropolitan Level*, Journal of Real Estate Finance and Economics, Vol. 16:3, pp. 317–42

Factor	Inflation	GDP Growth	Long-term nominal interest rate	Long-term real interest rate	Disposable Income	Aging Population
Increase	increasing	increasing			increasing	
Decrease			increasing	increasing		decreasing

Table 20: An environment that puts an upward pressure on real estate prices

A rise in real estate prices can be expected in an environment in which inflation, GDP growth, disposable income is rising, in which the population is not aging, and in which interest rates are decreasing.

A fall in real estate prices can be expected to fall in an environment in which inflation, GDP growth, disposable income are falling, the population is aging, and interest rates are rising.

Factor	Inflation	GDP Growth	Long-term nominal interest rate	Long-term real interest rate	Disposable Income	Aging Population
Increase			decreasing	decreasing		
Decrease	decreasing	decreasing			decreasing	increasing

Table 21: An environment that puts a downward pressure on real estate prices

5 CONCLUSION

The aim of this thesis has been to provide a guideline for Austrian institutional investors seeking to optimize their portfolios with real estate assets. The perspective of a hypothetical Austrian pension fund operating within the framework of Austrian law was chosen in order to facilitate this task.

The thesis was divided into four main sections. In the first section, the most important concepts relevant to the subject were defined. A qualitative overview of the most prominent forms of real estate investments was given. For each investment vehicle, the business model was described and the main difficulties associated with the investment were pointed out. The legal framework in Austria and the constraints that Austrian pension funds are subject to were elaborated on.

The second section defined the selected universe of Austrian real estate investments and the asset allocation of the representative Austrian pension fund

portfolio. The descriptive statistics for each of the four categories were presented and interpreted and the correlations between the categories were calculated. The problem of the short time series available for Austrian mutual real estate funds and open-end real estate funds was highlighted. It was pointed out that an investment in an index across a real estate asset category is not equivalent to an investment in randomly chosen category members. It was shown that selection abilities are of use to an investor when making a securitized real estate investment in Austria, and the qualitative approach was briefly introduced. Finally, the correlations were tested for their stability over time, and it was found that they are unstable. The conclusion was drawn that the instability of the correlations between the real estate asset categories warrants an ex-ante approach to optimization as opposed to an ex-post approach.

The third section addressed the diversification potential of Austrian real estate assets when added to the given asset allocation of an Austrian pension fund. The question whether real estate assets generally yield diversification benefits, and more specifically which assets in what combinations yield the most diversification benefits was addressed. The difference between an ex-ante and an ex-post approach were outlined, and the advantages of the latter were briefly discussed. The input parameters for the optimizations were detailed, and the seven possible combinations of Austrian real estate investment categories were defined. The different forms of optimization were described, and the results of the optimizations were presented and interpreted. The results were tested for their statistical significance. Finally, the problem of the lack of normal distribution of the returns was addressed by optimizing using the lower partial moment as opposed to the standard deviation as a measure of risk. It was shown that mutual funds and open-end real estate funds offer the most diversification benefits, whereas the IATX does not appear to offer much diversification. However, none of the performance improvements were statistically significant.

The fourth section addressed the problem that the paucity of statistical significance of the results in Section 3 may be due to the limited volume of data available for the analysis. It was pointed out that three years of data render it impossible to evaluate real estate investment vehicles over different phases of the business cycle. Section 4 identified the factors most commonly associated with changes in real estate prices in the corresponding literature, and outlined a positive and a negative environment for real estate investments.

The results of this thesis do not necessarily place into question the advisability of an investment in real estate investment vehicles or even in Austrian real estate investments, but rather point to a number of factors that are of interest to investors. The strict constraints that Austrian pension funds are subject to most likely limit the potential for diversification that real estate investments offer. Furthermore, the short data time-series that are available for Austrian instruments, in combination with the fact that this time-span almost exclusively incorporates the rise and fall of a real estate bubble, certainly affect the results. A third factor that is of significance is the limited universe of different real estate investments in Austria, as exemplified by the absence of REIT structures.

This thesis points to several further issues that may be of interest to institutional investors in Austria. For example, it would be of interest to determine whether Austrian real estate investments offer diversification benefits to investors that are not subject to the rigid constraints that Austrian pension funds face.

The recent introduction of the G-REIT in Germany may point to the pending introduction of similar structures in Austria. It would most certainly be of interest to investigate whether such instruments would yield diversification benefits in the portfolios of Austrian pension funds.

Finally, a further study of the effects of the current financial crisis on the real estate investments of Austrian institutional investors, or even on the real estate investments of Austrian pension funds may yield valuable information concerning the diversification benefits of real estate investments in times of crisis.

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7 Appendix

	HOLDING PERIOD								
PORTFOLIO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Representative Pension Fund Portfolio (PFP)									
Mean return p.a.	9.22%	5.77%	4.97%	-0.38%	1.94%	-0.16%	3.59%	0.83%	-3.32%
Modified Sharpe ratio	0.8085	0.4758	0.4082	-0.0292	0.1510	-0.0122	0.2624	0.0596	-0.2309
PFP + IATX	Number of modified Sharpe ratios higher than PFP: 2								
Naïve Allocation									
Return	3.41%	-1.59%	-1.34%	-5.49%	-2.84%	-2.68%	-0.02%	-1.66%	-4.54%
Mod. Sharpe Ratio	0.5372	-0.2206	-0.1734	-0.6308	-0.3221	-0.3027	-0.0176	-0.1852	-0.4947
Minimum Variance Portfolio									
Return	0.92%	-0.96%	-0.53%	-1.36%	-0.22%	0.84%	0.01%	0.35%	-1.03%
Mod. Sharpe Ratio	0.3158	-0.3377	-0.1712	-0.4057	-0.0706	**0.2871**	0.0149	**0.1165**	-0.3495
Maximum Modified Sharpe Ratio									
Return	1.44%	-1.25%	-1.27%	-3.06%	-1.71%	-1.57%	-0.02%	-0.91%	-1.92%
Mod. Sharpe Ratio	0.3952	-0.3371	-0.2691	-0.5886	-0.3289	-0.2803	-0.0270	-0.1754	-0.4651
PFP + MUT	Number of modified Sharpe ratios higher than PFP: 13								
Naïve Allocation									
Return	1.66%	3.06%	-0.31%	-0.05%	-0.03%	0.00%	0.01%	-0.02%	-0.07%
Mod. Sharpe Ratio	**0.8977**	0.4360	-0.0443	-0.0512	-0.0302	**0.0003**	0.0048	-0.0206	**-0.0669**
Minimum Variance Portfolio									
Return	1.50%	1.69%	-1.08%	0.04%	0.05%	0.06%	0.02%	0.04%	0.01%
Mod. Sharpe Ratio	**0.8321**	**0.9700**	-0.2677	**0.1847**	**0.1647**	**0.2468**	0.0379	**0.1184**	**0.0520**
Maximum Modified Sharpe Ratio									
Return	3.36%	0.81%	-1.43%	-0.02%	7.84%	-0.01%	0.00%	-0.01%	-0.01%
Mod. Sharpe Ratio	**0.8321**	0.3472	-0.3354	-0.0417	**0.2931**	-0.0292	0.0090	-0.0142	**-0.0371**
PFP + OPEN	Number of modified Sharpe ratios higher than PFP: 19								
Naïve Allocation									
Return	-0.01%	0.08%	0.09%	0.07%	0.08%	0.08%	0.09%	0.08%	0.06%
Mod. Sharpe Ratio	-0.1594	0.1816	0.1866	**0.1415**	**0.1780**	**0.1666**	0.1882	**0.1537**	**0.1237**
Minimum Variance Portfolio									
Return	0.00%	0.02%	0.02%	0.03%	0.03%	0.03%	0.03%	0.03%	0.01%
Mod. Sharpe Ratio	0.0047	0.4359	**0.4356**	**0.4926**	**0.4962**	**0.5797**	**0.4894**	**0.7948**	**0.1170**
Maximum Modified Sharpe Ratio									
Return	2.90%	0.03%	0.03%	0.03%	0.03%	0.00%	0.04%	0.03%	0.03%
Mod. Sharpe Ratio	**2.0231**	0.4258	0.3665	**0.3307**	**0.4505**	**0.0182**	**0.5066**	**0.5681**	**0.1983**
PFP + IATX + MUT	Number of modified Sharpe ratios higher than PFP: 9								
Naïve Allocation									
Return	0.11%	0.01%	-0.06%	-0.01%	-0.09%	-0.06%	-0.05%	-0.06%	-0.11%
Mod. Sharpe Ratio	**0.0976**	0.0173	-0.0443	**-0.0145**	-0.0677	-0.0440	-0.0327	-0.0442	**-0.0754**

Minimum Variance Portfolio									
Return	0.06%	0.01%	-0.01%	-0.03%	-0.03%	0.01%	-0.01%	-0.02%	-0.04%
Mod. Sharpe Ratio	**0.0985**	0.0173	-0.0153	-0.0449	-0.0502	**0.0162**	-0.0177	-0.0286	**-0.0590**
Maximum Modified Sharpe Ratio									
Return	0.06%	0.01%	-0.01%	1.20%	-0.04%	-0.02%	-0.02%	-0.03%	-0.05%
Mod. Sharpe Ratio	**0.0975**	0.0173	-0.0222	**-0.7801**	-0.0587	-0.0244	-0.0241	-0.0350	**-0.0663**
PFP + IATX + OPEN	Number of modified Sharpe ratios higher than PFP: 10								
Naïve Allocation									
Return	0.00%	0.01%	0.01%	-0.04%	-0.01%	0.00%	0.02%	0.01%	-0.01%
Mod. Sharpe Ratio	-0.0023	0.0067	0.0204	-0.0471	-0.0105	**-0.0031**	0.0211	0.0130	**-0.0069**
Minimum Variance Portfolio									
Return	1.77%	0.01%	0.01%	0.00%	0.02%	0.03%	0.03%	0.03%	0.02%
Mod. Sharpe Ratio	**1.3589**	0.0472	0.0277	**-0.0118**	0.0483	**0.1207**	0.0952	**0.0799**	**0.0614**
Maximum Modified Sharpe Ratio									
Return	2.12%	-0.01%	-0.01%	-0.05%	-0.03%	0.00%	-0.01%	-0.01%	-0.02%
Mod. Sharpe Ratio	**0.8651**	-0.0235	-0.0199	-0.0697	-0.0397	**0.0035**	-0.0183	-0.0150	**-0.0284**
PFP + MUT + OPEN	Number of modified Sharpe ratios higher than PFP: 10								
Naïve Allocation									
Return	1.58%	0.06%	0.02%	-0.01%	0.01%	0.03%	0.03%	0.01%	-0.02%
Mod. Sharpe Ratio	0.8676	0.0619	0.0337	**-0.0126**	0.0072	**0.0379**	0.0420	0.0168	**-0.0292**
Minimum Variance Portfolio									
Return	2.88%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%	0.02%	0.00%
Mod. Sharpe Ratio	**1.0294**	0.0342	0.0232	**0.0109**	0.0341	**0.0421**	0.0320	0.0453	**-0.0026**
Maximum Modified Sharpe Ratio									
Return	2.88%	-0.02%	-0.03%	0.01%	0.01%	-0.01%	0.02%	0.02%	0.00%
Mod. Sharpe Ratio	**1.0292**	-0.0417	-0.0701	**0.0109**	0.0300	-0.0219	0.0351	0.0454	**-0.0051**
PFP + IATX + MUT + OPEN	Number of modified Sharpe ratios higher than PFP: 6								
Naïve Allocation									
Return	1.52%	0.00%	-0.02%	-0.07%	-0.05%	-0.02%	-0.01%	-0.02%	-0.06%
Mod. Sharpe Ratio	0.7571	0.0040	-0.0199	-0.0713	-0.0455	-0.0220	-0.0109	-0.0224	**-0.0534**
Minimum Variance Portfolio									
Return	1.73%	0.01%	0.01%	-0.01%	0.02%	0.04%	0.03%	0.03%	0.02%
Mod. Sharpe Ratio	**0.8096**	0.0469	0.0376	**-0.0227**	0.0582	**0.1489**	0.1123	**0.0982**	**0.0628**
Maximum Modified Sharpe Ratio									
Return	1.91%	-0.01%	0.00%	-0.06%	-0.04%	-0.01%	-0.02%	-0.01%	-0.03%
Mod. Sharpe Ratio	0.6344	-0.0249	-0.0057	-0.0839	-0.0567	-0.0157	-0.0201	-0.0170	-0.0360

Table 17 (complete): Results for Minimum Variance and Maximum Modified Sharpe Ratio optimization – The representative pension fund portfolio and the optimal portfolios consisting of the representative pension fund portfolio and the various categories of real estate investments

	HOLDING PERIOD								
PORTFOLIO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Representative Pension Fund Portfolio (PFP)									
Mean return p.a.	0.18%	0.11%	0.10%	-0.01%	0.04%	0.00%	0.07%	0.02%	-0.06%
LPM	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008
Sortino Ratio	0.3380	0.1856	0.1564	-0.0103	0.0557	-0.0044	0.0976	0.0211	-0.0774
PFP + IATX	Number of modified Sharpe ratios higher than PFP: 1								
Mean return p.a.	0.02%	-0.03%	0.00%	-0.04%	-0.04%	0.00%	-0.11%	-0.10%	-0.06%
LPM	0.0001	0.0001	0.0002	0.0002	0.0003	0.0004	0.0018	0.0004	0.0005
Sortino Ratio	**1.9285**	-3.0034	0.0664	-2.0550	-1.3817	-0.0950	-0.6284	-2.414	-0.5425
PFP + MUT	Number of modified Sharpe ratios higher than PFP: ALL								
Mean return p.a.	0.03%	0.86%	0.07%	0.02%	0.02%	0.05%	0.05%	0.02%	0.01%
LPM	0.0002	0.0002	0.0002	0.0003	0.0003	0.0005	0.0008	0.0005	0.0005
Sortino Ratio	**1.7209**	**5.7062**	**3.3483**	**0.6482**	**0.5209**	**1.0039**	**0.5433**	**0.5165**	**0.2623**
PFP + OPEN	Number of modified Sharpe ratios higher than PFP: 8								
Mean return p.a.	0.00%	0.04%	0.05%	0.05%	0.05%	0.06%	0.05%	0.05%	0.04%
LPM	0.0002	0.0002	0.0002	0.0002	0.0003	0.0004	0.0004	0.0004	0.0004
Sortino Ratio	0.0011	**2.2782**	**2.3233**	**2.3315**	**2.0212**	**1.7379**	**1.3353**	**1.2010**	**1.1320**
PFP + IATX + MUT	Number of modified Sharpe ratios higher than PFP 1								
Mean return p.a.	0.02%	-0.04%	-0.05%	-0.06%	-0.05%	0.00%	-0.01%	-0.01%	-0.03%
LPM	0.0001	0.0001	0.0003	0.0002	0.0003	0.0004	0.0005	0.0004	0.0005
Sortino Ratio	**1.5395**	-5.2558	-1.9119	-3.3322	-2.0139	-0.0200	-0.1550	-0.2713	-0.6286
PFP + IATX + OPEN	Number of modified Sharpe ratios higher than PFP: 4								
Mean return p.a.	0.03%	-0.02%	-0.02%	-0.04%	-0.01%	0.01%	0.01%	0.00%	0.00%
LPM	0.0001	0.0002	0.0001	0.0001	0.0002	0.0003	0.0003	0.0003	0.0003
Sortino Ratio	**5.0403**	-0.8078	-1.0488	-3.9797	-0.4466	**0.4931**	**0.2954**	**0.1452**	-0.1481
PFP + MUT + OPEN	Number of modified Sharpe ratios higher than PFP: ALL								
Mean return p.a.	0.05%	0.03%	0.02%	0.04%	0.05%	0.06%	0.05%	0.04%	0.00%
LPM	0.0001	0.0005	0.0002	0.0003	0.0004	0.0003	0.0004	0.0004	0.0004
Sortino Ratio	**3.3509**	**0.7254**	**1.1768**	**1.4852**	**1.1577**	**1.8528**	**1.3475**	**1.0967**	**-0.0307**
PFP + IATX + MUT + OPEN	Number of modified Sharpe ratios higher than PFP: 1								
Mean return p.a.	0.04%	-0.02%	-0.02%	-0.06%	-0.03%	0.00%	0.00%	0.00%	-0.02%
LPM	0.0002	0.0003	0.0001	0.0002	0.0003	0.0004	0.0004	0.0005	0.0004
Sortino Ratio	**2.0483**	-0.7134	-1.7787	-2.9710	-0.9779	-0.0864	-0.0541	-0.0237	-0.5274

Table 19 (complete): Results for Lower Partial Moment optimization – the representative pension fund portfolio and the optimal portfolios consisting of the representative pension fund portfolio and the various categories of real estate investments

ABSTRACT

The aim of this thesis is to provide a guideline for Austrian institutional investors seeking to optimize their portfolios with real estate assets. The perspective of a hypothetical Austrian pension fund operating within the framework of Austrian law is chosen in order to facilitate this task.

The thesis is divided into four main sections. In the first section, the most important concepts relevant to the subject are defined. A qualitative overview of the most prominent forms of real estate investments is given. For each investment vehicle, the business model is described and the main difficulties associated with the investment are pointed out. The legal framework in Austria and the constraints that Austrian pension funds are subject to are elaborated on.

The second section defines the selected universe of Austrian real estate investments and the asset allocation of the representative Austrian pension fund portfolio. The descriptive statistics for each of the four categories are presented and interpreted and the correlations between the categories are calculated. The problem of the short time series available for Austrian mutual real estate funds and open-end real estate funds is highlighted. It is pointed out that an investment in an index across a real estate asset category is not equivalent to an investment in randomly chosen category members. It is shown that selection abilities are of use to an investor when making a securitized real estate investment in Austria, and the qualitative approach is briefly introduced. Finally, the correlations are tested for their stability over time, and it is found that they are unstable. The conclusion is drawn that the instability of the correlations between the real estate asset categories warrants an ex-ante approach to optimization as opposed to an ex-post approach.

The third section addresses the diversification potential of Austrian real estate assets when added to the given asset allocation of an Austrian pension fund. The question whether real estate assets generally yield diversification benefits, and more specifically which assets in what combinations yield the most diversification benefits is addressed. The difference between an ex-ante and an ex-post approach is outlined, and the advantages of the latter are briefly discussed. The input parameters for the optimizations are detailed, and the seven possible combinations of Austrian real estate investment categories are defined. The different forms of optimization are described, and the results of the optimizations are presented and interpreted. The

results are tested for their statistical significance. Finally, the problem of the lack of normal distribution of the returns is addressed by optimizing using the lower partial moment as opposed to the standard deviation as a measure of risk. It is shown that mutual funds and open-end real estate funds offer the most diversification benefits, whereas the IATX does not appear to offer much diversification. However, none of the performance improvements is statistically significant.

The fourth section addresses the problem that the paucity of statistical significance of the results in Section 3 may be due to the limited volume of data available for the analysis. It is pointed out that three years of data render it impossible to evaluate real estate investment vehicles over different phases of the business cycle. Section 4 identifies the factors most commonly associated with changes in real estate prices in the corresponding literature, and outlines a positive and a negative environment for real estate investments.

The results of this thesis do not necessarily place into question the advisability of an investment in real estate investment vehicles or even in Austrian real estate investments, but rather point to a number of factors that are of interest to investors. The strict constraints that Austrian pension funds are subject to most likely limit the potential for diversification that real estate investments offer. Furthermore, the short data time-series that are available for Austrian instruments, in combination with the fact that this time-span almost exclusively incorporates the rise and fall of a real estate bubble, certainly affect the results. A third factor that is of significance is the limited universe of different real estate investments in Austria, as exemplified by the absence of REIT structures.

DEUTSCHE ZUSAMMENFASSUNG

Das Ziel dieser Diplomarbeit ist es einen Leitfaden für institutionelle Investoren, die ihre Portfolios mit verbrieften Immobilieninvestitionen optimieren möchten, zu verfassen. Zu diesem Zweck wird die Thematik aus der Perspektive einer fiktiven exemplarischen österreichischen Pensionskasse beleuchtet.

Die Diplomarbeit ist in vier Teile gegliedert. Der erste Teil gibt eine Einführung in das Gebiet der Immobilieninvestitionen. Die wichtigsten Investitionsformen werden dargestellt, wobei die zugrundeliegenden Geschäftsmodelle beschrieben und die Risikoquellen der Investition aufgezeigt werden. Zuletzt werden die rechtlichen Rahmenbedingen, denen österreichische Pensionskassen unterliegen, zusammengefasst.

Der zweite Teil der Diplomarbeit definiert das Universum der Investitionsvehikel für die weitere Analyse, sowie die Veranlagung der fiktiven österreichischen Pensionskasse. Die Zeitreihen der selektierten Investitionsvehikel werden deskriptiv analysiert, und die Korrelationen zwischen den verschieden Kategorien von verbrieften Immobilieninvestitionen berechnet. Die Problematik der beschränken Länge der vorhandenen Zeitreihen für österreichische offene Immobilienfonds wird diskutiert. Es wird festgestellt, dass Selektionsfähigkeiten dem Investor zu Gute kommen, da die Investition in einen Index, bestehend aus den Komponenten einer Kategorie, sich ungleich einer Investition in ein einzelnes Wertpapier der Kategorie verhält. In diesem Kontext werden qualitative Selektionsansätze angedeutet. Die Instabilität der Korrelationen wird erkannt, welches für einen ex-ante Ansatz statt einen ex-post Ansatz bei der Optimierung spricht.

Die Optimierung selbst ist Thema des dritten Teils der Arbeit. Es wird hinterfragt, ob verbriefte Immobilieninvestitionen generell zu Diversifikationseffekten im Portfolio einer österreichischen Pensionskasse führen, und des Weiteren welche Kombination von Wertpapieren die angesprochenen Diversifikationseffekte maximiert. Die Unterschiede zwischen einer ex-ante und einer ex-post Optimierung werden besprochen, und die Vorteile ersterer werden herausgestrichen. Bevor die Resultate der Optimierung präsentiert, interpretiert, und auf statistische Signifikanz getestet werden, wird auf die Inputparameter der Optimierungen detailliert eingegangen. Die mangelnde Normalverteilung der Erträge wird thematisiert, und eine weitere Optimierung wird mit dem Lower Partial Moment als Riskikomaß anstatt der

Standardabweichung durchgeführt. Es wird der Schluss gezogen, dass in der untersuchten Periode Immobilienaktienfonds und offene Immobilienfonds die besten Diversifikationseffekte bieten. Allerdings sind keine der Performanceverbesserungen statistisch Signifikant.

Der letzte Teil der Diplomarbeit befasst sich mit der Problematik der, im Sinne des Zeitraums, beschränkt erhältlichen Daten zu den Entwicklungen von verbrieften Immobilieninvestitionen und identifiziert jene ökonomischen Faktoren, die in der Literatur mit Veränderungen von Immobilienpreisen assoziiert werden. Ein positives und ein negatives Szenario für Immobilieninvestitionen werden beschrieben.

Die Ergebnisse dieser Diplomarbeit stellen die Vorzüge von verbrieften Immobilieninvestitionen nicht generell in Frage, sondern streichen drei wesentliche Punkte für den interessierten institutionellen Investor heraus. Die Studie deutet darauf hin, dass die restriktiven Veranlagungsrichtlinien von österreichischen Pensionskassen das Diversifikationspotential von Immobilieninvestitionen beschränken. Weiters wird die Bedeutung von Datenqualität und Menge deutlich. Die kurzen Zeitreihen die für österreichische Immobilieninvestitionen erhältlich sind, sowie der Umstand, dass diese Daten genau mit dem Aufschwung und Abschwung einer Immobilienblase koinzidieren haben die Ergebnisse der Studie zweifelsohne beeinflusst. Zuletzt muss das dürftige österreichische Investitionsuniversum in diesem Bereich in betracht gezogen werden. Zukünftige Entwicklungen, beispielsweise die Anerkennung von REIT Strukturen in Österreich, könnten diesen Zustand merklich verbessern, und somit auch das Diversifikationspotential von verbrieften Immobilieninvestitionen erhöhen.

CURRICULUM VITAE

CLAUDIA PIGRUM, BA(Hons)

Zedlitzgasse 3/13
1010 Wien, Österreich
+4369911096599
claudia_pigrum@yahoo.co.uk

GEBURTSDATUM: 29.01.1981
NATIONALITÄT: Österreich/Großbritannien
SPRACHKENNTNISSE: Fließend: Deutsch, Englisch, Schwedisch
Gute Kenntnisse: Spanisch
Grundkenntnisse: Französisch

AUSBILDUNG:

10/07 - 06/09: **Institut für Strategische Kapitalmarktforschung - Portfoliomanagementprogramm**
Wissenschaftliche Analyse der Kapitalmärkte

10/03 - 02/09: **Diplomstudium Internationale Betriebswirtschaftslehre - Universität Wien**
Spezialisierungen: Investmentanalyse bei Prof. Dockner
Corporate Finance bei Prof. Zechner

10/00 - 06/03: **Baccalaureatsstudium Innenarchitektur, Kingston University**
Abschluss: Bachelor of Arts (Hons) Interior Design
Upper Second Class Honours

10/99 - 07/00: **Diplomstudium der Pharmazie, Universität Wien**

09/86 - 06/99: **Vienna International School**
Abschluss: International Baccalaureate (40 Punkte)
Matura, Bilinguales Diplom

BERUFSERFAHRUNG:

02/08 - 08/08: **INNOVEST AG**
Diplomarbeit „Immobilieninvestitionen für Institutionelle Investoren in Österreich“

06/07 - 03/09: **MEI- KO Liegenschaftsverwertungs GmbH**
Akquisition von Immobilien
Projektmanagement

10/03 - 02/06: **Qentis Holding GmbH**
Leiterin Europäische Online Sales
Leiterin Import Fernost

06/03 - 10/03: **Qentis Holding Ltd.**
Projekt Assistenz

SONSTIGE QUALIFIKATIONEN / TÄTIGKEITEN:

10/08: Mitglied des CFA Institutes
Voraussichtliche Prüfung Level 1: Juni 09

02/08: Reuters XTRA Zertifizierung

10/08 - 06/09: Diverse Bloomberg Schulungen

10/07 – 09/08: Ausbildung zur Ashtanga Yoga Lehrerin

08/98 - 02/99: Blindenschule der Stadt Wien
Aushilfe für Lehrkräfte

08/98 - 02/99: Medicins sans frontiers
Fundraising

10/00-06/03: Studienrichtungsvertreterin Innenarchitektur (siehe oben)
Kingston University, GB und Österreich