THE DEGREE OF ATTRACTIVENSS OF MIXED USE INVESTMENTS FROM THE PERSPECTIVE OF (DUTCH) INSTITUTIONAL INVESTORS

Gladys Okosun

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Author:	*Gladys Okosun*
University:	*The University of Groningen*
Faculty:	*The Faculty of Spatial Sciences*
Programme:	*Master of Science in Real Estate Studies*
Student number:	*S3711145*
E-mail:	*g.okosun@student.rug.nl*
Date:	*30 June 2019*
Supervisor:	*Prof. Dr. E. F. Nozeman*
Assessor:	*Prof. Dr. Ir. A.J. van der Vlist*
Graduation company:	*Syntrus Achmea Real Estate and Finance*
Company mentor:	*Jos Sentel MBA MSc*

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ABSTRACT

This paper investigated the direct ex-post financial performance of mixed use in comparison to single use investments in the Dutch real estate market. As one of the first studies to empirically examine this relationship a foundation has been established. This study was conducted using a multivariate hedonic OLS pricing model on a cross-sectional dataset for 2016, made up of 536 observations of which, 62 were determined to be mixed use and the remaining single use investments. Review of the existing literature on mixed use developments depicted a positive story. However, it also highlighted scarcity in the empirical analysis of mixed use investments. Results from this study show that mixed use investments may not necessarily perform better than comparable single use investments. Rents from mixed use investments are estimated to be lower relative to single use investments irrespective of the varying degrees of mixed use but caution in generalizing these results should be exercised due to data limitations. Conversely, it can be more assertively inferred from the results that mixed use developments are more expensive to operate. This finding was also robust to the varying degrees of mixed use. Results regarding net operating income were varied. Mixed use developments with a dominant use of 79 per cent or less were found to perform worse than single use investments, whereas the other two mixed use categories were estimated to yield equivalent profitability to comparable single use investments. Finally, city size was found to not significantly influence rent but the opposite was true for net operating income of mixed use investments. Discussions following the results however revealed that omitted variables could explain why (Dutch) institutional investors may still share in the enthusiasm of mixed use real estate investments and this study also highlighted important issues that need to be considered to maximize return on mixed use investments.

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1. INTRODUCTION

1.1 Motivation

Can mixed use properties provide added value for the real estate portfolios of institutional investors and do these types of property offer a better risk-return ratio than objects that are monofuntional (Syntrus Achmea Real Estate and Finance, 2018)? This is a question many institutional investors are probably faced with as mixed use developments continue to gain attraction in the inner city urban landscape whilst monofunctional real estate such as small office parks are approached with caution, even by lenders such as “De Nederlandsche Bank (the DNB)” as they are deemed in the Dutch market to have a lot of vacancies and limited redevelopment options (Vastgoedmarkt, 2019). According to Syntrus Achmea Real Estate and Finance, 2018 the availability of mixed use investment opportunities has grown rapidly. However, knowledge regarding the risk-return profile of mixed use developments is insufficient. This is partly due to the fact that mixed use investments are not recognized as a separate asset class, thereby historical data and appropriate benchmarks are lacking which could be used to adequately assess the performance of such projects, especially in the Netherlands (Syntrus Achmea Real Estate and Finance, 2018). Additionally, institutional investors are known to be risk averse and prefer single use properties such as residential, with which they are more familiar and perceive to have a good risk-return profile. The Netherlands is one of six European countries in which residential properties dominate the real estate asset portfolio of institutional investors; this is because Dutch residential properties have on the long term performed well when compared to real estate classes and other assets (IVBN and Finance Ideas, 2014).

There is a gap in the knowledge on mixed used developments, and more specifically those within a single structure or at the building level, that needs to be examined in order to help inform Dutch institutional investors about the degree of attractiveness of mixed use investment in comparison to single use alternatives. In addition over the past few decades as real estate is believed to account for a large proportion of emissions at around 40% (IPE Real Assets, 2018), mixed-use real estate development projects have become a popular notion for tackling sustainability issues as it is believed that it could offer ‘good densification’ that provides a cohesive, connected environment with abundance of open space where people can live, work and play if executed correctly (PWC and the ULI, 2018). Therefore, mixed use investments could help the increasing number of institutional investors who are considering more sustainable investments as “globally, 21% of pension funds and insurance companies are actively developing impact-investing strategies, and a further 44% are considering it (Phillips, 2018).”

The concept of mixed-use is however, not a new phenomenon. It is commonly identified in literature that Jacobs (1961) in The Death and Life of Great American Cities, was the first to advocate for a balanced mix of primary uses (residential, major employment and service functions) and secondary uses (shops, restaurants, bars and other small-scale facilities) in an urban block, which she argued might result in diverse, livable, safe and vibrant neighborhoods (Hoppenbrouwer and Louw, 2005; Koster and Rouwendal, 2011). Decades later, mixed-use in Europe was commonly seen as part of the compact city concept developed by Breheny (1992), which the European Commission promoted along with diversity within neighborhoods (Hoppenbrouwer and Louw, 2005; Koster and Rouwendal 2011; Breheny, 1995; Rowley, 1996). More recently, mixed-use continues to play an important role in European policy and in the Dutch context, the compact city concept has been at the centre of the countries planning policies for the last two decades encouraging mixing housing and employment in large cities such as Amsterdam and Rotterdam (Hoppenbrouwer and Louw, 2005; Dieleman et al., 1999).

Despite the status of mixed-use in public policy, the concept remains somewhat ambiguous due to the lack of consensus regarding its definition. Nevertheless, attempts have been made to clarify the definition of mixed-use real estate developments.

" The Urban Land Institute (1987) defines a mixed-use project as a coherent plan with three or more functionally and physically integrated revenue-producing uses. However, a combination of two functions can also denote mixed-use development (Hoppenbrouwer and Louw, 2005)."

Mateo-Babiano and Darchen (2013) further add that:

"Mixed-use developments may be categorised as either horizontal or vertical. Horizontal mixed use refers to the mix of land uses spread across a district, block or compound. On the other hand, vertical mixed use pertains to the extent to which mix of uses is accommodated in one vertical structure."

The continued attractiveness of mixed-use developments from a planning policy and user-demand perspective has arisen in the wake of rising population density and limited availability of new land for development, which is prevalent in most western metropolitan areas such as London and Amsterdam. In the Netherlands for instance, there is an increasing pressure on real estate in major Dutch cities resulting partly from the expected increase in single households by 700,000 to 3.6 million in 2037 (Syntrus Achmea Real Estate and Finance, 2018). Consequently, the current strategy of public policy in many of these regions encourages mixed-use development projects. An example of this can be found in Amsterdam's Structural Vision for 2040 which promotes mixed-use developments that combine functions and offers a suitable environment for living, working and leisure, as well as excellent public transport (City of Amsterdam, 2018).

The implication from an institutional investors perspective is a potentially attractive opportunity to extract additional returns from their investment and further enhance the benefits that could be derived from investing in real estate in urban environments that are densely populated. Meaning, it is becoming increasingly important to mix uses to increase investors' returns and user satisfaction given the depletion of available developable land in viable locations (Minadeo and Colliers Turley Martin Tucker, 2007). It is widely acknowledged that investing in real estate can provide risk reduction and diversification benefits, as well as serves as a hedge against inflation whilst delivering a more stable cash flow to an investor than for instance, investing in stocks. Thus, mixed-use real estate investments could offer institutional investors with the additional diversification of risk across the uses within the development.

However, as institutional investors tend to be risk averse, the outcome is that a large number is cautious about investing in mixed-use developments due to the added level of financial, design and management complexity, which increases information asymmetry and risk for the investor. This in turn makes it more difficult for investors to assess the financial viability or return from mixed-use investments when compared to single use investments (Rabianski et al., 2009). The added challenges posed by mixed-use investments reduce the attractiveness of investing in such an asset for institutional investors.

The focus of this paper is to contribute to the understanding of whether, given their risk-return profile, institutional investors should share in the enthusiasm of other professionals for mixed-use investments. Therefore, the performance of mixed-use investments in the larger metropolitan areas in the Netherlands will be examined to give insight into whether mixed-use investments offer superior returns and lower or identical risks in comparison to single-use investments.

1.2 Review of literature

Despite the aforementioned societal relevance and motivation for investing in mixed-use real estate developments, which include but are not limited to the issue of rising land prices combined with increasing population density in large cities, there is a severe gap in empirical research covering their performance.

As established by Rabianski et al. (2009) in their review of earlier literature on mixed-use real estate developments, they find that most studies are mainly of a descriptive nature and the real issue is a significant lack of theoretical and empirical academic investigation into the success and failures of mixed-use developments from a real estate business perspective. There is a scarce number of studies that have explored mixed use developments at the building level or within a single structure. Mateo-Babiano and Darchen (2013) and Huston and Mateo-Babiano (2013) both explore the growth patterns and development trends of vertical mixed use (VMU) developments in the central business district (CBD) of Brisbane. They use the Hoppenbrouwer and Louw (2005) typology to identify VMU properties and find that the CBD of Brisbane is dominated by single use with only 1.7% and 11.9% of structures accommodating two and three uses respectively; however, they corroborate the slow but growing trend of VMU developments is encouraged by statutory regulations (Mateo-Babiano and Darchen, 2013 and Huston and Mateo-Babian, 2013). Both papers however, do not conduct an empirical analysis of the success of VMU developments.

A majority of the other papers focusing on mixed-use real estate have captured the indirect performance of mixed-use assets and commonly indicate a net positive effect associated with mixed-use real estate developments. Most of these studies adopt a hedonic pricing technique to assess the spillover effect of mixing uses on surrounding property prices. Some examples include the effect of an open-air, mixed use shopping centre (Kholdy et al., 2014) and a mixed use area (Nakamura et al. (2018) on nearby property prices. Van Cao and Cory (1982), Song and Knaap (2004) and Koster and Rouwendal (2010) focus instead on the effect of mixed land use on surrounding property prices and all find evidence in favour of mixed land use. However, Koster and Rouwendal (2010) warn that household densities should not be too high. Further studies include Childs et al. (1996) who consider the option to redevelop in addition to mixed land use; they find that mixing uses gives positive results in respect to property value. Further studies by Addae-Dapaah (2005), NAIOP Research Foundation (2009) and Addae-Dapaah and Toh (2011) also find that mixed use properties can command a rent premium. It is worth noting that the majority of the literature in the aforementioned section investigates mixed use on a higher spatial level rather than on a building level.

In summary, most of the existing research on mixed use developments focus on the distance and externality impact brought about by the presence of multifunctional use of land or property with no comparison made to single use land or property. In this review, it is additionally clear that there is a lack of academic literature regarding the empirical analysis of the direct ex-post financial performance of mixed-use developments, especially for a single structure, and from a Dutch institutional investors perspective.

1.3 Research problem statement, aim and question

The research aim of this study is to fill a gap in the existing literature by assessing the financial performance of mixed-use real estate investments in comparison to single-use investments from the perspective of Dutch institutional investors. In light of the aim, the main research question is:

Do mixed-use investments show better financial performance than single-use investments and if so to what extent?

This question will be explored by focusing on the following three sub-questions:

1. What determines (mixed-use) property values?

To answer this sub-question it is important to investigate the characteristics that play a major role in determining the value of mixed-use investments. Whilst it is well known that the physical characteristics of a property may impact its value, it is also vital to understand the key theory on determinants of mixed-use property values to identify additional characteristics that could significantly alter mixed-use property values (i.e. physical, contextual, environmental, functional and socio-cultural characteristics). Consideration of critical determinants of mixed-use property values will contribute to the reduction of potentially omitted variables when conducting the empirical analysis in the research.

2. What financial result and risk is shown when comparing ex-post mixed use projects with single use projects in an empirical analysis?

This sub-question will be answered by empirically evaluating whether ex-post mixed use projects contribute more positively to the risk-return profile of institutional investors than single use projects. More specifically, a hedonic regression model will be utilized to understand the relationship between mixed use investments and financial performance. According to Brooks and Tsolacos (2015) the change in value of a building, that is its financial performance, can either be observed from investment transactions or estimated using rent or net operating income and yields. Data will be obtained from the Syntrus Achmea Real Estate and Finance (SAR&F) database, which lists 2546 properties. Of these properties 811 are ‘in exploitation’ (that is, still in use and held by SAR&F) and will be adopted as the sample in this paper, subject to data cleansing. This dataset has been chosen instead of MSCI data because the latter does not possess micro data on mixed use. This will be combined with Basisregistratie Adressen en Gebouwen (BAG) data to determine the proportions of each use within a building. The main limitation of the BAG data is that the use recorded is the intended use (i.e. that permitted by the Dutch government) and not the actual use, should this deviate from the intended use. As shown in the conceptual model (Figure 1), the aim of this study is thus, to determine the magnitude by which a mixed-use investment may lead to a superior financial performance over a single-use investment, taking into account the typical risk-return profile of institutional investors.

3. Are there certain characteristics of mixed use investments that increase or decrease the associated risk and return?

A robustness check will be carried out to ensure the findings established in this research possess greater credibility. To do this it is vital to understand the characteristics of mixed use properties that could significantly alter the risk and return thus, its attractiveness to institutional investors. This will be achieved by taking into account characteristics found in theory and existing literature as having a significant impact on the decision to invest or not invest in mixed use properties. According to Huston and Mateo-Babiano (2013) in their evaluation framework for VMU developments, such characteristics include the scale of land uses (i.e. number of floors), type of land uses and age of structure, among others.

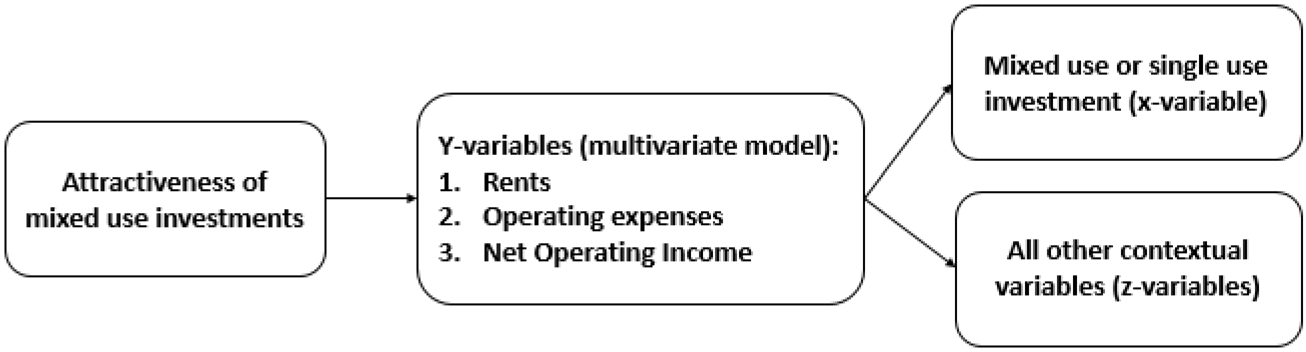

Figure 1. Conceptual model.

1.4 Reading guide

The remainder of this paper is organized as follows. Chapter 2 describes the findings regarding sub-question one that is, the theoretical framework and literature on the determinants influencing (mixed-use and single-use) property prices. Chapter 3 explains the empirical approach in addition to the data used in this study. Chapter 4 sets out the results obtained in relation to sub-question two and three. Lastly, Chapter 5 presents the conclusions and recommendations for future research.

2. THEORETICAL FRAMEWORK

To understand how property values are determined and to be able to empirically analyze their performance from the perspective of an institutional investor, it is important to consider the theoretical framework. Doing so provides the knowledge needed to determine the potential influences that could significantly affect property prices. This will help inform the variables that are necessary to include in the empirical analysis of mixed use investments and as mentioned previously, reduce the potential for omitted variable bias and its associated consequences. First, a conceptualization of the real estate market will be examined, followed by an identification of the value drivers of real estate assets. Then, existing literature will be explored to establish how mixed use developments can be classified and their performance assessed against comparable single use developments.

2.1 The real estate market

The real estate market is a multifaceted environment in which a wide range of factors affects the performance of assets. Before an investment decision is made, Geltner et al., (2007) argue that it is first crucial to be conscious of the two basic markets that are relevant when analyzing property investment opportunities. The real estate market can be described as consisting of the space market (also known as the rental or property market) and the asset market. The space market is the market for the right of use of land and building, and the current balance of demand and supply determines rent (Geltner et al., 2007). On the other hand, the asset market represents the ownership of real estate assets that generate future cash flows for their owners; asset values in this market are also established by the balance between demand and supply (Geltner et al., 2007).

First, special attention is given to the asset market. Real estate asset values in this market are often described using the capitalization rate (cap rate). It is an important measure which is synonymous to the current yield allowing the value of a real estate asset to be ascertained by dividing earnings (net rents) by the cap rate (Geltner et al., 2007). The cap rate is determined by the demand and supply of capital investment in the asset market, which is based on four main factors: (1) the opportunity cost of capital, (2) growth expectations, (3) risk, and (4) the treatment of real estate in the tax code (DiPasquale and Wheaton, 1996). Each factor affects the investor's willingness to pay for any property. If an investor is willing to pay more for a property due to for instance, lower perceived risk or higher expected growth in future net income, then the cap rate will fall as a result (Geltner at al., 2007) and the property value will increase. The value of properties exhibiting different physical characteristics will sell for the same cap rate provided they are each perceived as possessing similar growth and risk potential to the investor, due to the integrated nature of the real estate asset market (Geltner et al., 2007). The opposite is true for the space market. It is highly segmented and localized as rents can vary greatly even with properties that are physically similar; this is due to the fact that demand and supply in the space market are location and type specific (Geltner et al., 2007).

The aforementioned premise underlying the space market (which is part of the four-quadrant model discussed below) is of high importance for the main research question posed in this study. The proposition that rents vary greatly due to type specific demand and supply already indicates that as mixed use and single use developments are essentially different types of real estate, expectations could be formed that their rents or financial performance would differ. The extent to which the financial performance of mixed use and single use developments would differ lies in understanding the demand and supply factors that influence the cash flow that each type of investment could generate. The asset market, which makes up the other half of the four-quadrant model discussed below presents another measure of financial performance, namely asset values. An understanding of the interaction between these two markets is described below.

The two markets described above are linked in what is called the real estate system. Geltner at al., (2007) state that in the short run current property cash flows in the space market are translated into current property assets values in the asset market, while in the medium to long term the two markets are linked by the property development industry. As the third component of the real estate system, as indicated by Geltner et al., (2007) the property development industry governs the stock of supply available in the space market as it converts the financial capital produced in the asset market into physical capital.

The real estate system can be conceptualized graphically using the four-quadrant (4Q) model, which is shown in Figure 2. The 4Q model was developed by DiPasquale and Wheaton (1996) to illustrate the connections between the asset and space market. Geltner et al., (2007) specify that the 4Q model signify the long run equilibrium within and between the two markets, where the market has ample time for supply of built space to meet demand.

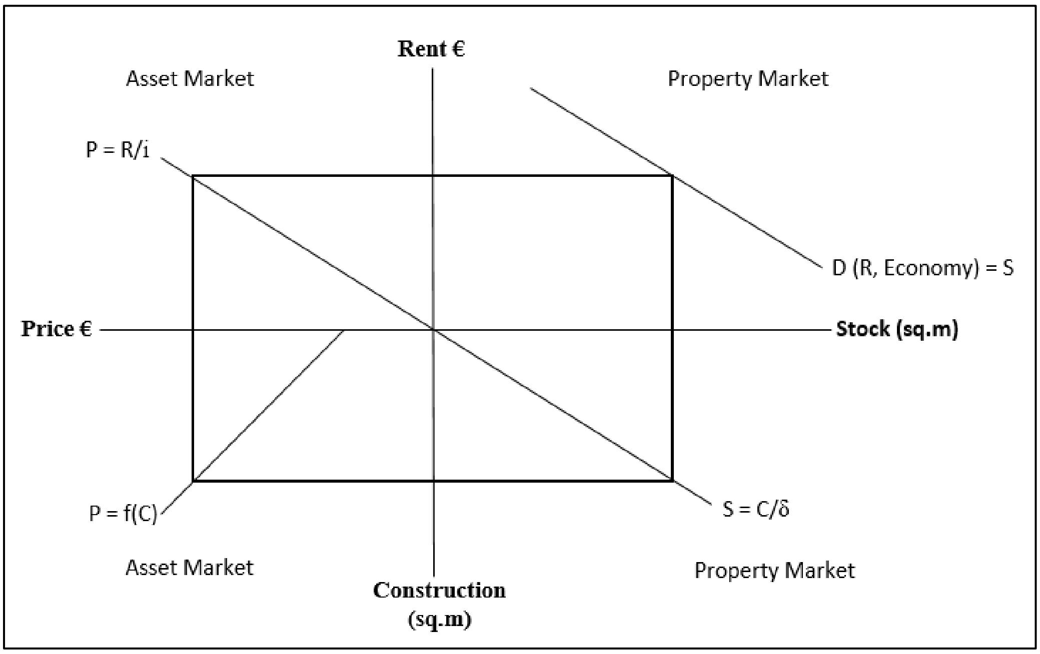

Figure 2. DiPasquale and Wheaton four-quadrant model (1996).

As can been seen in Figure 2 the left hand side of the quadrant denotes the asset market and the right hand side the space (or property) market. In the northeast quadrant, given the state of the economy and a level of stock, the rent of real estate assets is determined at where demand for the right to use a space equal supply (DiPasquale and Wheaton, 1996). This rent level is then translated into a value for the asset using the cap rate as indicated by the ray in the northwest quadrant (DiPasquale and Wheaton, 1996). Given the aforementioned asset values, the volume of new construction, C, in the real estate market is determined where asset value (price), P, is equal to replacement cost, f(C) as depicted in the southwest quadrant (DiPasquale and Wheaton, 1996). Note, there is a minimum value per unit of space that is required for new construction of real estate assets to proceed – this is shown by the intersection of the ray in the southwest quadrant with the price axis (DiPasquale and Wheaton, 1996). The final quadrant (southeast) represents the annual flow of new construction taken from the southwest quadrant that is converted into the long run stock of space in the real estate market (DiPasquale and Wheaton, 1996). In this long run position, DiPasquale and Wheaton (1996) state that the stock levels are constant, so that change in stock is equal to zero and thus depreciation, δ, will equal new completions. The real estate system described above provides a high level overview of the dynamics of the real estate market, but there are further exogenous influences that need to be considered in more detail.

According to Miller and Geltner (2005), the influences upon rents and prices in the real estate market can be broken down into: (a) macroeconomic influences which are factors affecting almost all properties within a country, and (b) microeconomic influences which are factors that impact the local supply and demand of properties. In order to determine these influences, Miller and Geltner (2005) highlight a need to recognize the unique characteristics of the real estate market, as they will form a basis for extracting the economic implications of how real estate prices are affected. Miller and Geltner (2005) consequently propose the following characteristics – with associated economic repercussions – as being distinctive to the real estate market:

- *Durability* – An inelastic short run supply curve as it can take time to add new properties to the market and real estate development patterns, whether good or bad, that last a long time.
- *Lumpy and large economic unit* – Real estate is an asset that is bought infrequently. Also, as new supply requires both time and debt, cycles in the real estate market are inevitable resulting in a market that tends to be oversupplied or undersupplied. Lastly, the need for debt means the capital market influences the property prices through interest rates and credit availability.
- *Costly information* – The real estate market is not perfectly competitive thus, it is characterized by imperfect information. Some economic agents can take advantage of this to achieve excess profits.
- *High transaction costs* – Costs such as brokerage fees, legal and recording fees, insurance fees and other closing costs where debt is required, stifle the ability to short sell real estate assets and make a profit from observed price trends. High transaction costs also contribute to increased liquidity risk of real estate assets.
- *Unique locations and heterogeneous nature* – Each property has a fixed location. This makes the real estate market highly segmented meaning that competition between properties occur within a localized submarket. Moreover, each property is subject to, either positive or negative externalities generated by surrounding properties that could influence value. In terms of heterogeneity, the physical characteristics of properties can differ greatly making them harder to compare and adding to price dispersion in the real estate market.
- *Regulated use by government* – The supply of real estate and therefore its price can notably be affected by government regulations such as ownership rights, building codes and zoning laws.

Equally, it is necessary to consider the time dimension of impacts on real estate rents and prices. In the short run (less than one year), supply is essentially fixed in the real estate market so demand is said to determine prices (Miller and Geltner, 2005). There are two key factors proposed to change demand in the short run namely, (a) seasonality, which is driven by schools, holidays, weather and employment hiring cycles, and (b) interest rates, which overtime affect affordability. In the intermediate to long term (more than one year), Miller and Geltner (2005) propose some additional factors that are important drivers of real estate markets – as shown in Table 1.

Another useful approach for investigating the issues that could impact prices in the real estate market is by conducting market analysis by property type. The types of property in the real estate market are commonly distinguished as being either residential or nonresidential properties (DiPasquale and Wheaton, 1996).

Table 1. Intermediate and long term influences on the real estate market – Miller and Geltner (2005).

Factors	Description
Employment trends	• Sustained demand in the real estate market is heavily dependent on positive local employment • Real estate demand will increase with growth in the regional export sector employment, which in turn increases total employment and population through the multiplier effect
Regional demographic trends	• Regional demographic factors include household size, education, birth and death rates, ageing patterns, stored wealth, ethnicity, national origin and migration patterns. • These patterns affect the type of real estate that is demanded

Nonresidential properties are often referred to as being commercial properties. Miller and Geltner (2005) list the major residential property types as being single family and multifamily properties, and the major commercial property types as industrial, office, retail, hotels and parking lots. They argue that for any property type, market analysis is vital for examining inputs and assumptions regarding rents, vacancies, operating expenses and financing; similarly they add that supply side influences on each property type should also be monitored (Miller and Geltner, 2005). Table 2 presents a summary of the key demand and supply factors, by property type, that Miller and Geltner (2005) suggested for consideration. Only information regarding property types covered in the data available for this study has been included.

Table 2. Key demand and supply factors by property type – Miller and Geltner (2005).

Property type	Demand factors	Supply factors
Residential single family	Population, household formation rates, business and professional employment growth rate, general employment rates, quality of life.	Available highway accessible land supply, ease of gaining zoning and building permits and cost of capital and profitability.
Residential multifamily (renters)	Population, household formation rates, general employment rates, local housing affordability.	Available land supply, zoning constraints, projected returns or risks, cost of capital, and government subsidies and incentives.
Office	Business service and professional employment growth rates, reasonable local earnings taxes, telecommuting trends, local incentives and taxes.	Availability of contiguous large blocks of Class A space, available sites, parking availability, zoning requirements, profitability and risks.
Retail	Population growth rates, income growth rates, employment growth rates, regional household wealth, lifestyle trends.	Availability of sites, zoning access, parking, relationship with local or national developers and retailers, innovative retailers, capital cost and supply, confidence to win market share and profitability.

2.2 Mixed use property values

A well-known theoretical framework in regard to mixed use is Rowley's (1996) conceptual model of mixed land use and development. Rowley (1996) suggested that the quality of a settlement is mainly determined by its texture and that its key features are: (1) grain – "the way in which its components are mixed," (2) density – which Hoppenbrouwer and Louw (2005) regard as referring to the intensity of activity which is dependent on the mix of uses and the number of uses, and (3) permeability – "derived from the layout of the roads, streets and paths" (Rowley, 1996). The model developed by Rowley (1996) indicates that mixed use can arise in four settings, namely at the district, street, street-block or building level. Additionally, Rowley (1996) designates the city/town centre, inner urban, suburban and greenfield sites as locations where mixed use setting should be established or promoted. However, according to Hoppenbrouwer and Louw (2005), the model proposed by Rowley (1996) did not account for time and only considered one dimension of mixed use namely, horizontal mixed use which they refer to as a flat surface with mixed use between buildings. Hoppenbrouwer and Louw (2005) therefore provide an improved typology for mixed use, which is built upon the basics of the Rowley's (1996) model but extends it by integrating an aspect of time as well as accounts for dimensions other than the horizontal type.

The Hoppenbrouwer and Louw (2005) conceptual model of mixed land use as shown in Figure 3 is composed of four elements, which they advise are important when analyzing mixed use developments:

- urban scale (building, block, district and city)
- urban texture (grain, density and interweaving of functions)
- function (housing and working)
- dimension

Based on the above criteria, Hoppenbrouwer and Louw (2005) developed a typology for mixed use developments that can take the form of four dimensions:

(1) shared premises (point) – when an individual space is shared between more than one function;
(2) horizontal – consists of different uses on a flat surface;
(3) vertical dimension – consists of multiple uses within a single structure; and
(4) time dimension – refers to sequential use of space that is, two or more functions utilize a particular space one after the other.

The Hoppenbrouwer and Louw (2005) typology provides a tool for classifying mixed use developments, which enables a more insightful like-for-like comparison of mixed use developments that fall within the same dimensions, as well as to comparable single use developments. However, in order to analyze the performance of mixed use developments it is necessary to consider factors that are deemed to significantly alter the value of these properties. Rabianski el al. (2009) investigate the financial feasibility of mixed use developments and they identify three main categories that could influence the financial success of mixed use developments: (1) economic and market, (2) financial, and (3) physical and public issues.

In terms of economics issues, Rabianski et al. (2009) state that a prerequisite for a financially successful mixed use development is a strong local economy indicated by a growing population, employment and disposable income. In addition, it is important to conduct market analysis on each use individually (in the same manner as would be for a single use project) to determine if they will attract sufficient net demand (supply less demand). Whilst it is commonly indicated that the demand for mixed use is growing, there appears to be a scarcity in literature considering which consumer groups are driving this demand. According to the Altus Group (2018) there is an evolution of consumer needs; the re-evaluation of traditional lifestyles has resulted in a desire for convenience and walkability to amenities and workplaces across generations such as for the millennial generation, the aging baby boomers and the time-poor. Rabianski et al. (2009) thus, calls for further examination of demand for mixed-use developments to determine if they can demand higher rents or prices than similar single-use developments. They argue that mixed use projects possess the potential to generate higher investment and market values than single use projects through increased customer patronage, sales volumes and rent levels provided uses are compatible, complementary and mutually supportive for synergy to exist (Rabianski et al., 2009).

Also, due to the inherent complications of multiple ownerships, loans and leases, increased cost of construction and development time that could occur with mixed use development projects, Rabianski et al. (2009) discuss financial planning and oversight as being essential for mixed use developments. They specifically mention minimizing the requirement for initial equity funds, obtaining high loan to value ratios and seeking incentives from the local jurisdiction as financial factors on which the feasibility of mixed use developments are dependent on (Rabianski et al., 2009).

Physical factors are also considered to be more complicated when combining uses as generally mixed use developments tend to incorporate higher densities and the needs and preferences for access and security may differ across the tenants and consumers (Rabianski et al., 2009). Thus, to achieve financial success there are some key elements that Rabianski et al. (2009) stipulate a mixed use development should account for; this includes physical features, improvements, integration of design and density with the surrounding neighborhood, phasing and timing, parking and providing each use with a distinct and separated front door (Rabianski et al., 2009). In other words, a mixed use development is about place-making, that is, a combination of complementary land uses that provides vibrant, pedestrian friendly areas (Rabianski et al., 2009) which reinforces Jacobs (1961) view that it is of high importance to consider the needs of the inhabitants and the way they utilize the space.

Adding to the physical issues identified by Rabianski et al. (2009), Hutson and Mateo-Babiano (2013) in their study of VMU developments recommend some common spatial characteristics that are important when examining VMU developments:

(1) the number of land uses within the structure;
(2) the scale (the number of floors);
(3) type of land uses;
(4) spatial structure of land uses within the building; and
(5) age of structure.

Finally, when examining the performance of a mixed use development it is also vital to consider public issues. According to Rabianski et al. (2009) development regulations are mainly written to govern single use developments therefore, the success of a mixed use development could be hampered if the exceptions to zoning regulations and adaptions to building codes that are often required for mixed use projects are not permitted. Rabianski et al. (2009) argue the key is to ensure the support from both the regulatory officials and the local community has been gained. Given this study will investigate mixed use development post completion it could be argued that consideration of public issues such as zoning regulations have already been accounted for.

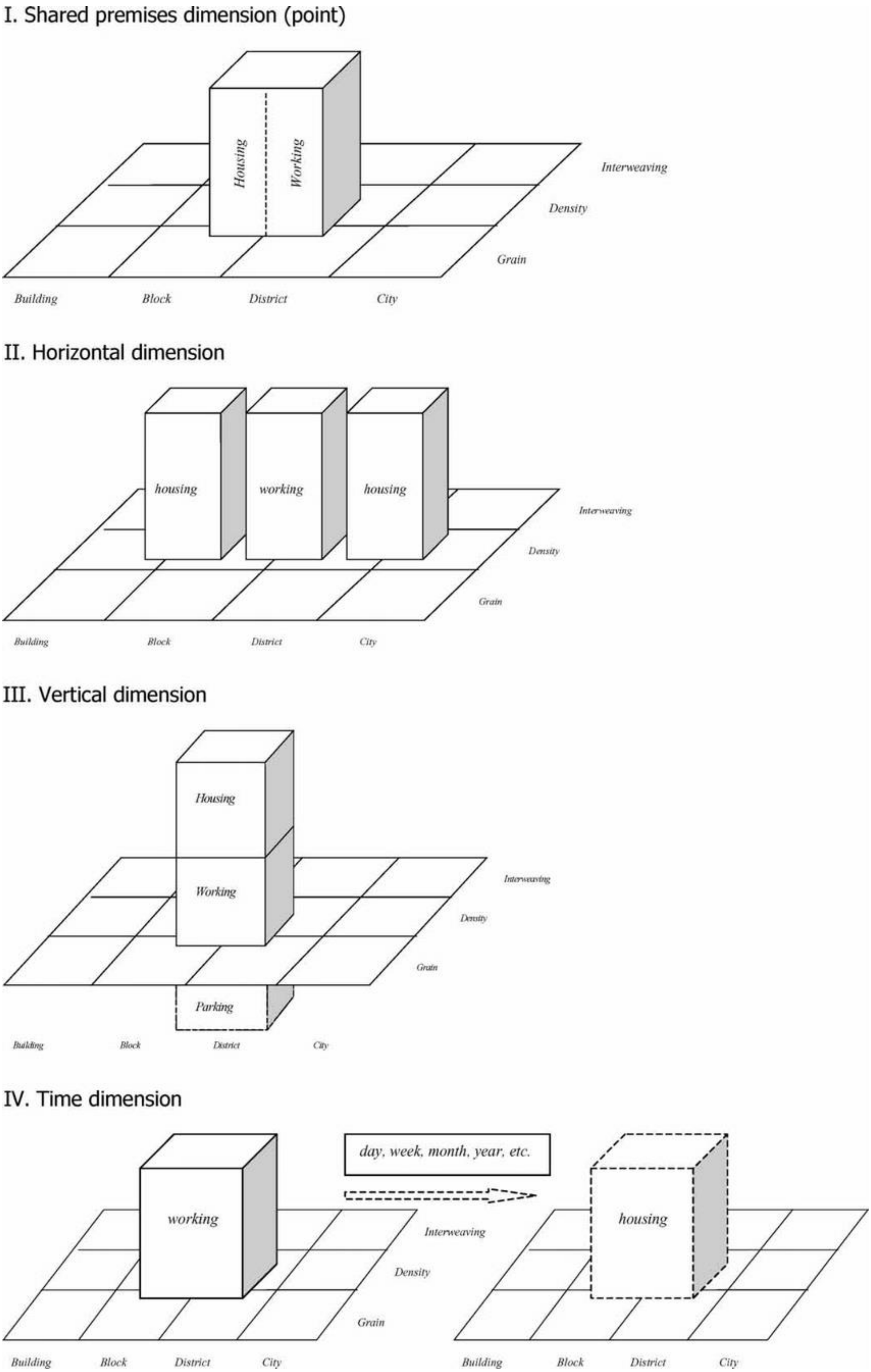

Figure 3. Hoppenbrouwer and Louw (2005) conceptual model of mixed land use for four dimensions.

2.3 Does city size matter?

A further consideration in assessing property values is city size. According to Evans (1972) rents are expected to rise as city size increases and he proposes a theoretical framework to understand this relationship, which is illustrated in *figure 4* below. Relatively speaking, curve R'P'R' represents a larger city whilst RPR represents a smaller city. The y-axis measures the rent per unit of floor area and the x-axis gives the radius of built up area in a city. The city centre is designated at zero on the x-axis. The larger city is characterised by higher rent, OP' and a larger built up area defined by OR' in comparison to the smaller city which has lower rent, OP and a radius of built up area OR. Evans (1972) assumes that:

- the market for real estate space is in long run equilibrium; and
- rents are highest in the city centre but decline at a diminishing rate with distance to the city centre because as the area of the city increases, the corresponding increase in the population can only be accommodated by a smaller increase in built up area of the city thus there are smaller increases in city centre rents.

The framework employs population as a measure for city size. Therefore, according to Evans (1972) a bigger city by definition would have a larger population than a smaller city because population density is greater in some parts of the city and, or its built-up area is greater since by assumption, the market is in a long run equilibrium. Evans (1972) additionally stipulates that the shape of the rent surfaces of the two cities should not differ substantially presuming the characteristics of their population are similar. "Hence if the rent at some given distance from the centre in the larger city is higher than it is at the same distance from the centre in the smaller city, it will be higher at all distances from the centre (Evans, 1972)".

The conceptualisation of city size effects on rents could help with understanding the motivation institutional investors may have for investing in larger cities. In a survey conducted by SAREF (2019) with their clients regarding their perspective on mixed use real estate investments, the overarching emphasis was on the importance of location. Some clients stressed that they would only consider investing in MUD in the top city centre locations of the largest cities in the Netherlands; whilst, an international institutional investor seeking exposure in the Netherlands specified that their investment in MUD would probably only be in the Randstad which encompasses the four major cities in the Netherlands – Amsterdam, Rotterdam, The Hague and Utrecht (SAREF, 2019).

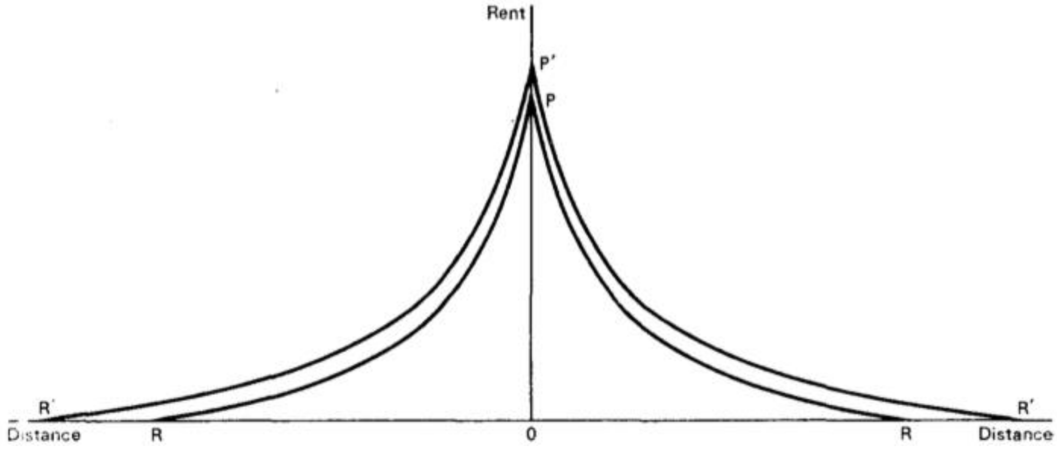

Figure 4. City size and rents (Evans, 1972).

The conceptualization of the value drivers of mixed use developments illustrates how complex they are in relation to single use developments. The added complications with mixed use developments create the need to examine additional issues which if not dealt with could result in the failure of the project. On the contrary, if the economic and market, financial, and physical and public issues associated with mixed use developments are accounted for, institutional investors could gain from some of the advantages believed by the Urban Land Institute to be brought about by mixed use developments: “1) higher densities; more rapid realization of site potential; (2) a means of product differentiation; a means of sharing the costs of infrastructure; (3) superior performance in terms of rents and values as compared with single-use development; (4) the economies of scale; and (5) a means of achieving greater long-term appreciation in land and property values both within the project itself and in the surrounding area although whether the latter will prove to be true given the problems of ageing, inflexibility, built-in obsolescence remains to be seen (Rowley, 1996, Schwanke, 1987, Feagin & Parker, 1990, p.123). ”

To summarise the analysis on the theoretical framework and literature on property prices, Table 3 below provides an overview of the relevant variables influencing the financial performance of mixed use and single use properties.

Table 3. Relevant variables.

Relevant Variables	Author, Year
Interest rate	Miller and Geltner, 2005
Employment growth rate/Employment	Miller and Geltner, 2005 Rabianski et al., 2009
Property type	Miller and Geltner, 2005
Population	Miller and Geltner, 2005, Rabianski et al., 2009 and Evans, 1972
Household formation rate	Miller and Geltner, 2005
Quality of life	Miller and Geltner, 2005
Local earnings taxes	Miller and Geltner, 2005
Income growth rate	Miller and Geltner, 2005
Regional household wealth	Miller and Geltner, 2005
Parking availability	Miller and Geltner, 2005 and Rabianski et al., 2009
Disposable income	Rabianski et al., 2009
(Building) improvements	Rabianski et al., 2009
Number of uses	Huston and Mateo-Babiano, 2013
Scale (Number of floors)	Huston and Mateo-Babiano, 2013
Types of uses	Huston and Mateo-Babiano, 2013
Age of property	Huston and Mateo-Babiano, 2013

It is worth pointing out that variables such as availability of land supply, government subsidies and incentives, initial equity funding, loan to value ratio, phasing and timing, zoning regulations and building codes are not considered to be relevant for this paper. These variables are more applicable to the development process of real estate properties and given that this study focuses on their performance after completion, it is not necessary to consider factors that influence the development stage.

Examining the theoretical framework and literature on property prices has provided the tools to identify what determines (mixed use) property prices, which sufficiently answers sub-question one of this research paper. However, a lack of empirical research in the current literature means there were no examples of model specifications to consider or empirical evidence of a significant positive or negative outcome to which this study can build on. It is highly surprising that the authors of previous literature investigate the externality effect of mixed use developments at various spatial levels but none have sought to discover whether mixed use developments have positive implications for direct financial performance. In light of this and given that most authors report mixed use developments as generating positive externalities, the hypothesis formulated in this study is that the mix of uses within a real estate development will in itself have a positive impact on the financial performance of said development. To further contribute to the literature on mixed use this paper will also consider city size effects. Given the theoretical framework presented in this chapter, it can be theorised that mixed use investments in bigger cities (when measured by population size) in the Netherlands should perform better that mixed use investments in smaller cities in terms of rents and net operating income.

3. DATA & METHOD

This chapter describes the source and selection of the data used in this study, and the methodology applied in investigating whether mixed use investments provide superior financial performance for Dutch institutional investors than single use investment in real estate.

3.1 Context

The dataset used in this research paper is compiled from various sources. Private data obtained from Syntrus Achmea Real Estate & Finance ("SAREF") regarding investments have been obtained from several of their data warehouses, namely VAG, Reaturn and CodaVAG. SAREF manages €22.5 billion worth of investments in real estate and mortgages for institutional investors (being one of the largest real estate investors in The Netherlands. The macroeconomic data were also retrieved through a private SAREF database, Woningmarktmonitor. However, the data itself are derived from the publicly accessible database of the Central bureau of Statistics (CBS) and the Leefbaarometer 2.0. Lastly, data regarding COROP regions were obtained from Arc map GIS although the underlying source is an open database called, Imergis.

The dependent variable: Data on the dependent variable were obtained from the CodaVAG database. It provides profit and loss data containing untaxed rental income (including untaxed service charges) and operating costs in relation to the real estate investments. The operating costs are made up of property taxes, insurance premiums, maintenance costs, property marketing costs, rental preparation costs, costs borne from contribution to association of owners, and service and heating costs. The aforementioned information was used to derive, total rents, total operating costs and NOI values for the investment, which is calculated as rents less operating costs and measures the profitability of the real estate investments.

The VAG database encompassed 2546 real estate investments at object level. The database is updated monthly to show the current real estate portfolio of SAREF. Data used in this study were accessed in February 2019. Moreover, as this study is concerned with the ex-post financial performance of the real estate investments, information on the status of each object was used to select only those in operation, resulting in the selection of 811 investments. The remaining investments excluded from the selection were not in operation.

The independent variables (micro-data): The Reaturn database provided data on the investments on a unit level. The unit level data comprised a large array of information but more relevant were the data on:

- The use or function;
- The useable or lettable surface area (in square metres);
- The construction date
- The contract rent (per month);

The categorisation of the an investment as mixed use or single use was not available in the dataset. Thus the contract rent data was important as it was used as a means to calculate the percentage attributable to each function in each investment object, to derive their classification as either mixed use (including sub-types) or single use. This was then used to create the main independent dummy variables of interest Type and Subtype. The data regarding the function of the units were moreover used to derive the number of uses and the availability of parking. Last but not least, the age of the investments was a result of taking the difference between the construction date and today's date (29 April 2019).

The independent variables (macro-data): The municipality name for each investment was taken from the VAG database. The municipality name was then used to extract data for the following variables: employment, disposable income per household, population, the number of households and the liveability score. Data for these variables were available from the Woningmarktmonitor for 2016. As previously noted, the data retrieved through the Woningmarktmonitor originate from the CBS database except for the liveability scores, which come from the Leefbaarometer. The leefbarometer is a score based on five dimensions that estimates the quality of life in all inhabited neighbourhoods in the Netherlands (Leefbaarometer, 2019). The interest rate for 2016 was accessed from Oxford Economics. Finally, the COROP regions for the Netherlands were matched to each investment using their municipality name. *Table 4* in Appendix I provides a summary of all the variables included in this study along with a short description.

Data limitations:

- The Reaturn database is updated on a monthly basis so that it is fairly up to date. However, this means that historic data on a unit level cannot be ascertained because the historic data are overridden.
- The SAREF databases do not contain the unique identifier in the Basisregistratie Adressen en Gebouwen (BAG). Due to this limitation it was difficult to tie the characteristic of the investments to the BAG dataset. However, the SAREF database did contain all the relevant variables from the BAG.
- The SAREF data were not differentiated sufficiently to enable the investments to be split into typologies or to investigate the financial performance of VMU investments in comparison to other typologies of MUD.
- Times series data were available for the financial variables, however it did not contain information about changing tenants and therefore, degree of mixed use so likely that the data would be correlated over time with no advantage of using time series. Hence, cross sectional data were adopted.
- 2016 was the most recent year information was available for all variables obtained from the Woningmarktmonitor. Hence, the use of the corresponding 2016 rents, operating expenses and NOI for the real estate investments.
- Some of the variables listed in Table 3 (chapter 2) deemed as influencing the financial performance of mixed use and single use properties could not be obtained, explicitly:
    - Local earnings taxes, although to some extent this is accounted for in the disposable income variable
    - Regional household wealth
    - Scale (number of floors)
- Seasonality has not been accounted for, as data used are cross-sectional.
- Data regarding financial vacancy were available for offices, retail and other commercial uses but not available for residential use. Thus, to ensure consistency, financial vacancy has not been accounted for in the rent figures for each investment.

3.2 Descriptive analysis

All of the private SAREF data warehouses contain an object number corresponding to each real estate investment. These object numbers have been used to match and combine the data from the various sources. The remaining macro-data have been matched to the dataset using the municipality name, as previously mentioned. This results in a combined dataset containing the rents, operating expenses and NOI in 2016 for a sample of 536 real estate investments after controlling for outliers and missing variables. Of these investments, 62 (12%) are to some degree mixed use and the rest, which makes up the majority, are single use developments. This could be seen as providing some evidence to the claim that Dutch institutional investors are yet to share in the enthusiasm of mixed use real estate investments providing the SAREF portfolio is representative. The summary statistics and frequencies for categorical variables are shown in *Table 5 and Table 6 respectively.*

This information is subdivided into SUD and MUD. There are some key differences between the two categories. *Table 5* shows that on average, SUD have a statistically significant higher rent (absolute and per square meter) and NOI (absolute and per square meter) compared to MUD. However, MUD display greater variance in their mean rent (absolute and per square meter) and NOI (absolute and per square meter) than SUD. The opposite is true for operating expenses. MUD on average generate significantly higher operating expenses per square meter than SUD. In line with theory that MUD are more complicated to operate financially and due to the greater number of functions and information asymmetry. The mean employment level, based on municipalities, is statistically significantly higher for MUD. This is also true for the average population and the number of households. This shows that MUD are located in municipalities with higher population and employment levels as opposed to SUD. Possible indications that MUD are more likely to be located within urban municipalities that are more densely populated.

Surprisingly, MUD in the data utilised for this study are in municipalities where the average disposable income per household and quality of life are actually lower in comparison to SUD. However, the p-value associated with the t-test on the quality of life variable is not statistically significant indicating that this difference (lower quality of life for mixed use than single use) is not substantial. There are however some similarities between the two categories. Explicitly the parking availability is practically the same across both categories. The p-value associated with the t-test indicate no significant difference between the mean age of MUD and SUD in the dataset. In this sample, an investment was considered mixed use if it had two or more revenue generating functions. SUD, as expected have only one function. Looking to *Table 6,* it is clear that the standard number of functions in MUD is two functions. Some of the MUD are characterised by three functions, the occurrence of four functions is rare with only one investment possessing this feature. In terms of the subtype 44 per cent the MUD have a function whose dominant use based on revenues is between 90 to 99 per cent. On the other end, there are 24 per cent MUD whose dominant use is no more than 79 per cent of its total rental income.

Table 5. Summary Statistics.

Category (Sample Size):		SUD (474)		MUD (62)	
	T-test (p-value)	Mean	SD	Mean	SD
Rent (€)	0.0002	361000	225000	240000	346000
Rent per sqm (€)	0.0000	92.442	27.783	68.127	50.898
Operating expenses (€)	0.2557	66806.63	68170.59	77790.73	93238.39
Operating expenses per sqm (€)	0.0000	16.803	14.535	31.411	25.644
Net Operating Income (€)	0.0000	294000	201000	162000	319000
Net Operating Income per sqm (€)	0.0000	75.639	29.317	36.716	59.548
Area (sqm)	0.9989	4.000.082	2.382.416	4.000.581	4.755.669
Age	0.7287	19.064	12.405	18.484	12.037
Type	-	0	0	1	0
Number of Functions	0.0000	1	0	2.323	0.505
Availability of Parking	0.0533	0.192	0.394	0.194	0.398
Disposable Income per Household	0.0106	40.939	5.227	39.134	5.064
Employment	0.0000	65.873	87.133	123.194	136.046
Number of Households	0.0000	64744.57	93226.99	126000	144000
Population	0.0000	133000	176000	246000	266000
Quality of life (Leefbaarometer score)	0.1685	2.07	1.171	1.855	1.006
COROP-region	0.1881	15.346	9.548	13.661	8.798
Interest Rate	-	0.3	0	0.3	0

Note: Full results including min and max displayed in *table 5* (Appendix III).

Table 6. Frequencies of categorical variables.

Category (sample size):	536		
	Per cent	Cum.	Total
SubType:			
MUD79	15	2.8	2.8
MUD80-89	20	3.73	6.53
MUD90-99	27	5.04	11.57
SUD100	474	88.43	100
Category (sample size):	SUD (474)	MUD (62)	Total
Functions			
1	474	0	474
2	0	43	43
3	0	18	18
4	0	1	1
QOL			
Good	184	25	209
Satisfactory	186	30	216
Excellent	3	0	3
Very good	89	5	94
Weak	12	2	14
Parking			
0	383	50	433
1	91	12	103
COROP			
Achterhoek	25	0	25
Agglomeratie Den Haag	22	6	28
Alkmaar e.o.	9	0	9
Arnhem-Nijmegen	43	4	47
Delft en Westland	5	1	6
Flevoland	19	1	20
Gooi en Vechtstreek	2	2	4
Groot-Amsterdam	25	10	35

Category (sample size):	SUD (474)	MUD (62)	Total
COROP (Cont.)			
Groot-Rijnmond	34	4	38
Haarlem e.o.	2	2	4
Kop van Noord-Holland	3	1	4
Leiden en Bollenstreek	10	5	15
Midden-Limburg	3	0	3
Midden-West-Brabant	15	2	17
Noord-Drenthe	19	1	20
Noord-Friesland	15	2	17
Noord-Limburg	7	0	7
Noord-Overijssel	12	2	14
Noordoost-Noord-Brabant	21	2	23
Oost-Zuid-Holland	10	0	10
Overig Groningen	4	1	5
Twente	22	1	23
Utrecht	42	6	48
Veluwe	27	2	29
West-Noord-Brabant	12	1	13
Zaanstreek	1	0	1
Zuid-Limburg	6	0	6
Zuidoost-Drenthe	5	0	5
Zuidoost-Friesland	9	1	10
Zuidoost-Noord-Brabant	24	4	28
Zuidoost-Zuid-Holland	8	0	8
Zuidwest-Drenthe	7	0	7
Zuidwest-Friesland	3	0	3
Zuidwest-Gelderland	1	0	1
Zuidwest-Overijssel	2	1	3

3.3 Hedonic regression model

This study uses a hedonic analysis to investigate the impact of mixed use investments on rents, operating expenses and NOI values in comparison to single use investments. In real estate, a hedonic analysis is commonly adopted and is used to attribute an economic value to individual characteristics of an investment. This allows differences in the value of each real estate investment to be explained by the bundle of the different characteristics it contains, as real estate is considered to be a heterogeneous good (Rosen, 1974). The use of a hedonic model in this study therefore means that an economic value can be attributed to whether an investment is a single use or mixed use development in order to ascertain its marginal effect on the rents, operating expenses and NOI value of the real estate development.

The hedonic analysis in this paper will be implemented with a multivariate, multiple linear regression model, which will be estimated using ordinary least squares ("OLS"). With this technique the relationship between the dependent variable and the independent variables can be estimated to understand which variables significantly influence rents, operating expenses and NOI values in the sample. According to Brooks and Tsolascos (2010), in order to use an OLS estimation method, the following assumptions are required:

Table 7. OLS assumption (Brooks and Tsolacos, 2010).

Assumption	Description
1. $E(\varepsilon_t) = 0$ [Linearity]	The error term should have a conditional mean of 0
2. $Var(\varepsilon_t) = \sigma < \infty$ [Homoscedasticity]	The variance of the errors is constant and finite
3. $Cov(\varepsilon_i, \varepsilon_j) = 0$ for $i = j$ [Autocorrelation]	The errors are statistically independent
4. $Cov(\varepsilon_t, x_t) = 0$ [Independence]	The error and the explanatory variables are not correlated
5. ε_t $N(0, \sigma^2)$ [Normality]	ε_t is approximately normally distributed

When conditions 1-4 are met, the resulting estimated coefficients will be consistent, unbiased and efficient (Brooks and Tsolascos, 2010). In other words, the estimated coefficients will approximately equal their true value and will have the smallest variance amongst all estimators. The estimators can therefore be classified as BLUE, which stands for Best Linear Unbiased Estimates. This means that inferences can be drawn about the relationship between the explanatory variables and the dependent variable, in order to make recommendations. Before proceeding with the empirical analysis, the dataset used in this study has been tested for these OLS assumptions. The issues identified were that the dependent variable, NOI was found to have heteroscedastic errors. The solution is to use robust standard errors. Also, spatial autocorrelation in real estate is inherent so it is recommended to use clustered standard errors in the empirical analysis. Robust standard errors are implied when using clustered standard errors (Mehmetoglu and Jakobsen, 2017); hence the use of clustered errors simultaneously solves both aforementioned issues. Lastly, the rent variable is not normally distributed however, as previously mention according to the Gauss-Markov theorem as long as the first four OLS assumptions hold the estimators for the rent equation will still be BLUE (Brooks and Tsolacos, 2010). However, it impact the confidence by which the results can be relied on. Further detail on the results and discussion regarding these tests are detailed in Appendix II. It is also important to consider whether there is multicollinearity present in the data, as this is an assumption needed to perform a multiple linear regression.

Multicollinearity occurs when an independent variable is highly correlated with another independent variable. When the independent variables are collinear it is difficult to draw precise inferences as standard errors may become inflated, confidence intervals would be wider and significance tests may therefore, result in inappropriate conclusion (Brooks and Tsolacos, 2010). A correlation matrix can be used to assess multicollinearity. In summary, the variables Functions and Household had to be removed due to multicollinearity. Further details and the results are provided in *Table 7* in Appendix III.

3.4 Empirical model

In light of the relevant influences on the financial performance of real estate investments emphasized in chapter two, the following multivariate baseline model will be estimated:

$$lnRent_i = \alpha_0 + \beta_1 Type_i + \delta_1 lnArea_i + \lambda_1 Age_i + \lambda_2 lnDispIncHH_i + \lambda_3 lnHH_i + \Sigma_i \lambda_4 QOL_i + \lambda_5 Parking_i + \Sigma i \phi_1 COROP_i + \varepsilon_i \quad (1)$$

$$lnOpex_i = \alpha_0 + \beta_1 Type_i + \delta_1 lnArea_i + \lambda_1 Age_i + \lambda_2 lnDispIncHH_i + \lambda_3 lnHH_i + \Sigma_i \lambda_4 QOL_i + \lambda_5 Parking_i + \Sigma i \phi_1 COROP_i + \varepsilon_i \quad (2)$$

$$NOI_i = \alpha_0 + \beta_1 Type_i + \delta_1 lnArea_i + \lambda_1 Age_i + \lambda_2 lnDispIncHH_i + \lambda_3 lnHH_i + \Sigma_i \lambda_4 QOL_i + \lambda_5 Parking_i + \Sigma i \phi_1 COROP_i + \varepsilon_i \quad (3)$$

Where: i represents each investment. The constant is represented by α_0. The dependent variables are rent, operating expenses ("Opex") and NOI. The variables Rent and Opex have been log transformed. The histograms before and after transformation of the dependent variables are shown in Appendix IV. The log transformation is not suitable when there are negative values hence; it is not used for NOI. Appendix IV similarly shows the histograms for any independent variables that have been transformed. Type represents the category MUD (=1) or SUD (=0). Area has also been transformed using the natural logarithm and is a variable that controls for the total useable surface area for each investment, measured in square meters. It is necessary to control for the total useable surface area to reduce the heterogeneity in real estate that is associated with the size of the properties. Age is a control variable representing the age of each development. DispIncHH is the average disposable income per household and has been log transformed. HH has also been log transformed and is an indication of the number of households in the municipality in which the investment is located. QOL is a dummy variable measured the by the leefbarometer score which ranges from weak to excellent. Parking is a dummy variable which takes on the value 1 if parking is available in the development and 0 otherwise. COROP is a fixed effect dummy variable used to control for the inherent heterogeneity that arises due to the location of real estate developments. Therefore, in the multivariate model, α, β_1, δ_1, λ_i and ϕ_1 are all coefficients to be estimated. The error term ε_i, is included in each equation to account for any omitted variables and will be estimated using a cluster based on the Corop-regions. Clustered errors are used as a solution to spatial autocorrelation as discussed in Appendix II, by assuming that investments within each COROP are comparable and impacted in a similar manner. In this study, four models will be estimated for a multivariate model consisting of three dependent variables: rent, opex and NOI. Equation one shows the baseline multivariate model, which includes all variables. After removing some variables, the second model will embody a more parsimonious model. Model three uses SubType instead of Type as the main independent variable of interest to provide a more in-depth picture of regarding the effect of mixed use investments on financial performance. Namely, SubType will be a dummy variable, with single use investments as the reference category, which will show the impact of varying degrees of mixed use. There are three categories of mixed use as previously explained in table 4, Appendix I. Lastly, for robustness a fourth multivariate model will be estimated using only a matched sample of comparable SUD and MUD, derived from a propensity score matching. This will ensure the findings established in this research possess greater credibility.

4. RESULTS & ANALYSIS

In this chapter, the multivariate OLS regressions result for the four different model specifications indicated in chapter three are presented. Based on the results for model 1 and 2, the first hypothesis generated in chapter 2 will be answered. Model 3 has been constructed to answer the second hypothesis formulated in chapter 2. All four specifications control for useable surface area of each investment, Corop-region fixed effects as well as for standard errors clustered by the 35 Corop-regions.

4.1 Hypothesis 1

H_0: There is no significant difference between the financial performance (in terms of rent, operating expenses and NOI) of MUD and SUD

H_1: There is a significant difference between the financial performance (in terms of rent, operating expenses and NOI) of MUD and SUD

Note: Should H_0 be rejected in favour of H_1, it is theorised that MUD will perform better than SUD in terms of rent and NOI

A parsimonious model is a model with the least variables but that possess a similar explanatory power to a model with additional variables. Therefore, to answer the hypothesis above model 1 *tables 8, 9 and 10* are exploited. This is because the baseline model includes all variables in comparison to model 1 which only includes influential or key variables of interest, yet still exhibits more or less a similar explanatory power to the baseline model. Hence, the discussion regarding the interpretation of the coefficients for each multivariate regression will be derived from model 1, which is based on 536 observations of which 62 are MUD. The next section will first provide an insight on the key variable of interest, Type which is a dummy variable which takes on the value 1 for MUD and 0 for SUD.

<u>*Equation 1:*</u> For model 1 (*table 8*) the R^2 value is 0.734, which indicates that 73.4 per cent of the variation in rents is explained by the regression model. The dependent variable is the natural logarithm of rents but the key independent variable of interest, Type, has not been transformed meaning that this is partly a log-linear specification. This means that the coefficient of Type will be interpreted as a growth rate. The coefficient for the variable Type is significant at the 5 per cent level, consequently the null hypothesis, H_0, that there is no difference between the financial performance of MUD and SUD in terms of rents is rejected. In fact, the coefficient of Type shows the relationship between Type and rents aas negative and that rents for MUD are 1.28 times lower than when the investment is a SUD.

<u>*Equation 2:*</u> The R^2 for model 1 (*table 9*) indicates that the independent variable explains 58.8 per cent of the variation in operating expenses, which is the independent variable. This R^2 figure is somewhat low, implying that there are some factors that could notably influence operating costs there were not included in the model. Variable operating expenses has been transformed using the natural logarithm thus this model is also partially a log-linear specification and the variable Type will be interpreted as a growth rate. The coefficient for the variable Type is significant at the 5 per cent level, which means that the null hypothesis, H_0, is rejected. Given the positive association between Type and

operating expenses, the results show that operating expenses are 0.66 time higher for MUD than SUD. This relationship is expected and can be inferred as validating the concern that MUD could indeed be costlier to operate when compared to single use real estate investments due to inherent complexity with having more than one function in a real estate development.

<u>*Equation 3:*</u> *Table 10* (model 1) presents the results for the dependent variable NOI. The models R^2 value indicates that the independent variables explain 52.2 per cent of the variation in NOI. Again, this satisfactory R^2 figure is a sign that there may be some omitted variables that could contribute significantly to explaining the variation in NOI, that have not been included in model. As both NOI and Type have not been transformed but other explanatory variables have been log transformed, this makes the model a linear-log specification. The coefficient of Type is only statistically significant at the 10 per cent level. This leads to a rejection of the null hypothesis, H_0, with 90 per cent confidence. *Table 10* shows a negative relationship between Type and NOI i.e. NOI is €82,665 lower for mixed use relative to single use real estate investments. The negative relationship found between MUD and both rent and NOI is contrary the notion proposed in chapter 2 that MUD provide superior financial performance in terms of rents and values when compared to SUD (Rowley, 1996, Schwanke, 1987, Feagin & Parker, 1990). To check for robustness an assessment of whether these results are still the same for varying degrees of MUD has been conducted and the results are discussed in section 4.2 below.

4.2 Robustness – SubType

The robustness of the impact of mixed use real estate investments on their financial performance has been further examined. This has been achieved by replacing Type with a dummy variable, SubType, which provides sub-categories of mixed use investments. The reference category is SUD100. They characterize single use investments with only one revenue generating function. There are then three categories of mixed use investments: (a) MUD90-99, where its dominant use accounts for between 90 and 99 per cent (c) MUD80-89, where its dominant use accounts for between 80 and 89 per cent and (c) MUD79, where its dominant use accounts for 79 per cent or less of its rental income per month. The sub-categories will be used to investigate whether the financial performance of real estate investment properties adjusts as the degree or mix of uses in a property development varies. The focus of this discussion will be on the results for which rent and NOI are the dependent variable since, it is for these equations the results were contrary to what was theorised in chapter 2. The results for the multivariate regression (model 2) are also shown in *table 8 and 10*. Where rent is the dependent variable, model 2 (*table 8)* provides further validation that MUD in the sample data set do not necessarily deliver better performance than SUD. All of the coefficients on the SubType categories are statistically significant at the 5 per cent level so we reject the null hypothesis so that there is a significant difference between the rents of MUD and SUD. Specifically, the results show a negative relationship between all coefficients of the SubType variable and rents, signifying that rent for mixed use investments are lower than rents for single use investments, regardless of the degree or mix of uses. It can also be observed that as the percentage of the dominant use in a mixed use real estate investment increases, the fall in rent relative to a single use real estate investment reduces. For NOI, an interesting outcome is observed. As a consequence of accounting for varying degrees of MUD the null hypothesis, H_0, that there is no significant difference between the NOI of MUD and

SUD cannot be rejected. This is because in model 2 (*table 10*), the coefficients on all of the SubType categories are not significant. Suggesting that there is no significant difference between the profitability (given NOI is simply the difference between rents and operating expenses) of single use and mixed use investment. Overall, the results from the robustness check convey MUD in the sample used in this study as not necessarily resulting in a better risk return profile than SUD for its institutional investors.

4.3 Other explanatory variables:

Some of the other explanatory variables namely, Area, DispIncHH and HH included in the models for all equations have been transformed using the natural logarithm. This will impact the way they are interpreted. However, the Age variable has not been transformed so can be interpreted in the usual manner.

Equation 1: Recall that the dependent variable is the natural logarithm of rents. T*able 8* presents the results for model 1 and 2 in which, the key independent variables of interest are Type and the dummy, SubType respectively. Across both models, the variables Area is significant at the five per cent level and has a similar impact on rents. As Area has been log transformed, a 1 per cent increase in the square meter useable area of an investment results in a 0.83 and 0.78 per cent increase in rents for model 1 and 2 respectively. Also, in both models the dummy for parking which equals 1 if there is parking provided in the investment and 0 otherwise is significant at the 5 per cent level indicating that the availability of parking is capitalised in the rents. The coefficients on the parking variable are positive and indicate that rents will be 28 per cent and 29 per cent higher in model 1 and 2 respectively when parking is available in the real estate development. However, the age of the investment and the number of households in the municipality in which the investment is situated is shown in *table 8* to not highly influence the rents of the sample data as their coefficients are not statistically significant. The insignificance of the Age variable could arise from the fact that the mean age of both SUD and MUD are quite similar at 19 and 18.5 years respectively, as shown in *table 5*.

Table 8. Estimation results for lnRent.

	Baseline model		Model 1		Model 2		Model 3	
Observations	536		536		536		98	
R-squared	0.735		0.734		0.744		0.786	
Corop fixed effect	Yes		Yes		Yes		Yes	
	Coef.	*Std. Err.*	*Coef.*	*Std. Err.*	*Coef.*	*Std. Err.*	*Coef.*	*Std.*
Type	-0.820***	-0.134	-0.824***	-0.136				
SubType:								
MUD79					-1.343***	-0.133	-1.899***	-0.282
MUD80-89					-0.943***	-0.121	-1.092***	-0.163
MUD90-99					-0.516**	-0.205	-0.490**	-0.19
lnPop							0.0729	-0.0767
lnArea	0.825***	-0.0629	0.828***	-0.0613	0.783***	-0.0669	0.697***	-0.147
Age	-0.000945	-0.00198	-0.000719	-0.0019	0.000597	-0.00174	0.00159	-
lnDispInc	0.406	-0.33						
lnHH	0.0365	-0.0341	0.021	-0.0303	0.026	-0.0285		
1.QOL	-0.250**	-0.108						
2.QOL	-0.251**	-0.12						
3. QOL	-0.442**	-0.171						
4. QOL	-0.317*	-0.165						
Parking	0.247***	-0.085	0.245***	-0.0845	0.255***	-0.082	0.556**	-0.212
Constant	4.136***	-1.279	5.498***	-0.614	5.779***	-0.644	5.992***	-1.804

Note: Dependent variable is log of rents. Standard errors are clustered by 35 Corop-regions and included in the table with ***, **, * indicating significant at 1%, 5% and 10%, respectively. Independent variables Pop, Area, DispIncHH and HH have been log transformed. The reference category for (a) SubType is SUD100 (representing single use investments (b) QOL is weak and (c) COROP is Achterhoek. 1.QOL = good, 2.QOL = satisfactory, 3.QOL = excellent and 4.QOL = very good. All models include constant term, fixed effects for location Corop-region and surface area in square meters. Full results shows in Appendix VI.

Table 9. Estimation results for lnOpex.

	Baseline model		Model 1		Model 2		Model 3	
Observations	536		536		536		98	
R-squared	0.596		0.588		0.593		0.664	
Corop fixed effect	Yes		Yes		Yes		Yes	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Type	0.495***	-0.125	0.507***	-0.125				
SubType:								
MUD79					0.323*	-0.18	0.544*	-0.28
MUD80-89					0.889***	-0.211	0.848*	-0.419
MUD90-99					0.367**	-0.174	0.415*	-0.212
lnPop							0.0427	-0.113
lnArea	0.823***	-0.0625	0.820***	-0.0605	0.834***	-0.0581	0.845***	-0.135
Age	0.0350**	-0.0033	0.0358**	-0.00346	0.0354**	-0.00348	0.0348***	-
lnDispInc	-0.774	-0.544						
lnHH	-0.0895	-0.0709	0.0332	-0.0585	0.0329	-0.0575		
1.QOL	-0.478*	-0.276						
2.QOL	-0.478**	-0.211						
3.QOL	-0.412	-0.599						
4.QOL	-0.618*	-0.322						
Parking	0.149	-0.125	0.153	-0.123	0.155	-0.123	0.184	-0.421
Constant	7.516***	-2.424	2.940***	-0.951	2.837***	-0.912	2.112	-1.665

Note: Dependent variable is log of operating expenses. Standard errors are clustered by 35 Corop-regions and included in the table with ***, **, * indicating significant at 1%, 5% and 10%, respectively. Independent variables Pop, Area, DispIncHH and HH have been log transformed. The reference category for (a) SubType is SUD100 (representing single use investments (b) QOL is weak and (c) COROP is Achterhoek. 1.QOL = good, 2.QOL = satisfactory, 3.QOL = excellent and 4.QOL = very good. All models include constant term, fixed effects for location Corop-region and surface area in square meters. Full results shows in Appendix VI.

Table 10. Estimation results for NOI.

	Baseline model		Model 1		Model 2		Model 3	
Observations	536		536		536		98	
R-squared	0.534		0.522		0.525		0.568	
Corop fixed effect	Yes		Yes		Yes		Yes	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Type	-83,138*	-48,800	-82,665*	-48,629				
SubType:								
MUD79					-125,010	-82,158	-342,266**	-150,382
MUD80-89					-115,067	-75,398	-236,503	-159,047
MUD90-99					-44,099	-62,379	-84,948	-63,381
lnPop							64,959**	-25,659
lnArea	127,948***	-19,961	130,776***	-19,773	125,442***	-23,117	80,876	-52,500
Age	-853.4	-682.5	-838.4	-627.2	-687.5	-609.5	-778.5	-1,831
lnDispInc	121,546	-96,662						
lnHH	45,659***	-13,232	28,818**	-11,430	29,336**	-11,024		
1.QOL	-73,428	-46,446						
2.QOL	-120,061***	-32,632						
3.QOL	-96,303	-69,981						
4.QOL	-65,053	-51,866						
Parking	102,151***	-28,706	103,051***	-28,436	103,937***	-29,003	159,275**	-75,142
Constant	-	-497,283	-1.122e+06***	-224,003	-1.088e+06***	-247,350	-1.09E+06	-652,161

Note: Dependent variable is NOI. Standard errors are clustered by 35 Corop-regions and included in the table with ***, **, * indicating significant at 1%, 5% and 10%, respectively. Independent variables Pop, Area, DispIncHH and HH have been log transformed. The reference category for (a) SubType is SUD100 (representing single use investments (b) QOL is weak and (c) COROP is Achterhoek. 1.QOL = good, 2.QOL = satisfactory, 3.QOL = excellent and 4.QOL = very good. All models include constant term, fixed effects for location Corop-region and surface area in square meters. Full results shown in Appendix VI.

Equation 2: In this equation, the dependent variable is the log of operating expenses. *Table 9* displays the results for model 1 and 2 that are being discussed. In both models, the useable area and age of the investment property are significant at the 5 per cent level and have a positive impact on operating expenses. That is, when the useable area increases by 1 per cent operating expenses are estimated to rise by 0.82 and 0.83 in model 1 and 2 respectively. In both models, the age of the investment causes a 3.6% increase in the operating expenses. This is expected as it is intuitive that as a real estate property ages, it may require more maintenance for instance, which would result in higher operating expenses. Lastly the availability of parking and the number of households is shown in model 1 and 2 (*table 9*) not to significantly influence operating expenses.

Equation 3: The final independent variable is NOI. In *table 10*, the results regarding model 1 and 2 are displayed. Age appears not to have a significant effect on the NOI of the real estate investment but the useable area, number of households and parking availability do as they are all positive and significant at the 5 per cent level. A 1 percent rise in the useable area measured in square meters results in an increase in NOI by €1,308 and €1,254 respectively. When the number of households increases by 1 per cent, NOI is also estimated to rise by €288 and €293 in model 1 and 2 respectively. In this case, the relationship between NOI and the number of households is as expected. This is because the number of households can be seen as a proxy for demand so it should follow that the higher the number of households within a municipality, the higher the demand for the use of space, thus the higher the NOI, ceteris paribus.

4.4 Hypothesis 2

H_0: Mixed use investments in bigger cities (measured by population size in the Netherlands) do not perform better than mixed use investments in smaller cities.

H_2: Mixed use investments in bigger cities (measured by population size in the Netherlands) do perform better than mixed use investments in smaller cities.

Model 3 is constructed to serve two purposes. The first is to answer hypothesis 2 by providing a possible explanation as to whether city size matters for the financial performance of mixed use investments. The multivariate regression model 3 (presented in *table 8*, *9* and *10*) is based on a reduced sample size of 98 observations (selection method revealed in Appendix V and discussed in section 4.4). The other purpose of model 3 is to ascertain robustness in the overall findings in this study by investigating the financial performance of comparable single use and mixed use real estate investments, which will also be covered in section 4.4. In model 3, an interaction variable (Subtype*Age) was also included to assess if there is a vintage effect in mixed use real estate developments. According to Rhem et al. (2006) the definition of a vintage effect is suggested by Randolph (1988) to be the initial unmeasured quality associated with a property constructed in a particular year. The coefficient of the interaction term was found to be insignificant (as shown in *table 11*, Appendix V) and not to alter results of the other coefficients greatly so it was removed from the final model 3 and interpretation therefore not discussed.

Does city size matter?

According to the theoretical framework proposed by Evans (1972), which is discussed in chapter two, rents are expected to increase with city size (measure by population size). Therefore, discussion of this hypothesis will again focus on the results for the rent and NOI equations. To examine whether a positive relationship exists between city size and the financial performance of mixed use investment, the population of each municipality has been included as a proxy for city size in model 4. The variable measuring the number of households, lnHH, has been removed to avoid issues associated with multicollinearity as it was determined previously in the correlation matrix (*table 7*, Appendix III) that is was highly correlated with the population variable. Population has been log transformed for all equations and as the dependent variable, rent has also been log transformed, this makes model 3 partly a log-log specification in *table 8*. This is not the case for the NOI equation, as the independent variable has not been transformed. The coefficient of the variable population is not statistically significant in *table 8*, which means that we cannot reject the null hypothesis that mixed use investments in bigger cities do not perform better in terms of the rents than those in relatively smaller cities. This is contrary to conceptualisation of the relationship between city size and rents. There could be several reasons why the population was not as influential on rents of the investments in this study. For instance, it has been reported recently that rent prices are rising especially outside of larger cities in the Netherlands as people turn to municipalities outside the four major Dutch cities: Amsterdam, Utrecht, Rotterdam and The Hague, as real estate prices there are unaffordable (NLTimes, 2018). However, the outcome realised in *table 10* is line with the theoretical framework. Population appears to have a positive and significant effect (at the 5 per cent level) on the NOI of the real estate investments in the sample portfolio. The null hypothesis is rejected in favour of the alternative hypothesis that mixed use investments in bigger cities do indeed perform better than mixed use investments located in relatively smaller cities. The magnitude of this difference is given by the coefficient of the population variable. It shows that a rise in the city size by 1000 is estimated to result in an increase in NOI by approximately €650.

4.5 Robustness – comparable single use and mixed use investments

To further the credibility of the findings in this paper, model 3 as previously mentioned is based on a smaller sample size. This sample size consist of 49 mixed use real estate investments and 49 comparable single use investments. The comparable single use investments have been identified using a propensity score match. The results of which are shown in Appendix V (*table 12*). The comparable SUD for each MUD observation is obtained by firstly running a logistic regression (output shown in *table 12*, Appendix V) to get the predicted probabilities for all observations, then using the propensity score matching method to obtain (nearest neighbour) matches between the two types of investments (Guo and Fraser, 2010). The investments from each Type (MUD vs SUD) have been matched based on a set of criteria namely, their useable floor area, the population size, disposable income per household in the municipalities in which they are located and their location denoted by their postcode. The initial match still had a very high bias or was not well balanced, in other words there were still significant differences in the comparable single use and mixed use investments. To reduce the bias and increase the balance in the propensity score, the use of a caliper is recommended. A caliper is simply the maximum tolerated difference between the propensity scores of matched observations and a level of 0.25 is generally adopted in practice (Rosenbaum and Rubin, 1985 and Lunt, 2014). Applying some statistical tests, the results of which are shown in *table 13* and *figure 5* in Appendix V, the bias in the matched sample has been reduced to an acceptable level and a better balance achieved but at the expenses of losing some 13 MUD observations. A rule of thumb is that bias should be less than 5 per cent and the p values on the test not significant (Guo and Fraser, 2010). Therefore, ensuring credibility regarding the comparability between the matched samples. The results *table 13* in Appendix V show that the bias of all variables except Postal Code has been reduced to below the 5 per cent rule of thumb. This is satisfactory as mean bias is still below 5 per cent and there is not much that can be done to reduce the postal code bias to below 5 per cent unless new SUD are added to the sample which are located closer to the MUD (or vice versa).

The matched sample was then used to run a multivariate regression resulting in model 4 in *table 8, 9 and 10*. The matched sample improved the explanatory power of all three multivariate regressions as indicated by the higher R^2 values of 78.6, 66.4 and 56.8 per cent for equation 1, 2 and 3 respectively (previously 74.4, 59.3 and 52.5 in model 3). The narration for the financial performance of mixed use and single use real estate investments is similar to the previous models. For operating expenses, the results are intuitive. Model 3 (*table 9*) provides supplementary evidence to model 1 and 2 that the 49 MUD, no matter the subcategory, are more expensive to operate than the 49 comparable SUD. The overall finding for the sample data employed in this study is that even when evaluating comparable MUD and SUD, mixed use investments are not shown to generate higher rents. Similar to model 1 and 2, the results from model 3 show that for all subcategories of MUD, rents are lower relative to SUD. For instance, the coefficient on MUD79 indicates that rent is 5.68 times lower in relation to a comparable single use investment. This finding is significant at the 5 per cent level according to the results in *table 8*. However, recall that the residuals of the rent equation were found not to follow a normal distribution (Appendix II). Therefore, whilst the estimates in the rent equation can be said to hold the desired properties of being BLUE, the non-normality of the residual means caution needs to be exercised in drawing inferences from the results. According to Brooks and Tsolacos (2010) if the normality condition on the residuals does not hold then it may not be possible to draw valid inferences about the population parameters. In other words, whilst it may be true for the 49 mixed use investments in the sample data that their rents are not higher in relation to the selected comparable single use investments, the results cannot be generalised with confidence to say that the same fate could be realised for the remaining 13 mixed use investments that were dropped following the propensity score matching or even to mixed use investments in the Dutch real estate market as a whole. Thus, we turn to the results for the NOI equation. As this equation did meet the normality conditions in relation to its residuals, greater reliance can be placed on results regarding the profitability of the mixed use investments in comparison to their single use counterparts. The results of model 3 (*table 10*) are mixed. The mixed use subcategory MUD79 is shown to be significant at the 5 per cent level. This leads to the rejection of the null hypothesis that there is no significant difference between the NOI of MUD in that subcategory and comparable SUD. The negative sign on the coefficient indicates that mixed use investments whose dominant use is 79 per cent or less are estimated to be €343,266 less profitable than analogous single use investments. Conversely, the robustness results confirm for the categories MUD80-89 and MUD90-99 the findings previously noted from model 2. That is, as the coefficient on these two variables are not significant mixed use investments whose dominant use are between 80-89 and 90-99 per cent generate NOI that is not significantly different from that of comparable single use investments. Therefore, one could infer from the results that Dutch institutional investors may find that their overall risk-return profile is neither reduced nor improved by investing in MUD80-89 and MUD90-99 as opposed to SUD as indicated by NOI. Therefore, it could be maintained that mixed use investments that fall within the two aforementioned categories would give institutional investors an equivalent financial performance to comparable single use investments in the Netherlands but do not necessarily deliver superior performance. Although it would have been insightful to compare the findings in this paper to results in previous studies, as already established in the review of the literature, studies empirically investigating comparing the financial performance of mixed use and single use investments did not come to light.

4.6 Further discussion

Although the results from the regression provide conflicting evidence to the claim that mixed use investments for the sample dataset could provide investors with superior rents when compared to similar single use investments, it is worth considering whether the relationship found is causal or whether there are other factors omitted in the empirical analysis that could explain why this difference exists.

One of the plausible explanations could be the dominant use present within each mixed use investment. *Figure 6a* and *6b* presents a graphical depiction of the dominant use of each investment in both the larger sample of 536 and the reduced matched sample dataset consisting of 49 MUD and 49 SUD. We can see that the matched sample is fairly representative of the larger sample employed in this study. From *figure 6b* it is evident that a vast majority (circa 94 per cent) of the single use investments in the sample are characterised by residential use. Conversely, approximately 53 per cent of the mixed use investments in the sample have retail as its dominant use with only circa 32 per cent having residential as its dominant use. Therefore, it could be argued that mixed use investments with retail as its dominant use could have lower densities than the single use investments that are residential as they would tend to encompass several units of homes. Therefore, as like for like are not being compared, it could be conjectured that a single use residential development with many tenants could generate higher rents than a retail dominant mixed use investment with only a few tenants.

In order to ascertain additional information regarding the possible reasons that rents levels for mixed use investments were found to behave contrary to what was expected, surveys were conducted with expert analysts at SAREF. Surveys were in the form of an open discussion following a short summary of the empirical results obtained. The discussion brought to light interesting knowledge and reasoning regarding why MUD in the sample portfolio appear to have lower rents relative to SUD. One of the key issues identified was the importance of micro-location. That is, even a distance of as short as 50-100 meters could mean a difference between an A location and a B location. Of which the A location would typically demand higher rents. Respondents indicated that the difference in rents is more volatile for commercial real estate uses in comparison to residential uses. Therefore, it could be a vast number of the mixed use investment have dominant retail use, this is causing a downward bias in the rents of the mixed use investments in relation to the single use investments.

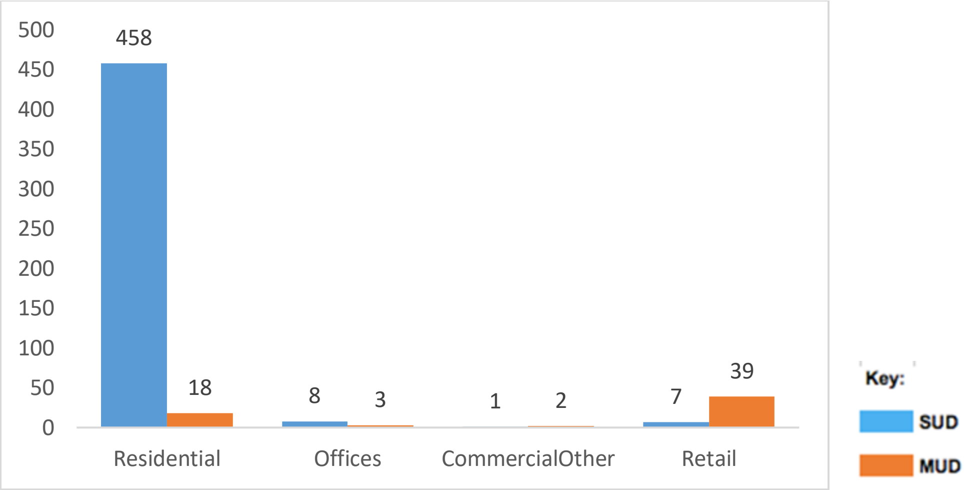

Figure 6a. Dominant function of initial sample of 536 investments.

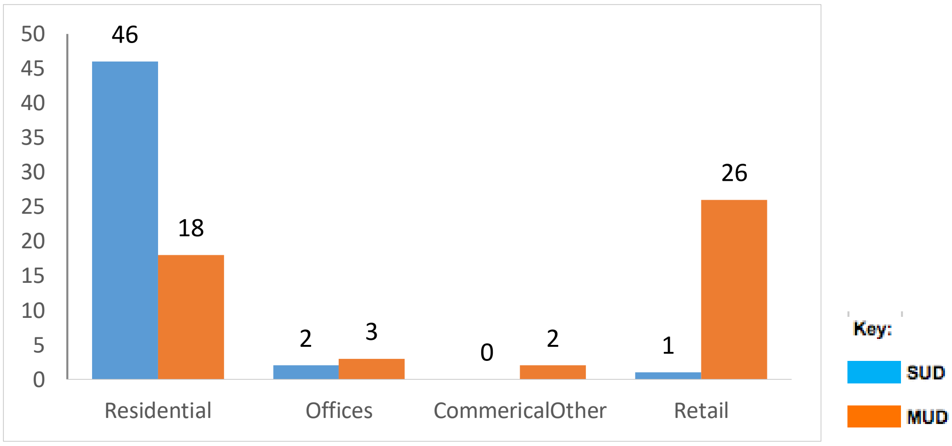

Figure 6b. Dominant function of reduced matched sample of 98 investments.

Recall also from *table 13* (Appendix V) that the postal code was the only matching criteria for which bias could not be reduced below the 5 per cent rule of thumb. Thus, this means there are some single use and mixed use investments situated for which the neighbourhood effect has not been accounted for sufficiently which would account for some of the difference in their rent level. This issue could be mitigated in future studies where a larger sample size of MUD can be obtained. Another fundamental explanation for the difference in rents found in this study between MUD and SUD is the tenants of the real estate investments. Many of the mixed use investments will be especially sensitive to the tenant mix given that they have a dominant retail use because the rents achieved will be determined by the tenants that are attracted to and that occupy the space. For instance, the willingness to pay for a start-up in comparison to a big player would be lower thus if the tenants were mainly of this calibre it would explain the lower rents achieved by MUD. This would be an insightful factor to account for within the empirical analysis but such information was not available in the data so the analysis could not be carried out.

To take this analysis further a comparable single use and mixed use investment has been identified accounting for the dominant use to aid a like for like evaluation. Then after filtering for the five largest cities given survey responses of the clients interviewed by SAREF regarding mixed use, several properties were identified. However to reduce neighbourhood effects, properties from each category were matched based on their postcode, which resulted in the selection of the developments shown in *table 13*. Object 1331 and 2322 are located approximately 11 minutes walking (or 6 minutes driving) distance away from each other so it is possible to presume that neighbourhood effects would not significantly alter rent levels. Object 1331 is a MUD with 95 per cent of its revenue generating use as residential and the remainder as other commercial use. Object 2322 is a residential development with no other revenue generating functions. By reporting the square meter price, this controls for any difference in rents due to the useable surface area. *Table 14* shows that the mixed use investment actually produces higher rents than the single use investment. However in this case, NOI of object 1331, which is the mixed use investment is lower due to having a higher operating cost than the single use investment which is to be expected.

Table 14. Sample of two comparable MUD and SUD.

ID	Type	Subtype	Residential	Commercial (other)	City	Area (M^2)	Rent per sqm	Opex per sqm	NOI per sqm
1331	1	MUD90-99	95%	5%	Den Haag	8429	102	12	90
2322	0	SUD100	100%	0%	Den Haag	5420	99	3	96

Whilst the above shows that mixed use investments can potentially provide Dutch institutional investors with higher rents than single use investments, though there is one important consideration to note. Operating expenses are consistently demonstrated to be higher for mixed use investments in comparison to single use investments for the sample data used in this study. Thus, if Dutch institutional investors are to maximise their return from investing in mixed use investments, meticulous control of operating expenses would be required in order for their performance to be superior to that of comparable single use investments. Alternatively, investors would need to obtain a low investment value to maximise yields.

5. CONCLUSION & RECOMMNEDATIONS FOR FUTURE RESEARCH

5.1 Conclusion

The purpose of this research was to empirically investigate the ex-post financial performance of mixed use investments relative to single use investments from the perspective of Dutch institutional investors. The review of literature on MUD generally indicated a net positive effect for these types of real estate assets. However, a majority of the studies were either of a descriptive nature or focused on the externality effect MUD had on surrounding house prices. Thus, they did not empirically assess the direct financial performance of the mixed use investments or make comparisons to single use investments. Consequently, this study attempted to fill the gap in the existing literature by using a multivariate OLS hedonic regression model to examine the effect MUD have on the dependent variables rents, operating expenses and NOI relative to SUD based on a sample of 536 observations in the Netherlands in 2016.

Using the multivariate hedonic model, the findings presented in this paper reveal that rents for mixed use investments are estimated to be significantly lower than those of single use investments. Even when accounting for varying degrees of mixed use and examining comparable MUD and SUD, the aforementioned findings are maintained. The results from the preferred model (model 4) show that mixed use investments (MUD90-99, MUD80-89 and MUD79) yield rents, which are 0.63, 1.57 and 5.68 times lower respectively in relation to comparable single use investments. Whilst this indicates that overall, rents for the 49 MUD in model 4 were lower than the matched sample of 49 SUD precaution needs to be adopted in making inferences from these results as the residuals of the rent equation are not normally distributed. This implies that it may not be appropriate to deduce that the results obtained may be similar for the population of mixed use investments in the Dutch real estate market.

In the multivariate model used in this study, operating expenses of MUD were the second dependent variable that was explored. The results presented provide consistent evidence that mixed use investments are more expensive to operate than single use investments; this finding is as expected. Once more, this discovery was robust even when accounting for three categories of MUD as well as for only matched SUD. The preferred model (model 4) shows that mixed use investments (MUD90-99, MUD80-89 and MUD79) are estimated to generate operating expenses that are 0.51, 2.33 and 0.72 time higher respectively than similar single use investments. The outcome is a forewarning that in order for institutional investors to maximise return on their mixed use investments, special attention will need to be directed at ensuring operating expenses are controlled so as to not unduly diminish the financial performance of their mixed use real estate assets.

Results regarding the NOI for the sample of mixed use investments considered in this study produce an interesting story. The initial finding presented in model 2 likewise indicated that MUD were actually found to perform worse than SUD in the sample dataset in terms of NOI. In fact, mixed use investments as a whole were estimated to result in NOI that was approximately €82,655 lower than for single use investments. Nevertheless, this result was not robust when the varying degrees of mixed use and when the performance of only the matched comparable sample of the 49 MUD with the 49 SUD was taken into account. The robustness check implemented in the preferred model (model 4) indicates that the outcome where MUD are shown to exhibit lower NOI than relative SUD is only significant for mixed use investments that fall into the category where their dominant real estate function accounts for 79 per cent or less of their revenue generating functions. In fact, NOI for mixed use investment in the MUD79 category are expected to generate NOI which is €342,266 lower than comparable SUD. This is however, not the case for mixed use investments that fall within the remaining categories. The robustness check actually uncovered that mixed use investments whose dominant function accounts for 80-89 and 90-99 per cent of revenue generating functions yield an equivalent financial performance to the matched comparable single use investments. The implication inferred from these results is that mixed investments (MUD80-89 and MUD90-99) provide Dutch institutional investors with equivalent profitability (indicated by NOI) as single use real estate investments.

Although the overall results from the empirical analysis for the sample dataset shows that mixed use investments do not necessarily result in a better financial performance than single use investments, reflections were made to consider whether this relationship was causal or could be explained as a consequence of factors omitted from the analysis. After examining the raw data and from surveys conducted with expert analysts at SAREF, some additional key factors were established as having the potential to significantly alter the results obtained. Due to various data limitations, these factors could not be appropriately corrected for in the empirical analysis. As discussed in section 4.5 these additional influential issues included difference in densities, type of (dominant) use, the importance of micro-location and information regarding the tenants of each real estate development. When all of the aforementioned issues were controlled for, it resulted in the selection from the reduced matched sample utilised in model 4 of two investments (*table 13*). These two investments situated in the Hague, were used to assess whether it could be the identified omitted variables could provide further insight regarding the ex-post financial performance of MUD in relation to SUD. The comparison shows contrary to the empirical results that rent for the mixed use object is actually higher than for the single use object but consistent is that the opposite is true for operating expenses. That is, the mixed use investment is costlier to operate than the single use investment resulting in the corresponding NOI of the MUD being lower than the SUD. Therefore, one particular important matter can be established given the findings and discussion in this paper regarding the first hypothesis. That is, operating expenses will play a highly important role in determining whether mixed use real estate assets could potentially provide (Dutch) institutional investors with better financial performance than comparable single use assets.

The preferred multivariate hedonic model (model 4) was lastly used to assess whether the theory that mixed use investments in bigger cities would exhibit higher rents and NOI than mixed use investments in relatively smaller cities. The total population in each municipality was used as a proxy for city size, and it was checked that these generally aligned. When the dependent variable is rent, contrary to expectations, the results indicate that city size does not significantly influence the rent achieved by a mixed use investment. However, as previously mentioned the non-normality of the rent equation means that inference about population parameters may not be valid. Therefore, the interpretation of the NOI may be better suited as it does not suffer from the non-normality defect in its residual. The outcome presented is a significantly positive relationship between city size and the NOI of mixed use investments, which supports hypothesis two. Specifically, a rise in the population (city size) of which the MUD is located in by

1000 leads to an increase in NOI by €650. Suggesting that Dutch institutional investors will extract better profitability from MUD in bigger cities relative to smaller cities.

To conclude, the findings in this paper show that rents for the sample data employed are not higher for mixed use investments relative to single use investments, irrespective of the varying degree of mixed use. An important remark to note regarding why rents for MUD may not be higher than SUD may be because some of the mixed use investments may not be mixed use in concept but rather by coincidence. For instance, a critical eye may point out that a development whose dominant use accounts for 90-99 per cent of its revenue generating use is not a mixed use real estate investment despite that on paper it exhibits some degree of mixed use. It could be maintained that the mixing of uses in such developments are merely an after-thought than an intention incorporated into the concept of the development. As indicated in the theoretical discussion, a financially successful MUD requires the presence of complementary functions that enables synergistic benefits arising from the different uses to be capitalised into the rents or profitability of the mixed use investment. The opposite is true for operating expenses, for which it is consistently shown that MUD are costlier to operate. As for NOI, it is found that there is no significant difference between the profitability of mixed use investments in the categories MUD80-89 and MUD90-99 however, the same outcome is not estimated for those in the category MUD79 which are expected to perform worse than comparable single use investments. The evidence presented in this research paper therefore points at mixed use not necessarily improving the risk-return profile of Dutch institutional investors in relation to single use investments. However, these findings come with caveats for which for future research could seek to solve. Discussion of the findings in this paper highlighted that Dutch institutional investors can gain from investing in mixed use assets but will need to pay close attention to several issues.

5.2 Recommendations for Future Research

This study has presented findings on the comparison of the financial performance of mixed use and single use investments from the perspective of (Dutch) institutional investors. It has provided a foundation for which other studies can conduct an empirical analysis into the said relationship. The following recommendations for future research are therefore suggested:

1. One of the major challenges faced in this study was the ambiguity around which real estate investments were classed as mixed use. As previously established MSCI data could not be exploited, as it did not provide micro-data on mixed use. Thus, there was also no benchmark to which the performance of the mixed use assets in the sample dataset could be compared to. As mixed use developments become more and more popular in the near future, maybe this will bring a more formalised measure of their financial performance. In surveys conducted with experts at SAREF it was often cited that as there was no established methodology for recording the financial performance of mixed use objects; the typical practice in the real estate industry is to define the development according to its dominant use. Hence, in conjunction with a larger sample of mixed use investments, the formalisation regarding the measuring of the financial performance of mixed use investments will allow future researchers to be more meticulous in their selection of mixed use investments to

study. Rather than having to accept a limited sample as was the case in this study, future research will be able to investigate the financial performance of mixed use investments that are defined as so by concept. This will mitigate the inclusion of mixed use investments that were more of a coincidence or an after-thought. By doing this, institutional investors will gain a better understanding of whether the synergies theorised to exist in mixed use real estate investments are actually capitalised in their financial performance.

2. Another starting point for future research would be accessing data that would overcome the obstacles that this study was confronted with due to omitted variables in the dataset employed in this study. An option for future studies is obtaining a sample consisting of a larger sample than 62 mixed use investments as was used in this study. This creates an opportunity whereby the researcher can minimise the bias between the matched comparable MUD and SUD, to ensure that a more like for like comparison can be made between the two types of investments. As a result the credibility of the results will be improved further as influences such as the type of (dominant) use and the micro-locations will be understood and accounted for.

3. Moreover, whilst times series data were available in regard to the rents, operating expenses and NOI, information on tenants within each development were not so using time series data would have caused methodological issues in this study without adding value to the insights from the results. Thus, another option for future research is to adopt time series data which include the tenants of each development to assess whether the presence and change of different types of tenants influences the financial performance of MUD in comparison to SUD.

4. Times series data could also be used to extend this study in another manner. As more and more mixed use projects in the pipeline get completed, future studies could look to use a difference in difference model to ascertain the impact mixed use investments have on various financial performance parameters before, on announcement of construction and after completion of MUD.

5. Lastly, the aim of this study was also to examine whether VMU developments performed better financially than other typologies of mixed use investments as established by Hoppenbrouwer and Louw (2005). However, the lack of differentiation of each investment in the dataset used created a further impediment that this study could not overcome. Should a future research be able to obtain data that includes information that enables the differentiation between the different typologies of MUD and the number of floors per building, it would be insightful to examine which mixed use typology provides institutional investors with the maximum return on their investment as well as allow comments on the marginal contribution on the number of floors.

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Appendix I: Summary of variables

Table 4. Variable descriptions.

Variable	Description
Dependent variables:	
Rents	Sum of: - Untaxed rental income - Untaxed service charges
Operating expenses	Sum of: - Property taxes - Property insurance premiums - Property maintenance costs - Property marketing costs - Rental preparation expenses - Contributions to association of ownership (Dutch: "VvE contributions") - Property service and heating costs
Net Operation Income (NOI)	Rents less Operating expenses
Independent variables (micro-data):	
Type	1 = MUD, 0 = SUD
Sub-type	- SUD100 is an investment with only one use - MUD90-99 is an investment whose dominant use is 90 to 99 per cent - MUD80-89 is an investment whose dominant use is 80 to 89 per cent - MUD79 is an investment whose dominant use is 79 per cent or less
Usable surface area	Measured in square meters. This is the area within the investment that can be used or let
Contractual rent	Rent stated in the contract
Age	Calculated as the difference between construction year and the date the data was being compiled
Functions	Number of uses that are within each investment
The independent variables (macro-data):	
Municipality name	The name of the municipality
Employment	The number of active people in employment
Disposable Income per household	Disposable Income per household 2016 is net of taxes
Population	The number of people per municipality in 2016
Growth in the number of households	The growth in the number of households in 2016
Quality of life	The leefbaarometer is a quality of life measure based on 100 indicators and covering the Netherlands. There are five possible responses: Uitstekend (Excellent), Zeer goed (very good), Goed (good), Ruim voldoende (Satisfactory) and Zwak (weak).
Postal code	Post code of each observation

APPENDIX II: OLS ASSUMPTIONS

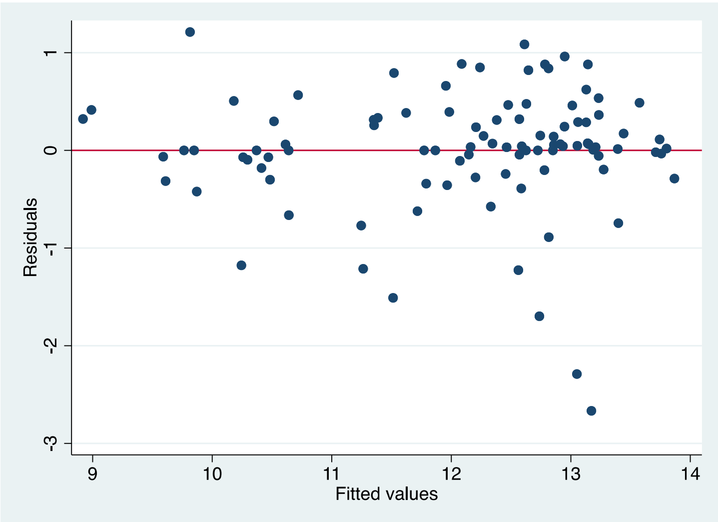
Assumption 1: Linearity

According to Brooks and Tsolacos (2010), this assumption will never be violated if a constant term is included in the regression equation, which will be the case for this study.

Assumption 2: (Homoscedasticity)

The rvfplot provides a visualisation of whether the errors are homoscedastic and the Bruesch-Pagan test is a statistical test. The null hypothesis is that the variance of the errors is constant and finite, thus homoscedatic. The conclusion of the results is that the errors for the rent and operating expense variables are homoscedastic as the P value is greater than 0.05 and the null hypothesis cannot be rejected but the opposite is true for the NOI variable. NOI is shown to exhibit heteorscedasticity in the errors. The solution is to run the regression with robust standard errors.

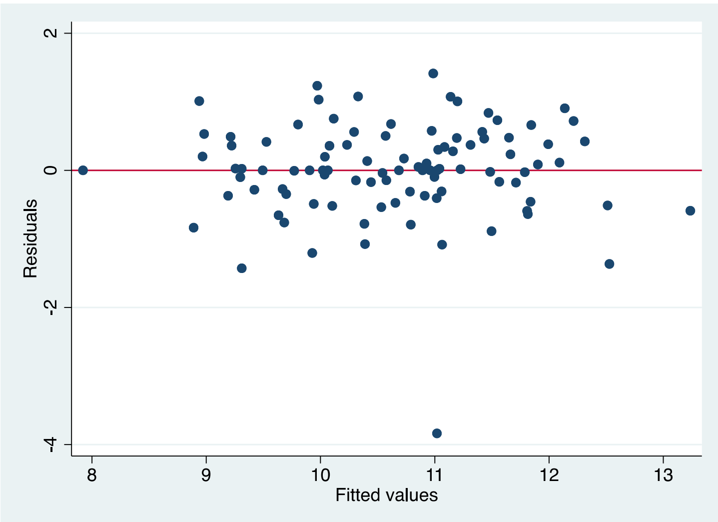
<u>Dependent variable (lnRent)</u>




```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnRent

         chi2(1)      =     2.05
         Prob > chi2  =   0.1519
```

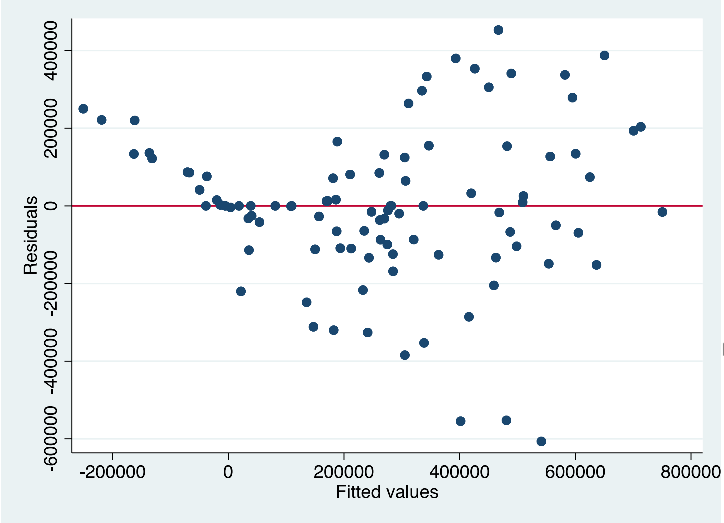
<u>Dependent variable (lnOpexSqm)</u>




```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnOpex

         chi2(1)      =     0.91
         Prob > chi2  =   0.3399
```

Dependent variable (NOI)




```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of NOI

         chi2(1)      =    11.00
         Prob > chi2  =   0.0009
```

Assumption 3 (Spatial autocorrelation)

As previously noted the data adopted in this study is cross-sectional there will be no autocorrelation of the errors across time. However, it may be the case that the errors are spatially autocorrelated. In real estate it is generally accepted to assume spatial autocorrelation in data as properties in close proximity tend to exhibit similar structural characteristics, accessibility conditions and neighborhood amenities amongst other things (Gillen et al., 2001). This could be due to omitted variables, model misspecification, data smoothness and trends, and misspecification of the true random error. (Brooks and Tsolacos, 2010). The resolution for autocorrelation is to use clustered standard errors when running the regression analysis.

Assumption 4 (Independence)

To test for independence, the Durbin-Wu-Hausman test can be performed. Under this test the null hypothesis is that there is independence between the error and the explanatory variable. The test is performed on SubType to check if there is a correlation between the independent variable and the error term. The results of the test shown below reveal that we do not reject the null hypothesis of independence, as the P-value is greater than 0.05. Thus the condition of independence is not violated.

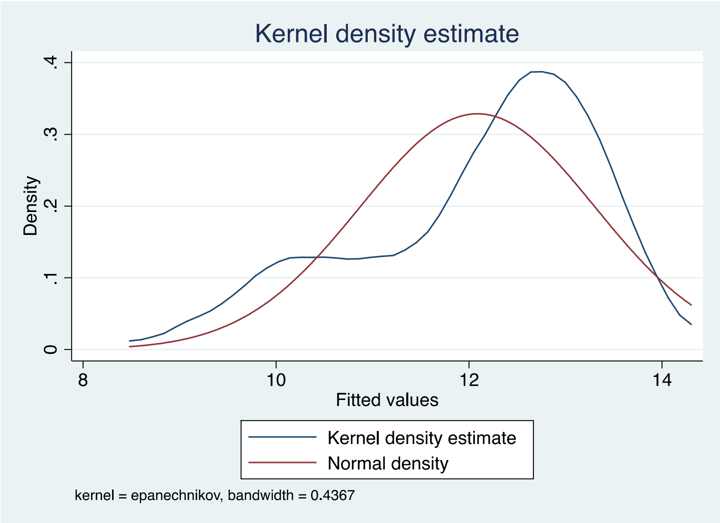
	lnRent	Std. Err.	lnOpex	Std. Err.	NOI	Std. Err.
r_SubTypelnRent	-0.2920	0.3572				
r_SubTypelnOpex			0.0798	-0.3961		
r_SubTypeNOI					-72106.15	112377.1
Constant	4.4244***	-1.5068	3.0911*	-1.6709	-1365435	474012.2
Observations	98		98		98	
R-squared	0.7842		0.6561		0.5669	

Note: Standard errors are included in the table with *** , **, * indicating significant at 1%, 5% and 10%, respectively. The output shows only the variables of interest and the constant.

Assumption 5 (Normality)

The normality assumption is assessed using the kernel density function. The results for the independent variables below show that rent has a skewed distribution function but operating expense and NOI have an approximately normal distribution as indication by the kernel density graph and the P-values in the Shapiro-Wilk test being greater than 0.05. This leads to the rejection of the null hypothesis that the errors the operating expenses and NOI are not normally distributed.

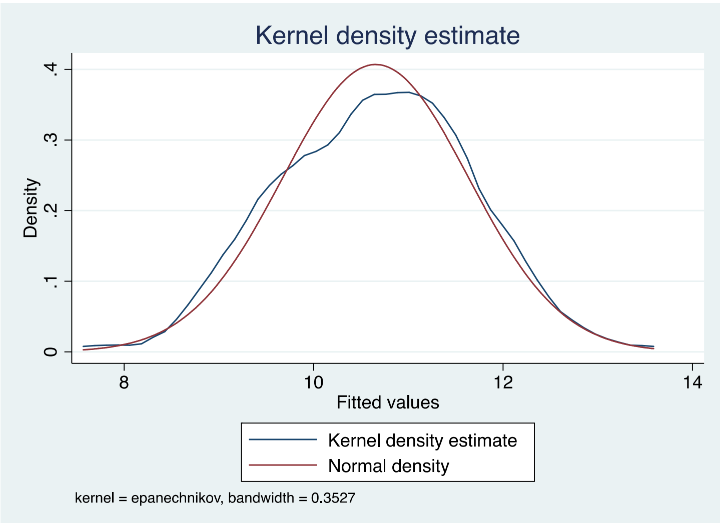
<u>Dependent variable (lnRent)</u>



Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r_lnRent	98	0.91573	6.841	4.261	0.00001

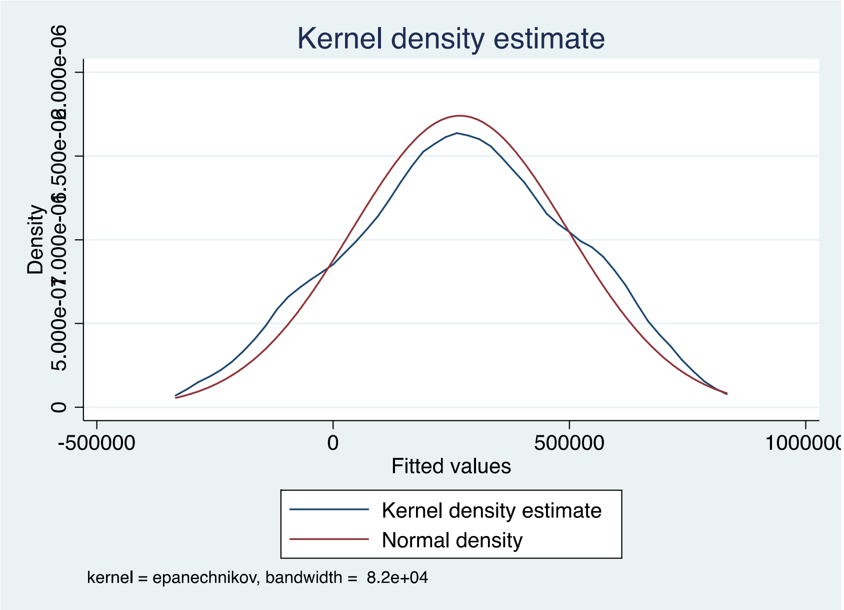
<u>Dependent variable (lnOpexSqm)</u>



Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r_lnOpex	98	0.99246	0.612	-1.087	0.86150

Dependent variable (NOI)



Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r_NOI	98	0.98728	1.033	0.071	0.47163

APPENDIX III: SUMMARY STATISTICS AND CORRELATION MATRIX FOR MUTLICOLLINEARITY

Table 5. Summary Statistics.

Category (Sample Size):		SUD (474)				MUD (62)			
	T-test (p-value)	Mean	SD	Min	Max	Mean	SD	Min	Max
Rent (€)	0.0002	361000	225000	8671.74	1360000	240000	346000	8042.88	1280000
Rent per sqm (€)	0.0000	92.442	27.783	1.6	213.369	68.127	50.898	1.873	206.272
Operating expenses (€)	0.2557	66806.63	68170.59	1184.1	462000	77790.73	93238.39	1315.87	414000
Operating expenses per sqm (€)	0.0000	16.803	14.535	0.1	180.458	31.411	25.644	0.085	133.191
Net Operating Income (€)	0.0000	294000	201000	-201000	1170000	162000	319000	-198000	1040000
Net Operating Income per sqm (€)	0.0000	75.639	29.317	-70.961	200.021	36.716	59.548	-109.504	201.319
	0.0000								
Area (sqm)	0.9989	4000.082	2382.416	116	20017	4000.581	4755.669	102	17538
Age	0.7287	19.064	12.405	2.436	65.37	18.484	12.037	1.077	63.367
Type	-	0	0	0	0	1	0	1	1
Subtype	-	4	0	4	4	2.194	0.807	1	3
Number of Functions	0.0000	1	0	1	1	2.323	0.505	2	4
Availability of Parking	0.0533	0.192	0.394	0	1	0.194	0.398	0	1
Disposable Income per Household	0.0106	40.939	5.227	27.5	55	39.134	5.064	27.5	55
Employment	0.0000	65.873	87.133	4	443	123.194	136.046	8	443
Number of Households	0.0000	64744.57	93226.99	3444	456462	126000	144000	6869	456462
Population	0.0000	133000	176000	7755	833625	246000	266000	16425	833625
Quality of life (Leefbaarometer score)	0.1685	2.07	1.171	1	5	1.855	1.006	1	5
COROP-region	0.1881	15.346	9.548	1	35	13.661	8.798	2	35
Interest Rate	-	0.3	0	0.3	0.3	0.3	0	0.3	0.3

Table 7. Correlation matrix.

	lnRent	lnOpex	NOI	lnArea	Age	Type	Functions	lnDispInc	lnEmp	lnHH	lnPop	QOL	Parking	COROP	IntRate
lnRent	1														
lnOpex	0.5079	1													
NOI	0.8102	0.3181	1												
lnArea	0.8039	0.6046	0.6099	1											
Age	-0.0297	0.4063	-0.1082	0.0123	1										
Type	-0.4314	-0.0255	-0.1906	-0.2621	-0.015	1									
Functions	-0.4482	-0.0236	-0.2163	-0.2634	0.0011	0.9276*	1								
lnDispInc	0.0673	-0.0144	-0.0086	0.0274	0.0794	-0.1122	-0.1134	1							
lnEmp	0.1106	0.0464	0.2902	0.1264	-0.1653	0.1837	0.1756	-0.6112	1						
lnHH	0.1043	0.0483	0.284	0.1226	-0.1605	0.1916	0.1831	-0.65	0.9965*	1					
lnPop	0.11	0.0456	0.2892	0.1281	-0.1648	0.1835	0.1751	-0.6205	0.9986*	0.9981*	1				
QOL	0.0828	-0.0206	0.0882	0.0993	-0.09	-0.0596	-0.0379	0.1562	-0.0178	-0.0189	-0.0102	1			
Parking	0.2667	0.1456	0.3517	0.2156	-0.1327	0.0013	-0.0182	-0.0363	0.1451	0.1543	0.1478	-0.0066	1		
COROP	-0.1049	-0.0633	-0.136	-0.1579	-0.0075	-0.0569	-0.0425	0.0675	-0.1886	-0.1895	-0.1889	-0.1169	-0.0293	1	
IntRate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	lnRent	lnOpex	NOI	lnArea	Age	SubType	Functions	lnDispInc	lnEmp	lnHH	lnPop	QOL	Parking	COROP	IntRate
lnRent	1														
lnOpex	0.5079	1													
NOI	0.8102	0.3181	1												
lnArea	0.8039	0.6046	0.6099	1											
Age	-0.0297	0.4063	-0.1082	0.0123	1										
SubType	0.5243	0.0711	0.271	0.3564	-0.0565	1									
Functions	-0.4482	-0.0236	-0.2163	-0.2634	0.0011	-0.8961*	1								
lnDispInc	0.0673	-0.0144	-0.0086	0.0274	0.0794	0.1221	-0.1134	1							
lnEmp	0.1106	0.0464	0.2902	0.1264	-0.1653	-0.141	0.1756	-0.6112	1						
lnHH	0.1043	0.0483	0.284	0.1226	-0.1605	-0.1479	0.1831	-0.65	0.9965*	1					
lnPop	0.11	0.0456	0.2892	0.1281	-0.1648	-0.1391	0.1751	-0.6205	0.9986*	0.9981*	1				
QOL	0.0828	-0.0206	0.0882	0.0993	-0.09	0.0608	-0.0379	0.1562	-0.0178	-0.0189	-0.0102	1			
Parking	0.2667	0.1456	0.3517	0.2156	-0.1327	0.0187	-0.0182	-0.0363	0.1451	0.1543	0.1478	-0.0066	1		
COROP	-0.1049	-0.0633	-0.136	-0.1579	-0.0075	0.0324	-0.0425	0.0675	-0.1886	-0.1895	-0.1889	-0.1169	-0.0293	1	
IntRate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

From the above results the main relationships of concern (indicated by an asterisk, *) are between:

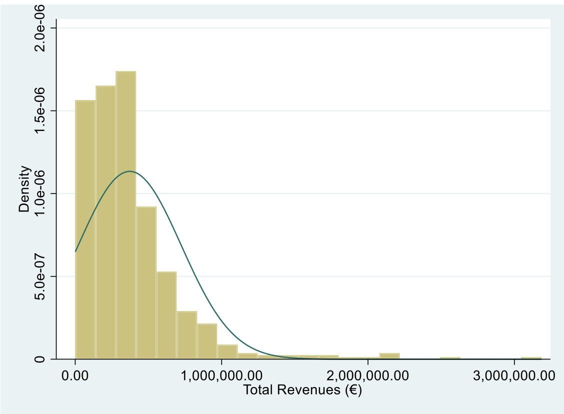
- Functions (the number of uses) and Type, and Functions (the number of uses) and Subtype
- Employment, Population Households

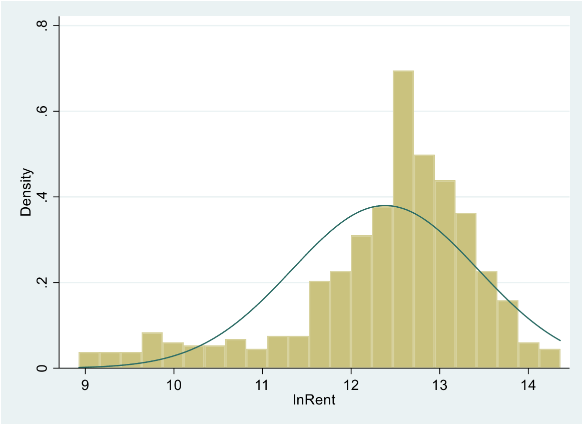
To mitigate the issue that these high correlations could cause, the variables Functions, Employment and Households will be dropped from the model as Sub/Type and Population are key variables of interest. Further tests for issues with multicollinearity have been carried out using the VIF test following removal of the 'troublesome' variables. The output has not been included here but the results show no issue with multicollinearity as all VIFs are below the standard benchmark of 10 (Mehmetoglu and Jakobsen, 2017).

APPENDIX IV: TRANSFORMATION OF VARIABLES

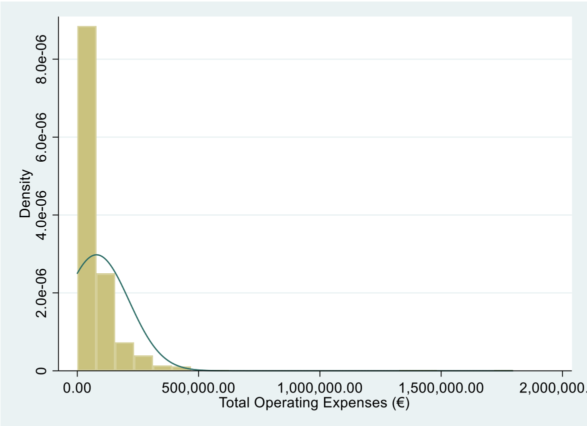
Dependent variables

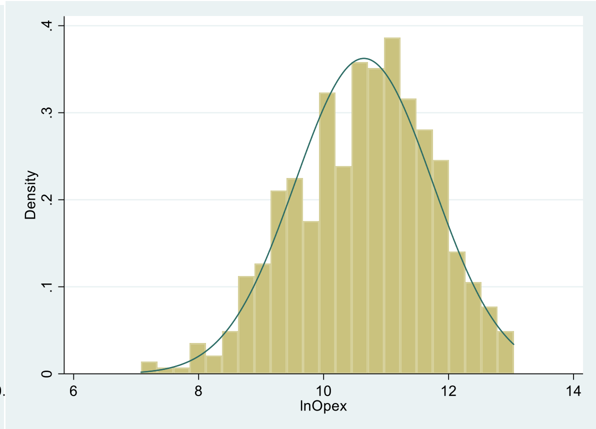
<u>*Rent*</u>





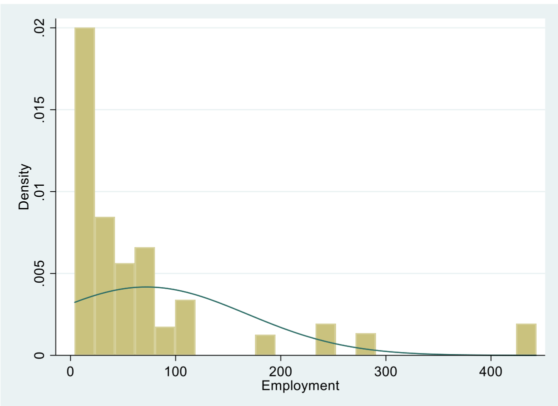
<u>*Operating expense*</u>

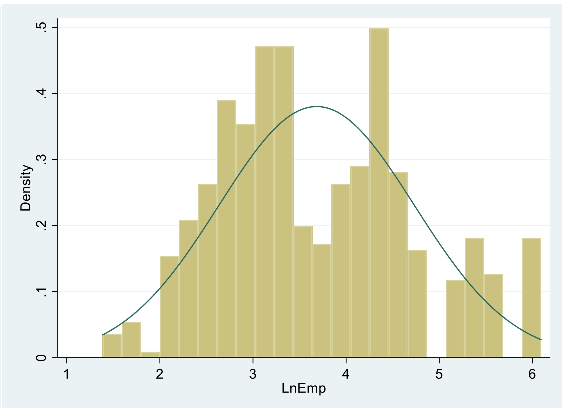




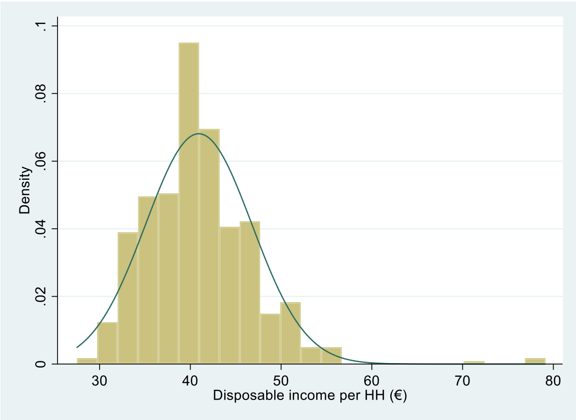
Dependent variables

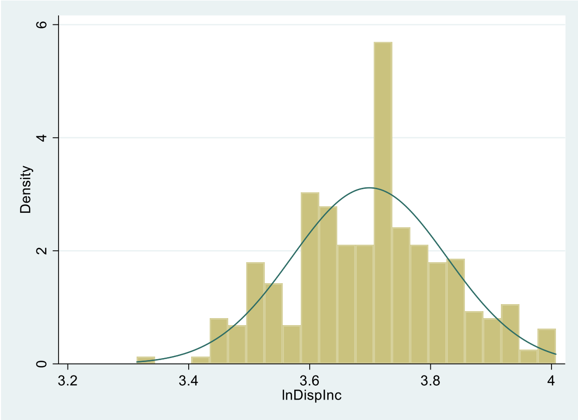
<u>*Employment*</u>



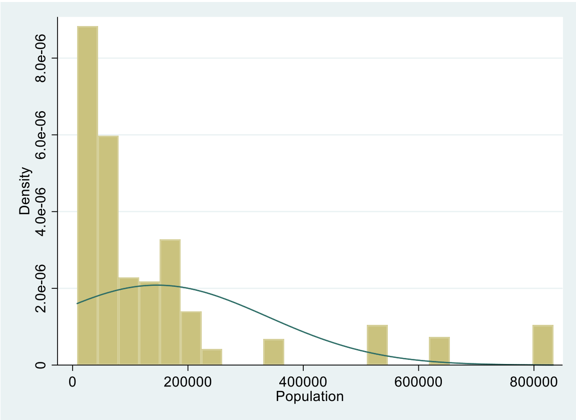


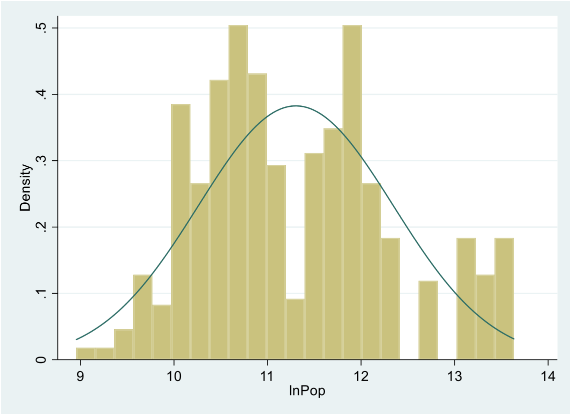
Disposable income per household



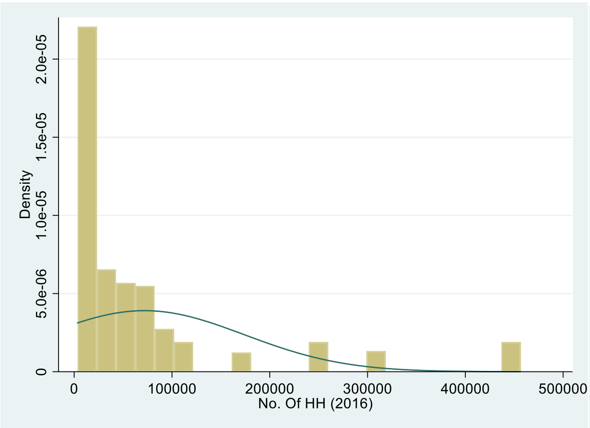


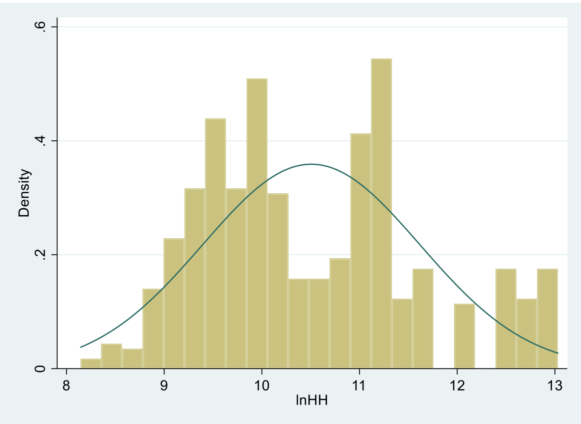
Population



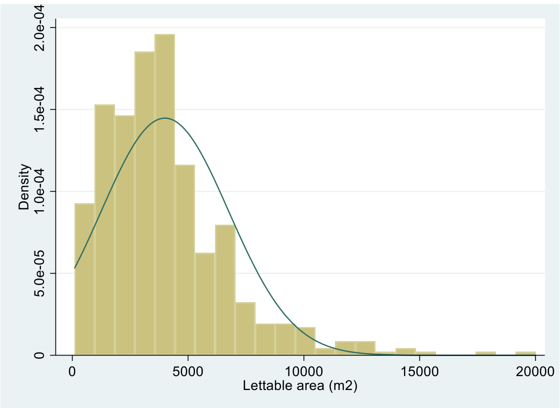


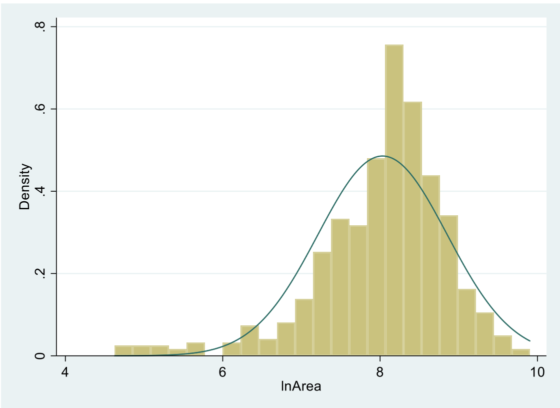
The number of households





Useable area in square meters





APPENDIX V: Full regression results and Propensity score matching

Table 8. Estimation results for lnRent.

lnRent	Baseline model		Model 1		Model 2		Model 3	
Observations	536		536		536		98	
R-squared	0.735		0.734		0.744		0.786	
Corop fixed effect	Yes		Yes		Yes		Yes	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Type	-0.820***	-0.134	-0.824***	-0.136				
SubType:								
MUD79					-1.343***	-0.133	-1.899***	-0.282
MUD80-89					-0.943***	-0.121	-1.092***	-0.163
MUD90-99					-0.516**	-0.205	-0.490**	-0.19
lnPop							0.0729	-0.0767
lnArea	0.825***	-0.0629	0.828***	-0.0613	0.783***	-0.0669	0.697***	-0.147
Age	-0.000945	-0.00198	-0.000719	-0.0019	0.000597	-0.00174	0.00159	-0.00436
lnDispInc	0.406	-0.33						
lnHH	0.0365	-0.0341	0.021	-0.0303	0.026	-0.0285		
1.QOL	-0.250**	-0.108						
2.QOL	-0.251**	-0.12						
3. QOL	-0.442**	-0.171						
4. QOL	-0.317*	-0.165						
Parking	0.247***	-0.085	0.245***	-0.0845	0.255***	-0.082	0.556**	-0.212
2.COROP	0.0635	-0.0888	0.0908	-0.0747	0.0764	-0.0722	-0.00575	-0.288
3.COROP	0.240***	-0.0259	0.257***	-0.0286	0.264***	-0.0294	0.166***	-0.0418
4.COROP	0.0409	-0.0449	0.018	-0.024	0.0572**	-0.0256	0.370**	-0.149
5.COROP	0.548***	-0.0506	0.526***	-0.0297	0.556***	-0.0296	0.891***	-0.31
6.COROP	0.0843	-0.0591	0.122***	-0.0394	0.149***	-0.0424	-0.078	-0.093
7.COROP	0.282***	-0.0872	0.346***	-0.057	0.370***	-0.0505	1.173***	-0.112
8.COROP	0.296***	-0.0797	0.341***	-0.0691	0.325***	-0.066	0.343	-0.226
9.COROP	0.145**	-0.0533	0.267***	-0.0332	0.254***	-0.0329	-0.0146	-0.242
10.COROP	0.270***	-0.0642	0.313***	-0.0485	0.134	-0.104	-0.25	-0.17
11.COROP	0.0281	-0.0578	0.0437	-0.0335	0.0468	-0.033		
12.COROP	-0.0336	-0.0597	-0.00481	-0.0501	0.0478	-0.0416	-0.0436	-0.149
13.COROP	-0.181***	-0.0229	-0.189***	-0.0206	-0.199***	-0.0207		
14.COROP	0.0884**	-0.0353	0.0838***	-0.0228	0.0921***	-0.0256	0.0762	-0.136
15.COROP	-0.063	-0.0404	-	-0.0183	-0.113***	-0.0236	-1.637***	-0.0901
16.COROP	-0.219***	-0.0535	-0.257***	-0.0229	-0.202***	-0.0288	-0.546***	-0.0754
17.COROP	0.0820**	-0.0328	0.0894***	-0.0179	0.0847***	-0.0175	-0.0997	-0.0666
18.COROP	0.0157	-0.0418	0.0246	-0.0399	0.000243	-0.0456	0.0466	-0.175
19.COROP	-0.000993	-0.0458	0.0323*	-0.0184	0.0681***	-0.0216	-0.542	-0.378
20.COROP	0.232***	-0.0535	0.280***	-0.0403	0.307***	-0.044		
21.COROP	0.00387	-0.04	-0.0447**	-0.0219	0.0467*	-0.0263	0.125	-0.133
22.COROP	0.0662*	-0.0387	0.0252*	-0.0143	0.0358**	-0.0145	-0.173***	-0.0491
23.COROP	0.0991*	-0.0535	0.144***	-0.0273	0.156***	-0.0263	-0.0281	-0.145
24.COROP	0.143***	-0.0331	0.170***	-0.0232	0.158***	-0.0254	-0.208	-0.21
25.COROP	0.214***	-0.0341	0.244***	-0.0145	0.278***	-0.0183	0.488***	-0.0731
26.COROP	0.161**	-0.0673	0.182***	-0.0526	0.206***	-0.0521		
27.COROP	0.112**	-0.0487	0.0790**	-0.0381	0.0575	-0.0389	-0.340**	-0.149
28.COROP	0.00296	-0.0368	-0.00448	-0.0371	-0.0196	-0.0372	-0.475	-0.313
29.COROP	-	-0.0208	-	-0.015	-0.108***	-0.0228	-1.555***	-0.209
30.COROP	0.252***	-0.0307	0.264***	-0.019	0.254***	-0.0228	0.730***	-0.124
31.COROP	0.028	-0.0626	0.0691	-0.05	0.0949*	-0.0499	-0.0851	-0.222
32.COROP	0.0104	-0.0288	0.000906	-0.0243	-0.00429	-0.0246		
33.COROP	0.00361	-0.0303	0.0126	-0.0297	-0.00187	-0.0283	-0.312***	-0.0956
34.COROP	0.343***	-0.065	0.372***	-0.044	0.418***	-0.0444		
35.COROP	0.0859	-0.059	0.0740*	-0.0364	0.224***	-0.0443	0.905***	-0.188
Constant	4.136***	-1.279	5.498***	-0.614	5.779***	-0.644	5.992***	-1.804

Note: Dependent variable is log of rents. Standard errors are clustered by 35 Corop-regions and included in the table with ***, **, * indicating significant at 1%, 5% and 10%, respectively. Independent variables Pop, Area, DispIncHH and HH have been log transformed. The reference category for (a) SubType is SUD100 (representing single use investments (b) QOL is weak and (c) COROP is Achterhoek. 1.QOL = good, 2.QOL = satisfactory, 3.QOL = excellent and 4.QOL = very good. All models include constant term, fixed effects for location Corop-region and surface area in square meters.

Table 9. Estimation results for lnOpex.

	Baseline model		Model 1		Model 2		Model 3	
Observations	536		536		536		98	
R-squared	0.596		0.588		0.593		0.664	
Corop fixed effect	Yes		Yes		Yes		Yes	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Type	0.495***	-0.125	0.507***	-0.125				
SubType:								
MUD79					0.323*	-0.18	0.544*	-0.28
MUD80-89					0.889***	-0.211	0.848*	-0.419
MUD90-99					0.367**	-0.174	0.415*	-0.212
lnPop							0.0427	-0.113
lnArea	0.823***	-0.0625	0.820***	-0.0605	0.834***	-0.0581	0.845***	-0.135
Age	0.0350***	-0.0033	0.0358***	-0.00346	0.0354***	-0.00348	0.0348***	-0.00769
lnDispInc	-0.774	-0.544						
lnHH	-0.0895	-0.0709	0.0332	-0.0585	0.0329	-0.0575		
1.QOL	-0.478*	-0.276						
2.QOL	-0.478**	-0.211						
3.QOL	-0.412	-0.599						
4.QOL	-0.618*	-0.322						
Parking	0.149	-0.125	0.153	-0.123	0.155	-0.123	0.184	-0.421
2.COROP	-0.136	-0.15	-0.339**	-0.136	-0.318**	-0.133	-0.322	-0.309
3.COROP	0.217***	-0.0738	0.169***	-0.0527	0.165***	-0.0509	0.845***	-0.0649
4.COROP	0.0973**	-0.0447	0.0719*	-0.0355	0.0821**	-0.0348	0.488***	-0.116
5.COROP	-0.0325	-0.116	-0.0267	-0.0559	-0.0945	-0.0699	-0.448	-0.581
6.COROP	0.122	-0.126	0.0185	-0.0856	-0.00784	-0.083	0.586***	-0.174
7.COROP	0.045	-0.117	-0.158**	-0.0596	-0.339***	-0.108	0.5	-0.532
8.COROP	0.0635	-0.152	-0.145	-0.122	-0.155	-0.118	0.501*	-0.273
9.COROP	-0.114	-0.121	-0.0315	-0.0667	-0.0239	-0.0653	0.438	-0.285
10.COROP	0.816***	-0.114	0.674***	-0.0722	0.750***	-0.0993	1.466***	-0.316
11.COROP	-0.0654	-0.316	-0.0978**	-0.0412	-0.187***	-0.0607		
12.COROP	-0.00148	-0.0668	-0.103***	-0.037	-0.190**	-0.071	0.298	-0.399
13.COROP	0.0643*	-0.034	0.112***	-0.0205	0.116***	-0.0223		
14.COROP	0.152**	-0.0625	0.135**	-0.0503	0.0915*	-0.0509	0.731*	-0.422
15.COROP	-0.230***	-0.0821	-0.324***	-0.0197	-0.315***	-0.0224	0.0998	-0.0952
16.COROP	-0.262***	-0.0691	-0.219***	-0.0498	-0.197***	-0.0494	0.0334	-0.14
17.COROP	-0.0454	-0.0849	-0.0348	-0.0374	-0.0333	-0.0368	0.552**	-0.209
18.COROP	-0.385***	-0.058	-0.417***	-0.0523	-0.430***	-0.0533	0.0161	-0.344
19.COROP	0.00321	-0.0863	-0.0680**	-0.032	-0.0502	-0.0313	-0.864*	-0.481
20.COROP	0.157	-0.105	0.0978**	-0.0434	0.0884**	-0.0428		
21.COROP	-0.676***	-0.0601	-0.571***	-0.0246	-0.531***	-0.0338	-0.108	-0.207
22.COROP	0.156**	-0.0667	0.130***	-0.0291	0.112***	-0.0292	0.546***	-0.171
23.COROP	0.102	-0.0928	-0.0637	-0.0413	-0.0816*	-0.043	0.618**	-0.264
24.COROP	-0.0718	-0.0639	-0.151***	-0.0409	-0.158***	-0.0412	1.173***	-0.221
25.COROP	0.399***	-0.0781	0.348***	-0.0313	0.363***	-0.0311	0.360***	-0.124
26.COROP	-0.645***	-0.144	-0.725***	-0.118	-0.733***	-0.116		
27.COROP	0.375***	-0.0797	0.427***	-0.0507	0.431***	-0.0461	1.217***	-0.272
28.COROP	-0.185***	-0.0551	-0.170***	-0.0422	-0.165***	-0.0443	-0.457	-0.273
29.COROP	0.039	-0.0277	0.101***	-0.014	0.115***	-0.0146	0.825***	-0.233
30.COROP	0.396***	-0.0596	0.352***	-0.0285	0.372***	-0.0297	0.359**	-0.138
31.COROP	0.593***	-0.127	0.598***	-0.0562	0.587***	-0.0626	1.148**	-0.437
32.COROP	-0.287***	-0.0414	-0.192***	-0.0227	-0.190***	-0.0234		
33.COROP	0.299***	-0.0592	0.272***	-0.0435	0.276***	-0.0445	0.258**	-0.121
34.COROP	-0.146	-0.143	-0.0819	-0.0676	-0.0943	-0.0666		
35.COROP	-0.0847	-0.0719	-0.152**	-0.0618	-0.0838	-0.0688	-0.0383	-0.332
Constant	7.516***	-2.424	2.940***	-0.951	2.837***	-0.912	2.112	-1.665

Note: Dependent variable is log of operating expenses. Standard errors are clustered by 35 Corop-regions and included in the table with ***, **, * indicating significant at 1%, 5% and 10%, respectively. Independent variables Pop, Area, DispIncHH and HH have been log transformed. The reference category for (a) SubType is SUD100 (representing single use investments (b) QOL is weak and (c) COROP is Achterhoek. 1.QOL = good, 2.QOL = satisfactory, 3.QOL = excellent and 4.QOL = very good. All models include constant term, fixed effects for location Corop-region and surface area in square meters.

Table 10. Estimation results for NOI.

	Baseline model		Model 1		Model 2		Model 3	
Observations	536		536		536		98	
R-squared	0.534		0.522		0.525		0.568	
Corop fixed effect	Yes		Yes		Yes		Yes	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Type	-83,138*	-48,800	-82,665*	-48,629				
SubType:								
MUD79					-125,010	-82,158	-342,266**	-150,382
MUD80-89					-115,067	-75,398	-236,503	-159,047
MUD90-99					-44,099	-62,379	-84,948	-63,381
lnPop							64,959**	-25,659
lnArea	127,948***	-19,961	130,776***	-19,773	125,442***	-23,117	80,876	-52,500
Age	-853.4	-682.5	-838.4	-627.2	-687.5	-609.5	-778.5	-1,831
lnDispInc	121,546	-96,662						
lnHH	45,659***	-13,232	28,818**	-11,430	29,336**	-11,024		
1.QOL	-73,428	-46,446						
2.QOL	-120,061***	-32,632						
3.QOL	-96,303	-69,981						
4.QOL	-65,053	-51,866						
Parking	102,151***	-28,706	103,051***	-28,436	103,937***	-29,003	159,275**	-75,142
2.COROP	50,712	-33,664	36,688	-27,798	34,100	-24,838	52,890	-96,981
3.COROP	71,880***	-12,032	79,815***	-11,634	80,806***	-12,091	-56,354***	-12,969
4.COROP	40,721***	-11,701	24,812***	-8,372	28,210**	-10,558	40,369	-72,926
5.COROP	142,101***	-18,076	103,464***	-12,740	110,153***	-14,347	77,539	-199,204
6.COROP	83,025***	-26,373	58,051***	-15,559	62,127***	-18,211	-81,608	-54,056
7.COROP	75,587**	-28,248	104,254***	-23,731	116,441***	-31,388	165,948	-126,000
8.COROP	175,490***	-31,238	173,449***	-24,399	172,359***	-22,282	109,090	-91,528
9.COROP	103,598***	-25,870	129,231***	-13,042	127,532***	-11,574	-6,068	-87,002
10.COROP	78,468***	-20,098	102,005***	-15,846	79,917***	-28,290	-34,434	-80,979
11.COROP	140,390***	-29,135	99,590***	-10,987	104,683***	-17,514		
12.COROP	14,066	-22,595	21,325	-18,929	31,289	-22,612	-16,782	-119,944
13.COROP	101,475***	-9,666	97,219***	-6,540	96,020***	-6,634		
14.COROP	24,361**	-10,145	-1,754	-7,079	1,423	-8,982	-2,853	-86,206
15.COROP	-6,661	-8,592	1,079	-5,913	-1,421	-7,711	-277,097***	-36,929
16.COROP	35,559**	-13,731	-11,170	-8,471	-6,724	-12,490	172.8	-61,800

17.COROP	47,823**	-19,494	19,501***	-6,774	18,951**	-7,152	-91,383***	-20,778
18.COROP	11,088	-15,489	18,994	-12,358	17,269	-12,562	-44,456	-120,221
19.COROP	32,139	-19,914	11,519**	-5,488	14,170*	-8,305	51,076	-180,647
20.COROP	187,078***	-27,646	169,292***	-14,079	172,521***	-15,961		
21.COROP	120,970***	-13,223	96,868***	-7,351	103,955***	-14,343	178,281**	-73,668
22.COROP	-10,794	-7,631	-12,759***	-4,405	-10,722**	-4,927	-54,297	-47,412
23.COROP	86,325***	-21,553	91,411***	-11,045	93,505***	-11,300	84,918	-71,733
24.COROP	61,485***	-11,458	75,178***	-7,373	74,271***	-7,056	-29,971	-83,187
25.COROP	52,820***	-12,844	37,879***	-4,980	40,561***	-7,732	102,395***	-26,716
26.COROP	67,074***	-22,140	35,627*	-20,514	38,419*	-22,047		
27.COROP	76,774***	-12,318	32,013**		29,629**	-13,327	-79,636	-51,533
28.COROP	33,213**	-15,672	34,130***	-11,875	32,360**	-12,094	-40,403	-112,929
29.COROP	-2,901	-7,341	-9,225	-5,990	-13,251	-8,349	-117,772	-99,879
30.COROP	49,983***	-13,613	36,916***	-6,524	34,842***	-6,568	159,126**	-65,351
31.COROP	55,428*	-29,681	28,281	-18,789	31,424*	-18,410	-89,583	-81,470
32.COROP	40,753***	-9,454	17,546**	-7,648	16,890**	-8,028		
33.COROP	-47,917***	-11,441	-41,824***	-9,980	-43,495***	-9,448	-130,801***	-31,691
34.COROP	249,569***	-32,208	198,345***	-12,367	203,652***	-13,630		
35.COROP	42,980*	-25,111	18,415	-13,074	29,893	-26,114	204,825	-128,643
Constant	-1.643e+06***	-497,283	-1.122e+06***	-224,003	-1.088e+06***	-247,350	-1.09E+06	-652,161

Note: Dependent variable is NOI. Standard errors are clustered by 35 Corop-regions and included in the table with ***, **, * indicating significant at 1%, 5% and 10%, respectively. Independent variables Pop, Area, DispIncHH and HH have been log transformed. The reference category for (a) SubType is SUD100 (representing single use investments (b) QOL is weak and (c) COROP is Achterhoek. 1.QOL = good, 2.QOL = satisfactory, 3.QOL = excellent and 4.QOL = very good. All models include constant term, fixed effects for location Corop-region and surface area in square meters.

Table 11. Inclusion of interaction term (SubtypeAge)

Independent variable:	lnRent		lnOpex		NOI	
Observations	98		98		98	
R-squared	0.79		0.677		0.579	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
SubType:						
MUD79	-2.621***	-0.457	1.554*	-0.855	-579,751**	-248,194
MUD80-89	-1.505***	-0.328	1.425***	-0.486	-372,239*	-190,532
MUD90-99	-0.714***	-0.212	0.729**	-0.324	-158,610	-97,640
Age	0.0476	-0.0304	-0.0295	-0.0408	14,341	-12,072
SubtypeAge	-0.0128	-0.00803	0.0178	-0.0108	-4,194	-3,058
Constant	5.999***	-1.781	2.102	-1.73	-1089000	-657265

Table 12. Logit Ouput and Propensity Score Matches.

Logit Model		
Observations	536	
Model chi-square	63.36	
Degrees of freedom	4	
Prob > chi2	0.0000	
Variable	Coef.	Std. Err.
lnArea	-0.937***	(0.157)
lnDispinc	-1.573	(1.762)
lnPop	0.349	(0.224)
PostalCode	-0.00341***	(0.00122)
Constant	7.981	(8.686)

*** p<0.01, ** p<0.05, * p<0.1

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
lnRent	Unmatched	11.2493227	12.5722147	-1.32289197	0.119725875	-11.05
ATT	ATT	11.6924649	12.4829961	-0.790531217	0.266151642	-2.97

Note: S.E. does not take into account that the propensity score is estimated

psmatch2: Treatment assignment	psmatch2: Common		
	Off support	On support	Total
Untreated	0	474	474
Treated	13	49	62
Total	13	523	536

Table 13. Pstest results.

	Mean			t-test		
Variable	***Treated***	***Control***	***%bias***	***t***	***p>t***	***V(T)/V(C)***
lnArea	7.9287	7.8951	3	0.15	0.88	1.4
lnDispInc	3.664	3.6581	4.6	0.23	0.819	1.29
lnPop	11.742	11.703	3.6	0.16	0.871	0.99
PostalCode	232.69	242.84	-6.3	-0.3	0.761	1.07

* if variance ratio outside [0.56; 1.77]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.002	0.22	0.994	4.4	4.1	9.4	1.23	0

* if B>25%, R outside [0.5; 2]

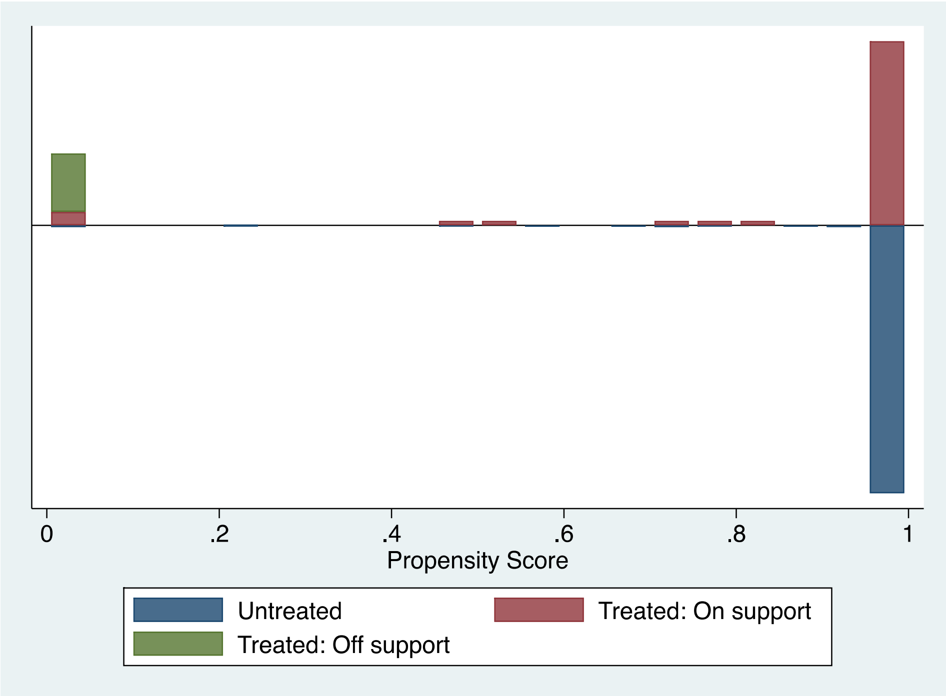


Figure 5. Psgraph.

Appendix VI: STATA syntax

```
clear all
*cd "/Users/user/Desktop/MUD/Final data set/Final STATA files"
use MUDvSUD.dta

*Delete irrelavant variables*
drop TotalOpex Constant Constructionyear Todaysdate Municipality NoofHH2015 Residential Offices CommericalOther Shops Municipalitysizekm2

*renaming variables*
rename Objectnumber ID
rename TotalRevenues Rent
rename TotalOperatingExpenses Opex
rename NetOperatingIncome NOI
rename Lettableaream2 AreaM2
rename Parkingavailability Parking
rename Numberofuses Functions
rename Employment Employ
rename DisposableincomeperHH DispIncHH
rename Population Pop
rename NoOfHH2016 HH
rename Interestrate IntRate

*Outliers: 3 observations deleted*
drop if AreaM2 ==0
drop if Opex < 0
keep if Parking ==0 | Parking ==1
keep if Type ==0 | Type ==1

*Converting String variables*
destring ID, replace force dpcomma
describe ID

describe Subtype
encode Subtype, generate (SubType)
describe SubType

describe Liveabilityscore
encode Liveabilityscore, generate (QOL)
```

```
describe QOL

describe Corop
encode Corop, generate (COROP)
describe COROP

describe Postcode
encode Postcode, generate (PostalCode)
describe PostalCode

*Outliers: 5 observations deleted - Category SUD, mismatch 2 functions --> reason: 2nd function is negligibe i.e. <1 percent)*
drop if ID ==109 | ID == 1818 | ID == 2238 | ID == 2267 | ID == 2372

*Dependent variable (Rents): checking for normality
hist Rent, normal
spikeplot Rent
twoway scatter Rent Type
*Outlier: 3 observation deleted*
drop if Rent > 2500000 | Rent < 4000
*Log transformation*
gen lnRent=ln(Rent)
hist lnRent, normal
twoway scatter lnRent Type
*Outliers: 10 observations deleted*
_pctile lnRent, p(1 99)
return list
drop if lnRent < r(r1) | lnRent > r(r2)
hist lnRent, normal
twoway scatter lnRent Type
pnorm lnRent
sum lnRent, detail

*Dependent variable (Operating Expenses): checking for normality*
hist Opex, normal
twoway scatter Opex Type
*Outlier: 3 observations dropped*
drop if Opex ==0
*Outlier: 4 observations dropped*
```

```
drop if Opex > 500000
*Generate log transformation*
gen lnOpex=ln(Opex)
hist lnOpex, normal
twoway scatter lnOpex Type
qnorm lnOpex
*Outliers: 4 observations dropped*
drop if lnOpex < 7
hist lnOpex, normal
twoway scatter lnOpex Type
pnorm lnOpex

*Dependent variable (NOI): checking for normality*
hist NOI, normal
twoway scatter NOI Type
*Outliers: 10 observations dropped*
_pctile NOI, p(1 99)
return list
drop if NOI < r(r1) | NOI > r(r2)
hist NOI, normal
twoway scatter NOI Type
qnorm NOI
pnorm NOI

*Independent variables - histogram (excluding categorical variables)* - is this even necessary
hist Age
sum Age, detail

hist Employ, normal
sum Employ, detail
gen lnEmp = ln(Employ)
hist lnEmp, normal

hist DispIncHH, normal
sum DispIncHH, detail
*Outliers: 3 observations deleted*
drop if DispIncHH > 70
gen lnDispInc = ln(DispIncHH)
hist lnDispInc, normal
```

```
sum lnDispInc, detail

hist Pop, normal
sum Pop, detail
gen lnPop = ln(Pop)
hist lnPop, normal
sum lnPop, detail

hist HH, normal
sum HH, detail
gen lnHH = ln(HH)
hist lnHH, normal
sum lnHH, detail

hist AreaM2, normal
sum AreaM2, detail
gen lnArea = ln(AreaM2)
hist lnArea, normal
sum lnArea, detail

*Dependent variables per sqm - used in summary statistics*
gen RentSqm = Rent/AreaM2
gen OpexSqm = Opex/AreaM2
gen NOISqm = NOI/AreaM2

*Summary Statistics*
ssc install asdoc
bys Type: asdoc tabstat Rent RentSqm Opex OpexSqm NOI NOISqm AreaM2 Age Type SubType Functions Parking DispIncHH Employ HH Pop QOL COROP IntRate, replace stat(N mean sd min max)
ttest Rent, by(Type)
ttest RentSqm, by(Type)
ttest Opex, by(Type)
ttest OpexSqm, by(Type)
ttest NOI, by(Type)
ttest NOISqm, by(Type)
ttest AreaM2, by(Type)
ttest Age, by(Type)
ttest Functions, by(Type)
ttest Parking, by(Type)
```

```
ttest DispIncHH, by(Type)
ttest Employ, by(Type)
ttest HH, by(Type)
ttest Pop, by(Type)
ttest QOL, by(Type)
ttest COROP, by(Type)

*Frequnecies for dummy variables*
tab SubType
tab2 Functions Type
tab2 QOL Type
tab2 Parking Type
tab2 COROP Type

*Correlation Matrix (Type & Subtype)*
correlate lnRent lnOpex NOI lnArea Age Type Functions lnDispInc lnEmp lnHH lnPop QOL Parking COROP IntRate
correlate lnRent lnOpex NOI lnArea Age SubType Functions lnDispInc lnEmp lnHH lnPop QOL Parking COROP IntRate
graph matrix lnRent lnOpex NOI lnArea Age Type SubType Functions lnDispInc lnEmp lnHH lnPop QOL Parking COROP IntRate, half

///Regressions
reg lnRent Type lnArea Age lnDispInc lnHH ib5.QOL Parking lnMunicipSize i.COROP
reg lnRent Type lnArea Age lnDispInc lnEmp ib5.QOL Parking lnMunicipSize i.COROP
reg lnRent Type lnArea Age lnDispInc lnPop ib5.QOL Parking lnMunicipSize i.COROP
*lnHH/Emp/Pop all insignificant and affect model in similar manner. Model 1, 2 and 2 use lnHH. Model 4 use lnPop

///Baseline model
manova lnRent lnOpex NOI = Type c.lnArea c.Age c.lnDispInc c.lnHH ib5.QOL Parking i.COROP, vce(cluster COROP)
reg lnRent Type lnArea Age lnDispInc lnHH ib5.QOL Parking i.COROP, vce(cluster COROP)
outreg2 using RegRent.doc, replace ctitle (Baseline Model)
reg lnOpex Type lnArea Age lnDispInc lnHH ib5.QOL Parking i.COROP, vce(cluster COROP)
outreg2 using RegOpex.doc, replace ctitle (Baseline Model)
reg NOI Type lnArea Age lnDispInc lnHH ib5.QOL Parking i.COROP, vce(cluster COROP)
outreg2 using RegNOI.doc, replace ctitle (Baseline Model)
```

```
///Model 1: Parsimonious model
manova lnRent lnOpex NOI = Type c.lnArea c.Age Parking c.lnMunicipSize i.COROP
reg lnRent Type lnArea Age lnHH Parking i.COROP, vce(cluster COROP)
outreg2 using RegRent.doc, append ctitle (Model 1)
reg lnOpex Type lnArea Age lnHH Parking i.COROP, vce(cluster COROP)
outreg2 using RegOpex.doc, append ctitle (Model 1)
reg NOI Type lnArea Age lnHH Parking i.COROP, vce(cluster COROP)
outreg2 using RegNOI.doc, append ctitle (Model 1)

///Model 2: Using SubType
manova lnRent lnOpex NOI = ib4.SubType c.lnArea c.Age Parking c.lnMunicipSize i.COROP
reg lnRent ib4.SubType lnArea Age lnHH Parking i.COROP, vce(cluster COROP)
outreg2 using RegRent.doc, append ctitle (Model 2)
reg lnOpex ib4.SubType lnArea Age lnHH Parking i.COROP, vce(cluster COROP)
outreg2 using RegOpex.doc, append ctitle (Model 2)
reg NOI ib4.SubType lnArea Age lnHH Parking i.COROP, vce(cluster COROP)
outreg2 using RegNOI.doc, append ctitle (Model 2)

///Propensity score matching (based on lnRent) [no caliper]
*Step 1: Obtain prdicted probabilities
logit Type lnArea lnDispInc lnPop PostalCode
outreg2 using logit1.doc, replace ctitle (logit)
*Step 2: create logit using predicted probabilities
predict p
g logit=log((1-p)/p)
*Step 3: Create random variable to sort sample data
g x=uniform()
sort x
*Step 4: use constant seed number to ensure same results
set seed 1000
*Step 5: run propensity score matching*
psmatch2 Type, outcome(lnRent) pscore(logit) noreplace neighbor(1)
pstest lnArea Age lnDispInc lnPop PostalCode
psgraph
psmatch2 Type, outcome(lnRent) pscore(logit) caliper(0.25) noreplace neighbor(1)
pstest lnArea lnDispIn lnPop PostalCode
psgraph
*Step 6: Keep only matched sample*
gen pair = _id if _treated==0
```

```
replace pair = _n1 if _treated==1
bysort pair:egen paircount = count(pair)
drop if paircount !=2
*After this there are 98 observations 49 SUD and 49 MUD
tab1 Type

/// Model 3: Using only matched sample
manova lnRent lnOpex NOI = ib4.SubType c.lnArea c.Age Parking c.lnPop i.COROP
*manove shows Parking, Pop and COROP not significant*
reg lnRent ib4.SubType lnArea Age Parking lnPop i.COROP, vce(cluster COROP)
outreg2 using RegRent.doc, append ctitle (Model 3)
reg lnOpex ib4.SubType lnArea Age Parking lnPop i.COROP, vce(cluster COROP)
outreg2 using RegOpex.doc, append ctitle (Model 3)
reg NOI ib4.SubType lnArea Age Parking lnPop i.COROP, vce(cluster COROP)
outreg2 using RegNOI.doc, append ctitle (Model 3)

/// Inclusion of interaction variable in model 3
gen SubtypeAge = SubType*Age

reg lnRent ib4.SubType lnArea Age SubtypeAge Parking lnPop i.COROP, vce(cluster COROP)
outreg2 using Interaction.doc, append ctitle (lnRent)
reg lnOpex ib4.SubType lnArea Age SubtypeAge Parking lnPop i.COROP, vce(cluster COROP)
outreg2 using Interaction.doc, append ctitle (lnOpex)
reg NOI ib4.SubType lnArea Age SubtypeAge Parking lnPop i.COROP, vce(cluster COROP)
outreg2 using Interaction.doc, append ctitle (NOI)

///OLS assumption testing (based on model 3)
*lnRent equation
quietly reg lnRent ib4.SubType lnArea Age Parking lnPop i.COROP
estat vif
predict r_lnRent
*Test for heteroscedasticity (A2)
rvfplot, yline(0)
estat hettest
*Test for independence - Durbin Wu Hausman Hausman test (A4)
quietly reg lnRent ib4.SubType lnArea Age Parking lnPop i.COROP
quietly reg SubType lnArea Age Parking lnPop i.COROP
predict r_SubTypelnRent
reg lnRent SubType r_SubTypelnRent lnArea Age Parking lnPop i.COROP
```

```
outreg2 using DWH_lnRent.doc, replace ctitle (lnRent)
*Test for normality (A5)
kdensity r_lnRent, normal
pnorm r_lnRent
qnorm r_lnRent
swilk r_lnRent

*lnOpex equation
quietly reg lnOpex ib4.SubType lnArea Age Parking lnPop i.COROP
estat vif
predict r_lnOpex
*Test for heteroscedasticity (A2)
rvfplot, yline(0)
estat hettest
*Test for independence - Durbin Wu Hausman Hausman test (A4)
quietly reg lnOpex ib4.SubType lnArea Age Parking lnPop i.COROP
quietly reg SubType lnArea Age Parking lnPop i.COROP
predict r_SubTypelnOpex
reg lnOpex SubType r_SubTypelnOpex lnArea Age Parking lnPop i.COROP
outreg2 using DWH_lnRent.doc, append ctitle (lnOpex)
*Test for normality (A5)
kdensity r_lnOpex, normal
pnorm r_lnOpex
qnorm r_lnOpex
swilk r_lnOpex

*NOI equation
quietly reg NOI ib4.SubType lnArea Age Parking lnPop i.COROP
estat vif
predict r_NOI
*Test for heteroscedasticity (A2)
rvfplot, yline(0)
estat hettest
*Test for independence - Durbin Wu Hausman Hausman test (A4)
quietly reg NOI ib4.SubType lnArea Age Parking lnPop i.COROP
quietly reg SubType lnArea Age Parking lnPop i.COROP
predict r_SubTypeNOI
reg NOI SubType r_SubTypeNOI lnArea Age Parking lnPop i.COROP
outreg2 using DWH_lnRent.doc, append ctitle (NOI)
```

```
*Test for normality (A5)
kdensity r_NOI, normal
pnorm r_NOI
qnorm r_NOI
swilk r_NOI

***End of file***
```

ADDENDUM

Reference

Evans, A. W., 1972, The Pure Theory of City Size in an Industrial Economy. Journal of Urban Studies, 9(1): 49–77.